Greater Wellington Regional Council

2013 WTSM Update

Technical Note 2: Observed Commercial Vehicle Matrix Development

November 2014

TDG Ref: tn2 - observed commercial vehicle matrix development v3.docx

Greater Wellington Regional Council

2013 WTSM Update

Technical Note

Quality Assurance Statement

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Status: Version 3 - Final

Date: 26 November 2014

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1. Introduction

The technical note is part of a series documenting the 2013 update of the Wellington Transport Models, which are maintained by Greater Wellington Regional Council (GWRC).

The transport models include the Wellington Transport Strategy Model (WTSM), which is a four stage model developed in 2001 and updated in 2006 and then again in 2011, as well as the Wellington Public Transport Model (WPTM) a more detailed public transport assignment model developed in 2011.

This technical note documents the process of producing the sample and expanded matrices of 2013 commercial vehicle (medium and heavy) trips at both daily level and for the AM, interpeak, PM and overnight time periods. The observed matrices form the basis from which the new Commercial Vehicle Model will be developed, which will be embedded in WTSM. The Commercial Vehicle Model development is documented separately.

The technical note is organised to document:

- The input data;
- The process of converting tracking data into trips;
- Expansion of the sample data; and
- A summary of key figures.

2. Input Data

Four datasets were used to create the 2013 commercial vehicle matrix. They were:

- Raw and processed vehicle tracking of commercial vehicles (obtained by TDG and provided from NZTA eRUC data);
- 2013 Census meshblock boundary;
- Road centrelines;
- 2013 average weekday commercial vehicle traffic counts by time period.

Each dataset is described individually in the following sections.

2.1 Vehicle Tracking Data

Tracking data for commercial vehicles was used to determine the origin and destination of medium and heavy vehicle trips, as well as the frequency and time period for these trips.

Approximately a month's worth of raw tracking data for commercial vehicles was obtained by TDG. In addition, processed tracking data from electronic Road User Charges (eRUC) was provided by NZTA for roughly the same period. The final TDG data filtered to only include trips within or through the Greater Wellington Region (GWR) covered 22 weekdays from 28 February to 29 March 2013. The processed NZTA data consisted of records from 21 weekdays from 1 March to 29 March 2013. Data was collected for March as WTSM represents travel in this month.

The two datasets were combined at the end of the processing to create the final sample commercial vehicle matrix. However, since the sampled periods did not exactly overlap with each other, to maintain as much data as possible in the final matrices, the TDG and NZTA matrices were averaged separately and added together to create the final sample matrix. More details of this process can be found in section 3 of this technical note.

2.1.1 Vehicle Tracking Data Obtained by TDG

There were over 3 million records in the raw tracking database obtained by TDG. These records were supplied by two sources for the period from late February 2013 to mid-March 2013, including weekends. The tracking data is commercially sensitive and hence the sources that provided the information cannot be disclosed. However, we can confirm that different companies provided data to TDG and NZTA so there is no overlap in the samples, hence they can be combined without any further adjustments.

Each tracked record included a location stamp (expressed as longitude and latitude), time stamp (including date and time, to the second), tracked vehicle reference (unique vehicle identifier) and movement status (whether the vehicle is moving or stopped).

2.1.2 eRUC Commercial Vehicle Data Provided by NZTA

The commercial vehicle information provided by NZTA was based on data collected through eRUC. The data included trips made in the month of March 2013 within the GWR area, including weekends.

The data had been processed so each record represented a commercial vehicle trip with mid trip time (date and time, to the second), origin and destination (expressed as WTSM zones). No further checking of this data was possible by TDG.

2.2 2013 Census Meshblock Boundary

The 2013 meshblocks in the Wellington region were used to compress the tracking data into matrices, for calculating average trips from area to area, rather than address to address.

These meshblocks were published by Statistics NZ in 2013. To allow conversion from meshblock to model zone, a look up table was built between the WTSM model zones and 2013 meshblocks. It is worth noting that the original model zones were built from 2001 meshblocks, therefore, with the 2013 updated meshblocks, there will be some slight changes to the zone boundaries. However, the changes are insignificant.

The meshblock boundaries were also used to exclude erroneous tracking points in the TDG tracking dataset that lay outside of the New Zealand boundary (after taking account of the waters between the North and South Island for vehicles travelling on the Interislander ferry).

A similar process was applied to the NZTA data. WTSM zone boundaries, updated to 2013 meshblocks, were supplied by TDG. This was used to convert trips from address-to-address to zone-to-zone.

2.3 Road Centrelines

Road centrelines were used to eliminate intermediate stops in the TDG dataset. This included checking for stops at railway crossings, intersections, as well as determining the point of entry for external traffic entering or exiting GWR (via SH1 or SH2).

The road centrelines used were published by National Map.

2.4 2013 Average Weekday Traffic Counts

Average weekday commercial vehicle traffic counts for the year 2013 were used to expand the sample matrix to a full matrix that represented all commercial vehicle movements in the GWR area. The traffic counts were available for the following time periods:

- AM Peak Period: 07:00 – 09:00
- Interpeak Period: 11:00 – 13:00
- PM Peak Period: 16:00 – 18:00

- Daily 24 hours

Overnight (18:00 - 07:00) traffic counts were also required for the processing. These were calculated as the difference between the daily traffic count and the sum of the AM two hour period, the PM two hour period, and the interpeak period, the latter factored by 7/2 to convert the two hour traffic count into the seven hours from 09:00 to 16:00. This calculation was adopted because hourly traffic counts were not available at all locations. Checks on hourly traffic counts for non-state highway locations indicated that the estimated overnight traffic count was potentially 10% high. The same checks applied to counts on state highways indicated a potential overestimate of around 7%. These checks confirm that the approximation for the overnight traffic counts will not produce an order of magnitude error. It is also worth noting that the overnight sample was only processed to check daily totals and will unlikely be used in WTSM.

Overall, counts from 43 locations were used to expand the sample matrices.

3. Sample Matrix Creation

3.1 Overview

A WTSM zone level sample matrix was created from the tracking inputs described in the previous section for each of four time periods, which were:

- AM Peak Period: 07:00 – 09:00
- Interpeak Period: 09:00 – 16:00
- PM Peak Period: 16:00 – 18:00
- Overnight Period: 18:00 – 07:00

The sample matrices were created in three steps:

- First, the raw tracking data obtained by TDG was converted from tracking points to trips;
- Second, these trips were aggregated and averaged to form a zone level sample matrix;
- Lastly, this sample matrix was combined with the processed data from NZTA to generate the final commercial vehicle sample matrix.

It is worth noting that the interpeak period in WTSM is validated to the average hour of the two hour period from 11:00 to 13:00. Although it does appear that the model may have been originally validated to the average hour between 09:00 and 16:00 – the reason for the change is no longer evident. To retain the maximum amount of travel data, sampled trips between 09:00 and 16:00 were included for the interpeak, then expanded using the two hour interpeak traffic counts (11:00 to 13:00). This means that more possible travel patterns are included and we also believe this is likely to be consistent with the processing of the Household Interview Survey data for person-based travel.

The time periods for the sampled trips were determined by their mid trip time. This will mean that any long haul trips will be allocated to a time period based on their half-way point. However, long haul trips entering Wellington region at the external points to the model are a relatively small proportion of the overall sample, with only 6% of sampled trips being external.

The processing of the TDG tracking dataset to convert the tracking points to trips is described in the next two sections; the third section outlines how this dataset was combined with the pre-processed NZTA dataset and the final sample matrices produced.

3.2 From GPS to Trips – TDG Dataset

The processing described in this section only applies to the tracking data obtained by TDG. The NZTA data was provided already processed in matrix form.

This step removed the data not required and the 'false' or invalid stops from the raw tracking database then assigned origin and destination meshblocks to the valid stops to form trips. This process was delivered through the following steps:

- Identify and remove tracking records that do not meet the specification for the data processing. For example, weekday matrices are being developed, so remove tracking records at weekends;
- Identify and remove trips that are not through or within Wellington region;
- Recalculate how long a vehicle was stopped for (idle duration). This was required as the different sources had definitional differences. How long a vehicle was stopped at a particular tracking point is critical in determining if this is the end of a trip or represents queuing at traffic signals or waiting at a railway crossing, for example;
- Identify and remove tracking points associated with a stationary vehicle for very short times as these are associated with stops at railway crossings or queuing at congested intersections;
- Identify and remove trailers attached to trucks where tracking data is included for both the truck and the trailer;
- Allocate meshblocks to enable aggregation from addresses.

These steps are outlined in the following sections.

3.2.1 Remove Data Not Required

The first step was to identify and remove tracking records that did not meet the specification for the Commercial Vehicle Model.

Trips at weekends and light vehicles trips were included in the dataset but were removed to produce weekday medium and heavy vehicle travel.

There were also duplicated records that were removed at this stage. A record was considered a duplicate if it had the same location, time stamp and vehicle ID as a previous record. Duplicated records will occur when a GPS device is attached to both the truck and trailer.

Further checks were applied later in the process to identify and remove records associated with a trailer that may not appear at the exact same location as the truck it is attached too.

3.2.2 Remove Data NOT Within or Through Wellington Region

The tracking dataset included travel throughout New Zealand. The data was processed to identify stops (tracking records) that related to trips within or through Wellington region.

This was accomplished by identifying tracking points within the region; external-internal trips where a tracking point was outside the region but then travelled into the study area; internal-external trips where the reverse occurred; and any potential external-external trips through Wellington region.

The complexity in the processing was because at this stage, tracking points have not been linked into trips. So determining where (geographically) a trip occurs depends on the previous and next tracking records – i.e. three records are required to obtain directionality and location.

As an example, for a tracking point at Palmerston North, the next tracking location and the previous location must be checked to see if either was within Wellington region. If either the next or previous location was within Wellington, then this is either an external-internal ("next" point within Wellington) or an internal-external ("previous" point within Wellington) trip depending on the direction of travel. In this case, the tracking point outside the region boundary must be retained in the data sample. It is even more complicated because if the previous location was Blenheim (i.e. Blenheim to Palmerston North), then this trip must have passed through the study area and has to be retained as an external-external trip.

The first step in identifying tracking records associated with trips within or through the region was to transform the tracking records into points on a map using the longitude and latitude location in the database. Each tracking point was then allocated a geographic area as listed below:

(i) Greater Wellington Regional Council Area (including waters around GWR) ('Area 1');

(ii) Rest of North Island (including waters around North Island) ('Area 2');

(iii) South Island (including waters between North and South Island) ('Area 3').

Points that did not fall within one of the above areas (i.e. outside of New Zealand) were removed from the procedure as they were spurious. For every remaining point, the area the point was <u>within</u> was assigned. For example, a tracking point in Palmerston North would have "Area 2" appended to the record.

Then, every point with the same vehicle ID was assigned the area identifier of the point before and after it was recorded (i.e. the location where the vehicle has come from and the location where it is going to). As a result, each point would have three area references: one for where it came from, one for where it was at, and where it was going to. Effectively, at this stage, trips could be created from all points with both valid current and next area IDs. This is illustrated in the following figure.

	This Area	Previous Area	Next Area
New Plymouth	Area 2 North Island		Area 2 (North Island
Whanganui	Area 2 (North Island)	Area 2 (North Island)	Area 2 (North Island
Palmerston North	Area 2 (North Island)	Area 2 (North Island)	Area 1 (GWR)
Wellington	Area 1 (GWR)	Area 2 (North Island)	Area 3 (South Island)
Blenheim	Area 3 (South Island)	Area 1 (GWR)	Area 3 (South Island)
Christchurch	Area 3 (South Island)	Area 3 (South Island)	

Figure 1: Example of Area Allocation to Determine Points Within or Through Study Area

Lastly, the points were split into four groups based on the relationships of its three area references.

(i) First point of the trip (i.e. there is no previous area reference). This would be New Plymouth in the example above;

(ii) Point inside GWR. These points are the internal end of either an internal-internal, internal-external or external-internal trip. This would be the tracking point in Wellington in the example above;

(iii) Point outside GWR but where the current area ("this area", in the example above) is different to the next area. For example, points associated with trips from the North Island (outside Wellington) to the South Island (external-external trips); Wellington to the South Island (internal-external trips), or the North Island to Wellington (external-internal trips);

(iv) Points that are not inside GWR, and not from or to GWR (all other cases that do not satisfy the above). This basically identifies tracking points associated with trips within the South Island, or within the North Island (excluding Wellington region), i.e. those that are not within or pass through the study area.

Points in groups (i) and (iv) (as listed above) were removed from the dataset as they are associated with trips that did not travel through GWR or cannot form trips (the information on the start trip location for trips in group (i) has been appended to the next tracking point). As a result, at the end of this process, only points inside Wellington region and points immediately before entering or after exiting the region remained.

3.2.3 Recalculate Idle Duration / Vehicle Stop Time

As the tracking data was sourced from different providers, there was a different definition for the vehicle movement times and the idle times (i.e. when a vehicle was stationary) between the two sources.

This step transformed the data so that for every remaining valid record, when the vehicle was idle or stationary was recorded consistently. The process then calculated:

- Time when the vehicle stopped;
- Time when the vehicle started moving again; and
- How long the vehicle stopped for.

To expedite the processing, this transformation was only applied to points inside Wellington region and not to points immediately before entering, or after leaving, the region. This is because the purpose of this calculation is to determine the correct duration of a vehicle stop, in order to identify and then eliminate 'false' stops that may have occurred at intersections or railway crossings. For points outside of Wellington region, they were only retained to identify external trips, and their stop time as not required.

Note that this step was a time-based calculation to support the next processing step, which was to identify and remove invalid stops (i.e. not trip ends). No tracking records were removed in this step.

3.2.4 Remove Stops that are NOT Ends of Trips

This step identifies and removes any tracking points where a vehicle has stopped for a short period of time, such as at an intersection or a railway crossing. These stops are not trip ends and must be removed prior to linking the tracking points to create trips.

Any points that fell within a 20m buffer of the SH2 railway crossing (at Featherston Street) were identified and removed as they are not a destination but a stop mid-way on a trip.

The stop duration and location of the tracking points were reviewed. It was determined that applying a threshold of 120 seconds would eliminate tracking points associated with congestion at intersections. So for points inside the region, any tracking records identified as 'stop' in the moment type field and with a stop duration of less than 120 seconds were removed.

3.2.5 Remove Duplicate Trucks and Trailers

In some cases, the tracking sensor was placed on the truck as well as the trailer, resulting in double counting of trucks and trailers. Removal of tracking points for trailers was not undertaken, as this is a valid trip if the associated truck does not have a tracking sensor.

Note that the first step in the overall processing included removal of tracking points where the location and time stamp of a vehicle were identical (see section 3.2.1). This step checked for small geographical differences in location and small time differences.

If a trailer always appeared within 10 metres and 2 minutes of the same truck, it was considered to be a duplicate record and removed. The movements by the truck were retained.

3.2.6 Assign Stops to Meshblocks

The remaining cleaned/valid tracking points were assigned a meshblock to enable aggregation of address-based data to meshblocks.

This was straightforward for the tracking points inside Wellington region (excluding points that fell in the surrounding waters, which were allocated a meshblock as below).

For tracking points outside of the region that had travelled to or from (or through) the study area:

- If the tracking point was inside Wellington region (including the surrounding waters), then it was matched to the closest meshblock within 200m. If no meshblock was found within 200m of the tracking point, it was assumed the vehicle used the port and this was allocated as the meshblock;
- If the tracking point was in the South Island (Area 3), then the tracking point was allocated as to the port meshblock;
- If the tracking point was in the rest of the North Island (Area 2), then it was matched to the closest state highway within 2km. If no state highway was found within 2km of the point, it was assumed the vehicle used SH1 and this was allocated.

Dummy meshblock identifiers were assigned to the port (10), SH1 (11) and SH2 (12) for this process.

At the end of this step, all tracking points inside, immediately before entering, and after leaving Wellington region were assigned a meshblock for their current, previous and next location.

3.2.7 Summary

Every remaining tracking record in the database represented a valid medium or heavy vehicle trip originating in the current meshblock and destined for the next meshblock. Only trips within or through Wellington region remained.

Duplicate trailers and 'false' stops have been identified and removed.

Weekend data has been removed.

3.3 From Trips to Matrices by Time Period – TDG Dataset

The trips from the dataset sourced by TDG, which were produced by applying the process described in the last section to tracking points, were aggregated and averaged to produce matrices by time period. This process is explained below.

Every trip remaining in the database was assigned a time period, based on their mid trip time. Time periods were AM, interpeak, PM, or overnight and are reiterated below:

- AM Peak Period: 07:00 – 09:00
- Interpeak Period: 09:00 – 16:00
- PM Peak Period: 16:00 – 18:00
- Overnight Period: 18:00 – 07:00

As the tracking data sourced by TDG was from different providers, the sampled days did not exactly align between the two sources. Consequently, some days at the start and end of the month were found to have significantly fewer trips compared to days in the middle of the month. If all of the data was used to calculate a weekday average without further adjustment, the resulting matrix would underrepresent commercial vehicle travel as it would be skewed by different samples at the start and end of the period.

The issue of low sample at the start and end of the period could have been simply addressed by discarding sample days at the start and end where the number of trips was significantly lower. However, maximising the sample was considered paramount.

It was also found that there were some vehicles in the dataset that only made trips at the start (or end) of the period. Removing these sample days would have resulted in the loss of travel patterns, and of greater concern, would have skewed the average weekday sample. For example, consider a vehicle that makes 4 trips on Monday, 1 trip on Wednesday and no trips on Tuesday, Thursday or Friday. This vehicle made 5 trips in the week, so the average weekday trip making is 1 trip per day. If Monday was discarded from the sample, then the number of trips made on an average weekday drops to 0.25 (1 trip on Wednesday divided by four days remaining in the sample). While the expansion of the sample data to total travel will somewhat correct for the numeric difference, the loss of the travel patterns on the Monday cannot be compensated.

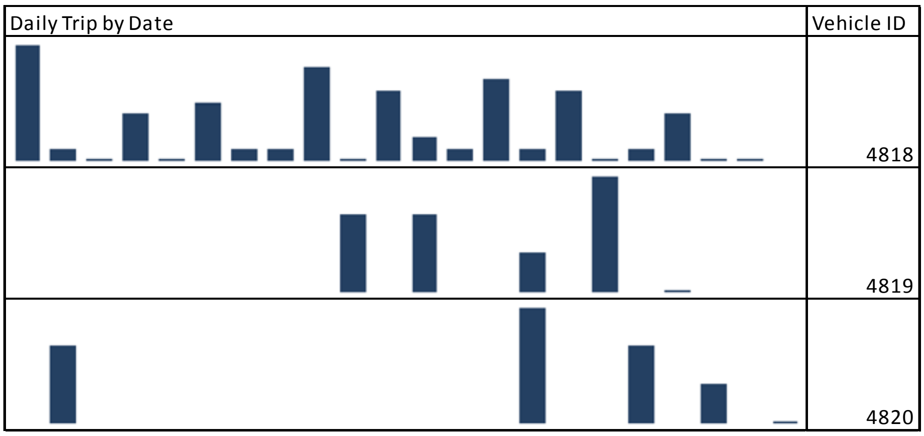
To retain as much of the sample data as possible, and minimise any skewing in the calculation of average daily travel, a process was setup to identify partially sampled vehicle trips and remove these from the dataset. This was achieved in two steps:

- Identify days where the sample is considered low; and
- For these low sample days, evaluate trip making on an individual vehicle basis and remove vehicles that do not make any trips or make a very low number of trips.

Firstly, a process was setup to quantify which dates had low samples at the start and end of the period. To do this, daily trip totals were calculated by date for all remaining records. The average number of daily trips and the standard deviation was then calculated, also by date. For any date where the daily trip total was outside of the 90% confidence interval (average +/- 1.65 * standard deviation), that date was considered to be a low sample day.

Secondly, on low sample days, vehicles that made unusually low or no trips were removed from the database. This was because it was concluded that only partially observed trip data had been provided for these vehicles on these days. Note that trips were only removed from low sample days. The total number of sampled days was recalculated for these vehicles, with the low sample days removed.

For example, the following graphic shows the daily trips by date for three different vehicles, where each row represents a different vehicle and each bar represents trips made on each day, from day 1 to day 22.



Over the sampled period for the whole sample, we determined that the first (1) and last (22) days were low sample days. Therefore, using the method above:

- Vehicle 4818: include day 1, exclude day 22, in total 21 days sampled
- Vehicle 4819: exclude both day 1 and day 22, in total 20 days were sampled
- Vehicle 4820: exclude both day 1 and day 22, in total 20 days were sampled

While there is a subjective element to determining if the vehicles above did or did not travel on day 1 and day 22, it was evident from the aggregate data that sampling was not consistent across the period and the sample was low at the start and the end. Hence an adjustment was deemed preferable.

3.4 Produce Average Weekday Sample Matrices

The next step was to produce WTSM zone matrices for an average weekday by each of the four time periods, and then combine the TDG and NZTA datasets.

The tracking data sourced by TDG, from which a small number of vehicle trips on low sample days at the start and end of the period had been removed, was averaged across the total number of days sampled by vehicle and time period. Then, the average trips by vehicle and time period were aggregated to form origin-destination matrices by time period at meshblock level. The meshblock sample matrices were then compressed to WTSM zone matrices. Meshblock level processing was undertaken to retain the maximum granularity and enable the sample data to be rezoned to a finer zone system at a later date if required.

The eRUC data received from NZTA was averaged and aggregated to create WTSM zone level matrices by time period. It is worth noting that, similar to the tracking data obtained by TDG, the NZTA dataset had significantly lower numbers of trips for certain dates at the start and end of the period. Given the NZTA data was provided pre- processed, it could not be related back to individual vehicles, so all trips on the low sample days were removed from the NZTA dataset during the averaging process.

In addition, because the sample period of the tracking data obtained by TDG and data supplied by NZTA did not exactly correspond, the two datasets were averaged separately and then summed afterwards to create the final sample matrices. As noted before, the company that provided information to NZTA is not the same as the two companies that provided data to TDG, hence there is no overlap in the datasets. Due to confidentiality constraints, the companies providing the data cannot be named.

At the end of this stage, the sampled trips had been converted to WTSM zoned matrices by time period, which summed to a 24 hour matrix, and covered the periods:

- AM Peak Period: 07:00 – 09:00
- Interpeak Period: 09:00 – 16:00
- PM Peak Period: 16:00 – 18:00
- Overnight Period: 18:00 – 07:00

The sample matrices are provided in Appendix A at sector level for each of the four time periods. The definition of the sectors is provided in the following section.

4. Expansion of Sample Matrix

Average 2013 weekday commercial vehicle traffic counts were used to expand the sample to full matrices. To do this, various expansion methods were trialled based on sample matrix analysis. In the end, a hierarchical screenline method was chosen as the preferred method for the matrix expansion. This is described in the following text.

4.1 Sample Matrix Analysis

As indicated in the summary table below, the final sample commercial vehicle matrices had around 8,000 trips, with the majority of the trips falling in the longer interpeak and overnight periods.

Sample Summary	AM (0700-0900)	IP (0900-1600)	PM (1600-1800)	ON (1800-0700)	Daily 24 Hours
TDG	410	1,665	343	1,437	3,855
NZTA	640	2,400	338	784	4,163
Total	1,050	4,065	682	2,222	8,018

Table 1: Commercial Vehicle Sample by Time Period

Overall, there are 228 zones in WTSM, which equates to 51,984 origin and destination (OD) pairs. The sample from NZTA included trips between 10,496 OD pairs, while the TDG sample contained trips between 9,557 OD pairs. Altogether, the total matrix covered 15,109 OD pairs, which is about 30% of the total number of potential OD pairs in WTSM – noting that there could be some movements where there are no commercial vehicle trips.

A comparison of the trip ends by model zone indicated that the data in the two sample sets had different geographic focus. The NZTA sample was more concentrated in the northern part of the region, whereas the TDG sample was centred on the Wellington city area. The combined sample therefore provided greater geographic coverage across the region.

The following figure depicts the trip end comparison results between the NZTA and TDG sample, where blue indicates that TDG had more samples compared to NZTA, and red indicates more samples from NZTA.

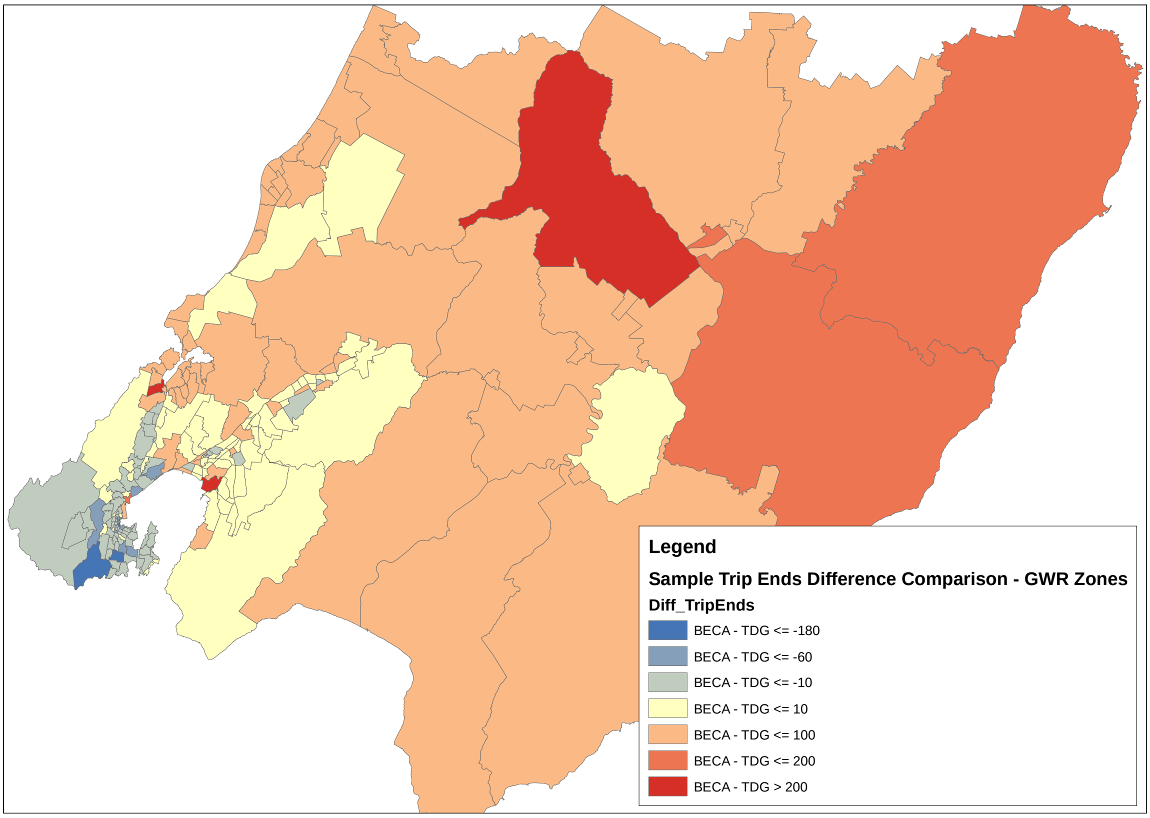


Figure 2: Concentration of Commercial Vehicle Sample in TDG and NZTA Datasets[1]

4.2 Expansion Methods Considered

Several expansion methods were considered, from simple to complex, and subsequently discarded. The methods considered are noted here for reference purposes. Note that using assignment techniques, and hence matrix estimation, was avoided – this was to eliminate route choice discrepancies arising from assigning a sample matrix.

The first method considered was to calculate and apply a single factor for all time periods, and all origins and destinations. To calculate that factor, trips crossing key locations were extracted from the matrix and compared with counts. This effectively created small screenlines that followed zone boundaries and count locations, trips crossing the screenlines in the matrix were compared with the traffic counts to calculate an expansion factor. Several such screenlines were selected, and the results indicated that, at daily level, the percentage of sample was around 5% to 20%, with 10% being the median value. Consequently, 10 was used as the expansion factor (1/10%).

This crude and simple method was applied to expand the sample matrix. But, as might be expected, when the simple expanded commercial vehicle matrices were assigned to the network, the output commercial vehicle volumes on the network did not match well with the counts. The results showed a mismatch by location as well as time period. This confirmed that time period specific expansion would be required as well as incorporating geographic differences.

[1] NZTA tracking data referred to as "Beca" in the figure as Beca provided the processed data.

The second method built on the results of the first method, with additional factors calculated based on the assignment results. Counts were grouped by Territorial Local Authority (TLA), and the sample was factored up or down by TLA to improve the match with the counts. This process was repeated separately for each time period. As a result, additional expansion factors were created by TLA for each of the four time periods.

This method also failed to produce matrices that when assigned to the network, matched well with counts on a screenline basis (i.e. not considering any errors due to route choice). This indicated differences in the sample within the TLAs.

Therefore, these methods were abandoned and a full hierarchical screenline expansion method, to be manually calculated and applied, was developed. Details on this method are discussed in the next section.

It is worth noting that after the hierarchical expansion was completed, automatic matrix estimation was tested for the AM peak period. This was conducted using CUBE software, which has the option of controlling the estimation to counts by screenline total to minimise the error from route choice discrepancies. While the estimated matrix produced a good correspondence between modelled and observed flows at screenline level, as expected, there were a large range of factors for individual origin-destination cells. The largest factor from the sample to the estimated matrix was over 1900, which was considered excessive. Inputs could have been changed to (potentially) limit the large changes individual cell values, but it was considered that there was little additional value from an automatic estimation process compared with the manual hierarchical factoring adopted.

4.3 Expansion Method Adopted - Hierarchical by Screenline

After simple expansion methods were tested and failed to produce an acceptable observed matrix, a hierarchical screenline method was adopted as the preferred method and used for final matrix expansion.

This method expanded trips travelling through screenlines in the sample matrix to the total using counts, in the order of the geographical significance of screenlines. Note that alternative orders of screenlines were also tested – but almost all other combinations resulted in negative trips. This section explains the specifics of this method, such as which screenlines were used and how the sample was expanded.

4.3.1 Screenline Definition and Hierarchy

The standard WTSM screenlines are not watertight and were therefore not used for expansion of the sample matrix. New screenlines were developed for expansion based on available 2013 traffic counts and following WTSM zone boundaries. Overall, 15 screenlines were created which divided the study area into 16 sectors. Note that there is a limit on the number of screenlines and sectors that can be created based on the available traffic counts.

The following figure depicts the final screenlines used for the matrix expansion with a separate window provided to focus on the Wellington City area. Note that in a few places, sections of some screenlines overlapped with others, so they may appear to be incomplete in the figure (which they are not). The screenline numbering is not sequential; uniquely numbered screenlines were created, and if they were not subsequently used in the expansion, their unique screenline number was not reused for other locations. As an example, screenline 8 crossed the complete study area north of Paraparaumu and north of Upper Hutt. Sectors were reduced in size, and screenline 8 was split into two sections, with the new screenlines numbered 81 and 82 (joined them together would be equivalent to screenline 8). The screenline numbering does not affect the process – the non-sequential numbering is retained in this technical note to enable future referencing of the raw calculations if required.

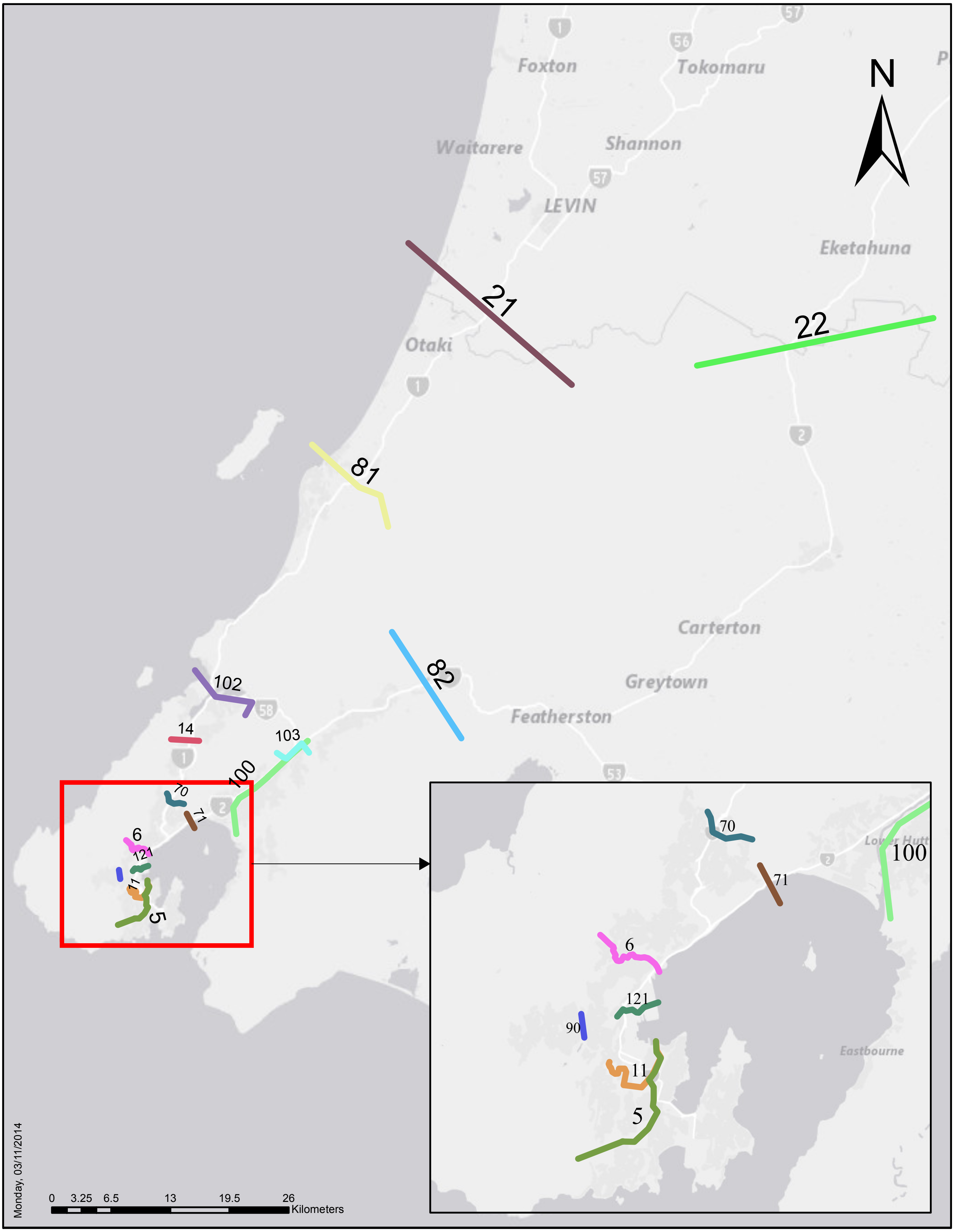


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Fig 3: Screenlines for Sample Matrix Expansion

TDG

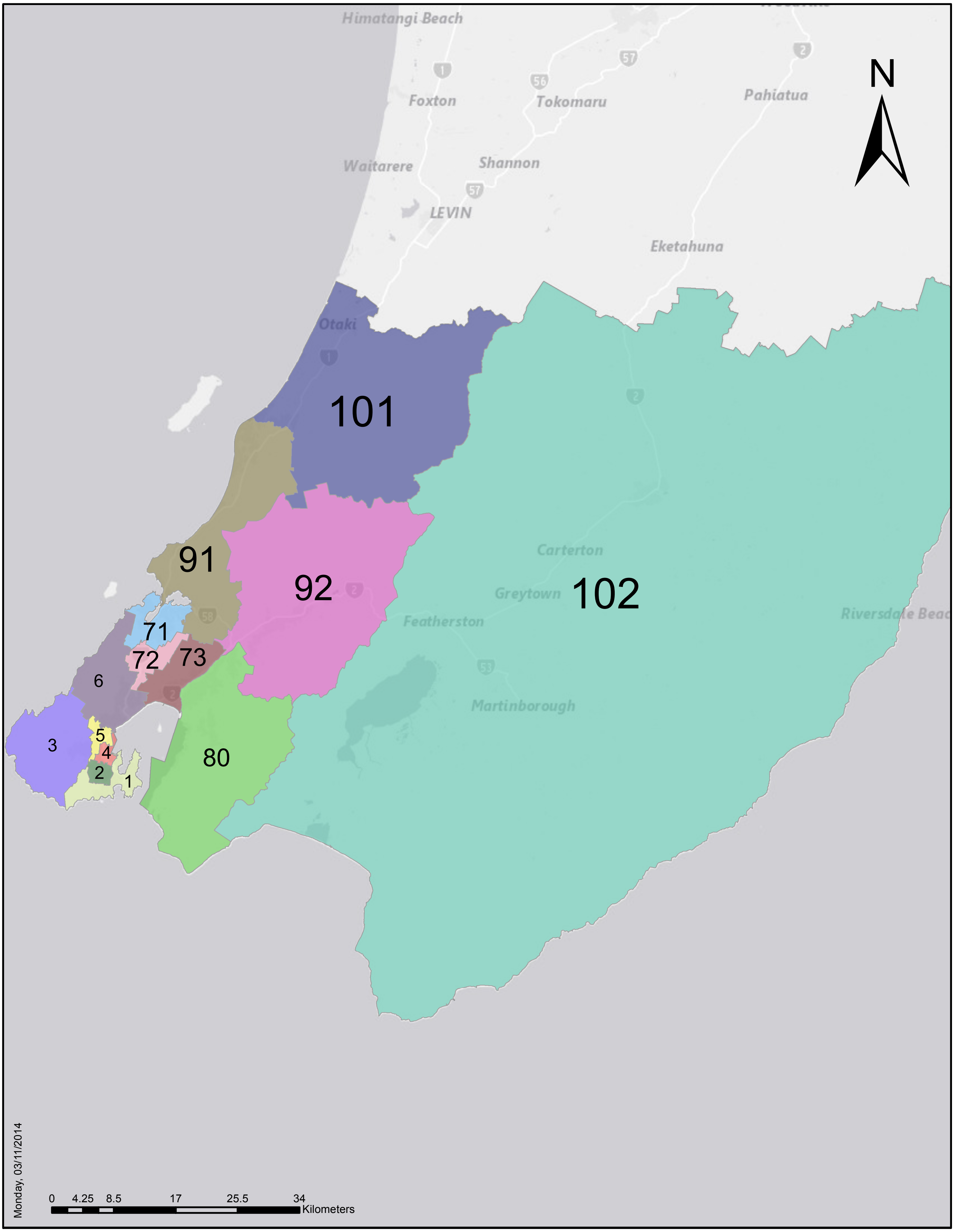
These screenlines were created to be as watertight as possible, so that the study area was divided into segments without holes or gaps. It is worth noting, however, that not all the traffic counts were located on model zone boundaries (i.e. some counts are in the middle of zones); and in some locations, minor roads crossing a screenline were not counted. The impact of this on the final output was considered to be minimal. Traffic volumes from the TDG sample using the un-captured minor roads were checked to ensure low usage.

Below is the list of screenlines, in the order they were used for expansion. Details on the count sites used to form these screenlines are listed in Appendix B. As noted above, different orders of screenlines were tested for the expansion – but only this combination did not produce a mismatch between sector-to-sector trips and screenline crossing volumes.

- Screenline 70: North of Ngauranga, SH1 corridor
- Screenline 71: North of Ngauranga, SH2
- Screenline 6: South of Ngauranga
- Screenline 21 Externals via SH1
- Screenline 22 Externals via SH2
- Screenline 11: South of Wellington City
- Screenline 5: South of Newtown
- Screenline 90: East of Karori
- Screenline 121: North of Wellington CBD
- Screenline 82: North of Upper Hutt on SH2 corridor
- Screenline 81: North of Paraparaumu
- Screenline 102: South of Mana
- Screenline 103: North of Lower Hutt
- Screenline 100: West of Lower Hutt
- Screenline 14: South of Porirua

Out of the total of 55 count sites available for the 2013 model validation, 42 were used to create these expansion screenlines.

The next figure shows the expansion sectors created by the screenlines. Note that sectors 111 and 112 are not shown as they represent the external traffic entering and leaving the region via SH1 and SH2 in the north respectively. External traffic coming into and leaving the region via the Port or the Interislander were included in sector 5.



2013 WTSM Update

Fig 4: Sample Matrix Expansion Sectors

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4.3.2 Expansion Factor Calculation

With the expansion screenlines and sectors defined, the sample matrix was compressed to these sectors retaining the four time periods separately. The process described below was carried out separately for each time period – but with the same ordering/ranking of screenlines.

There were some trips in the sample matrix from the external on SH1 to the external on SH2, and vice versa, as well as some "internal" trips within each of the two external sectors. These were small numbers of trips in each case and represent anomalies in either the data or the processing. These trips, which are illogical, were removed from the sample matrix for the expansion factor calculation.

Origin-destination cells in the sector sample matrix were grouped and compared with the corresponding traffic count to calculate the expansion factor. Cells were multiplied by the expansion factors in the order of their corresponding screenline ranking.

Note that each cell, in both the full origin-destination and in the sector matrix, was only factored once. After all the cells crossing a screenline were factored, the expansion factor for the next screenline was recalculated based on the remaining cells crossing that screenline (and taking account of the trips crossing that screenline that have already been factored).

There was no traffic count data that could be used to expand the intra-sector movements. The larger sectors were subsequently reduced in size to minimise the 'unknown' element of the expansion, however, this was limited by available traffic counts and the need to predetermine the route choice (i.e. using a transparent manual expansion approach rather than automatic matrix estimation). To provide context for the scale of these intra-sector movements, the proportion of intra-sector movements to the total sample ranged from 50% to 57% depending on the peak period.

Alternative data was therefore sourced to expand the intra-sector trips. Trip rates were collated from standard traffic engineering sources and applied to estimate the total number of trips (i.e. sector-to-sector and intra-sector combined) in each of the peak periods. The trips crossing screenlines were subtracted from this total, with the remainder allocated as intra-sector trips in the same proportion as the sample. For example in the AM peak, 22% of all intra-sector trips remained within sector 102, which is the sector covering the largest geographic area. So 22% of the estimated intra-sector trips to be allocated were allotted to sector 102. Note that this process is not designed to estimate trip numbers precisely which is not possible. It was designed to estimate orders of magnitude of trips that did not cross screenlines and improve on earlier expansion processes.

It is worth noting that, to be consistent with WTSM and the counts available, the interpeak period sample matrices (09:00-16:00) were expanded to match the counts for the two hour period from 11:00 to 13:00. Again, this retained the maximum amount of travel pattern data and likely corresponded with the approach to develop the person matrices.

In many locations, counts were only available for the AM peak, interpeak, PM peak and at a daily level. So the overnight sample had to be expanded based on an estimated traffic count. The estimated overnight traffic count was calculated by subtracting the AM, interpeak and PM peak period counts from the daily count. As the interpeak count only represented two hours, it was factored before subtraction to approximate seven hours by multiplying the average hourly interpeak counts by seven. Note that the overnight period matrix was created to control all values back to daily, and will not necessarily be required in the model.

The expansion factor for intra-sector trips for the overnight period was set to 1.0 (i.e. no expansion of the sample). This was because the trip rate data suggested a significantly greater proportion of daily trips in the combined AM, interpeak, and PM peak periods compared with the sample, hence no factoring of the overnight intra-sector trips was required. While it is considered unlikely that there will actually be significantly fewer intra-sector trips overnight, the overnight period is not required in WTSM and hence no further resolution of this discrepancy in overnight trips was attempted.

Commentary on the resulting expansion factors is provided in the next section.

4.3.3 Expansion Factors and Commentary

The tables below report the final sector-based expansion factors by time period.

AM	1	2	3	4	5	6	71	72	73	80	91	92	101	102	111	112
1	4.9	19.0	12.7	12.7	12.7	6.2	3.3	3.3	9.9	9.9	3.3	9.9	3.3	9.9	3.3	9.9
2	12.5	4.9	12.7	12.7	12.7	6.2	3.3	3.3	9.9	9.9	3.3	9.9	3.3	9.9	3.3	9.9
3	14.5	14.5	4.9	25.3	25.3	6.2	3.3	3.3	9.9	9.9	3.3	9.9	3.3	9.9	3.3	9.9
4	14.5	14.5	3.3	4.9	42.2	6.2	3.3	3.3	9.9	9.9	3.3	9.9	3.3	9.9	3.3	9.9
5	14.5	14.5	3.3	70.9	4.9	6.2	3.3	3.3	9.9	9.9	3.3	9.9	3.3	9.9	3.3	9.9
6	10.2	10.2	10.2	10.2	10.2	4.9	3.3	3.3	9.9	9.9	3.3	9.9	3.3	9.9	3.3	9.9
71	2.6	2.6	2.6	2.6	2.6	2.6	4.9	25.5	2.6	2.6	10.6	9.9	12.5	9.9	5.9	8.2
72	2.6	2.6	2.6	2.6	2.6	2.6	28.1	4.9	2.6	2.6	10.6	9.9	12.5	9.9	5.9	8.2
73	8.2	8.2	8.2	8.2	8.2	8.2	3.3	3.3	4.9	19.5	3.3	12.5	3.3	1.0	3.3	0.8
80	8.2	8.2	8.2	8.2	8.2	8.2	3.3	3.3	27.0	4.9	3.3	12.5	3.3	1.0	3.3	0.8
91	2.6	2.6	2.6	2.6	2.6	2.6	7.2	7.2	2.6	2.6	4.9	7.2	12.5	1.0	5.9	0.8
92	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	7.3	7.3	10.6	4.9	12.5	1.0	5.9	0.8
101	2.6	2.6	2.6	2.6	2.6	2.6	17.3	17.3	2.6	2.6	17.3	17.3	4.9	1.0	5.9	0.8
102	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	1.0	1.0	1.0	1.0	1.0	4.9	5.9	0.8
111	2.6	2.6	2.6	2.6	2.6	2.6	4.9	4.9	2.6	2.6	4.9	4.9	4.9	4.9	0	0
112	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	3.9	3.9	3.9	3.9	3.9	3.9	0	0

Table 2: AM Peak Period Expansion Factors

IP	1	2	3	4	5	6	71	72	73	80	91	92	101	102	111	112
1	1.8	3.4	2.3	2.3	2.3	2.0	1.1	1.1	3.1	3.1	1.1	3.1	1.1	3.1	1.1	3.1
2	0.9	1.8	2.3	2.3	2.3	2.0	1.1	1.1	3.1	3.1	1.1	3.1	1.1	3.1	1.1	3.1
3	2.5	2.5	1.8	1.2	1.2	2.0	1.1	1.1	3.1	3.1	1.1	3.1	1.1	3.1	1.1	3.1
4	2.5	2.5	3.1	1.8	8.9	2.0	1.1	1.1	3.1	3.1	1.1	3.1	1.1	3.1	1.1	3.1

IP	1	2	3	4	5	6	71	72	73	80	91	92	101	102	111	112
5	2.5	2.5	3.1	8.4	1.8	2.0	1.1	1.1	3.1	3.1	1.1	3.1	1.1	3.1	1.1	3.1
6	0.8	0.8	0.8	0.8	0.8	1.8	1.1	1.1	3.1	3.1	1.1	3.1	1.1	3.1	1.1	3.1
71	0.7	0.7	0.7	0.7	0.7	0.7	1.8	6.6	0.7	0.7	2.3	3.1	5.8	3.1	2.9	2.5
72	0.7	0.7	0.7	0.7	0.7	0.7	9.4	1.8	0.7	0.7	2.3	3.1	5.8	3.1	2.9	2.5
73	2.5	2.5	2.5	2.5	2.5	2.5	1.1	1.1	1.8	6.1	1.1	1.4	1.1	1.0	1.1	1.4
80	2.5	2.5	2.5	2.5	2.5	2.5	1.1	1.1	6.4	1.8	1.1	1.4	1.1	1.0	1.1	1.4
91	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.7	0.7	1.8	0.8	5.8	1.0	2.9	1.4
92	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	1.5	1.5	2.3	1.8	5.8	1.0	2.9	1.4
101	0.7	0.7	0.7	0.7	0.7	0.7	8.4	8.4	0.7	0.7	8.4	8.4	1.8	1.0	2.9	1.4
102	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	1.0	1.0	1.0	1.0	1.0	1.8	2.9	1.4
111	0.7	0.7	0.7	0.7	0.7	0.7	1.8	1.8	0.7	0.7	1.8	1.8	1.8	1.8	0	0
112	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	1.1	1.1	1.1	1.1	1.1	1.1	0	0

Table 3: Interpeak Period Expansion Factors

PM	1	2	3	4	5	6	71	72	73	80	91	92	101	102	111	112
1	6.2	54.1	16.0	16.0	16.0	10.2	2.7	2.7	8.4	8.4	2.7	8.4	2.7	8.4	2.7	8.4
2	1.0	6.2	16.0	16.0	16.0	10.2	2.7	2.7	8.4	8.4	2.7	8.4	2.7	8.4	2.7	8.4
3	35.2	35.2	6.2	23.1	23.1	10.2	2.7	2.7	8.4	8.4	2.7	8.4	2.7	8.4	2.7	8.4
4	35.2	35.2	10.5	6.2	55.7	10.2	2.7	2.7	8.4	8.4	2.7	8.4	2.7	8.4	2.7	8.4
5	35.2	35.2	10.5	92.3	6.2	10.2	2.7	2.7	8.4	8.4	2.7	8.4	2.7	8.4	2.7	8.4
6	8.5	8.5	8.5	8.5	8.5	6.2	2.7	2.7	8.4	8.4	2.7	8.4	2.7	8.4	2.7	8.4
71	2.7	2.7	2.7	2.7	2.7	2.7	6.2	17.3	2.7	2.7	14.6	8.4	41.8	8.4	13.8	6.0
72	2.7	2.7	2.7	2.7	2.7	2.7	18.4	6.2	2.7	2.7	14.6	8.4	41.8	8.4	13.8	6.0
73	6.0	6.0	6.0	6.0	6.0	6.0	2.7	2.7	6.2	25.9	2.7	12.1	2.7	2.9	2.7	8.1
80	6.0	6.0	6.0	6.0	6.0	6.0	2.7	2.7	32.9	6.2	2.7	12.1	2.7	2.9	2.7	8.1
91	2.7	2.7	2.7	2.7	2.7	2.7	5.6	5.6	2.7	2.7	6.2	5.6	41.8	2.9	13.8	8.1
92	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	9.7	9.7	14.6	6.2	41.8	2.9	13.8	8.1
101	2.7	2.7	2.7	2.7	2.7	2.7	41.5	41.5	2.7	2.7	41.5	41.5	6.2	2.9	13.8	8.1
102	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	4.6	4.6	4.6	4.6	4.6	6.2	13.8	8.1
111	2.7	2.7	2.7	2.7	2.7	2.7	5.7	5.7	2.7	2.7	5.7	5.7	5.7	5.7	0	0
112	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	3.6	3.6	3.6	3.6	3.6	3.6	0	0

Table 4: PM Peak Period Expansion Factors

ON	1	2	3	4	5	6	71	72	73	80	91	92	101	102	111	112
1	1.0	50.7	12.1	12.1	12.1	4.7	3.4	3.4	4.9	4.9	3.4	4.9	3.4	4.9	3.4	4.9
2	0.7	1.0	12.1	12.1	12.1	4.7	3.4	3.4	4.9	4.9	3.4	4.9	3.4	4.9	3.4	4.9
3	23.8	23.8	1.0	6.9	6.9	4.7	3.4	3.4	4.9	4.9	3.4	4.9	3.4	4.9	3.4	4.9
4	23.8	23.8	5.4	1.0	78.8	4.7	3.4	3.4	4.9	4.9	3.4	4.9	3.4	4.9	3.4	4.9
5	23.8	23.8	5.4	50.5	1.0	4.7	3.4	3.4	4.9	4.9	3.4	4.9	3.4	4.9	3.4	4.9

ON	1	2	3	4	5	6	71	72	73	80	91	92	101	102	111	112
6	1.8	1.8	1.8	1.8	1.8	1.0	3.4	3.4	4.9	4.9	3.4	4.9	3.4	4.9	3.4	4.9
71	1.8	1.8	1.8	1.8	1.8	1.8	1.0	78.1	1.8	1.8	15.6	4.9	4.5	4.9	7.6	5.7
72	1.8	1.8	1.8	1.8	1.8	1.8	72.8	1.0	1.8	1.8	15.6	4.9	4.5	4.9	7.6	5.7
73	5.7	5.7	5.7	5.7	5.7	5.7	3.4	3.4	1.0	11.3	3.4	8.0	3.4	1.0	3.4	2.9
80	5.7	5.7	5.7	5.7	5.7	5.7	3.4	3.4	6.1	1.0	3.4	8.0	3.4	1.0	3.4	2.9
91	1.8	1.8	1.8	1.8	1.8	1.8	7.8	7.8	1.8	1.8	1.0	7.8	4.5	1.0	7.6	2.9
92	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	1.9	1.9	15.6	1.0	4.5	1.0	7.6	2.9
101	1.8	1.8	1.8	1.8	1.8	1.8	13.5	13.5	1.8	1.8	13.5	13.5	1.0	1.0	7.6	2.9
102	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	1.0	1.0	1.0	1.0	1.0	1.0	7.6	2.9
111	1.8	1.8	1.8	1.8	1.8	1.8	5.2	5.2	1.8	1.8	5.2	5.2	5.2	5.2	0	0
112	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	1.7	1.7	1.7	1.7	1.7	1.7	0	0

Table 5: Overnight Period Expansion Factors

While the majority of the expansion factors lie in a reasonable range for sampling (i.e. a sample of between 5% and 20%), there are some large expansion factors indicating very small samples for some movements, some expansion factors with a value less than one where the sample was reduced, and in two cases, there were also expansion factors that were negative which were resolved by using a value of one.

Commentary on the large expansion factors and those with a positive value less than one is provided below.

- The largest expansion factor in the AM peak is for movements from sector 5 to 4 (Wellington CBD) with a value of 70.9. The reason and checks conducted are discussed immediately below;
- There are large expansion factors for movements from sector 4 to 5 (Wellington CBD) and vice versa in the AM, PM, and overnight periods. This occurs because these movements are factored mid-way through the process, during the adjustment for the ninth screenline out of 15 (screenline 121). Different orders of screenlines were tested in order to try and reduce the expansion factors for these movements but without success. There were no combinations that did not result in negative trips, particularly if trips through Ngauranga are not factored first;
- Sample trips from Petone, Lower Hutt, and further north to the SH2 external (sector 112) were slightly reduced in the AM peak with an expansion factor of 0.8. However, this only equates to removing 2 trips, hence no further adjustment was made and the calculated expansion factor retained;
- The interpeak period has, by far, the lowest expansion factors, a result of the longer time period used for the travel patterns (09:00 to 16:00). The largest expansion factor in the interpeak is 9.4. There is a greater occurrence of expansion factors less than one in the interpeak, with three movements being factored by 0.7, 0.8 and 0.9 respectively. These factors relate to removing 49, 22 and 5 trips respectively. Positive expansion factors less than one may occur because of discrepancies associated with using seven hours' of travel data, or because of using a full months' worth of data to produce an average weekday. No further adjustment was made as the implications were considered to be minor;

- The largest expansion factor in the PM peak is for movements from sector 5 to 4 (Wellington CBD) with a value of 90.2. This same movement had a high factor in the AM peak and was further discussed in the second bullet point above.

The two cases with negative expansion factors are noted below. A negative expansion factor is where not only does the sample need to be removed completely, but it needs to be less than zero to satisfy a screenline traffic count.

- In the AM, interpeak, and overnight periods, a negative expansion factor was calculated for trips to/from the large Masterton/Carterton sector (sector 102) from/to Petone, Lower Hutt and Upper Hutt. This equated to trying to remove 14 and 23 trips in the AM peak (by direction); 24 and 24 trips in the interpeak; and 61 and 17 trips in the overnight period. These trips were not removed – the expansion factor was simply set to a value of one for these movements, which will result in some movements marginally higher than the screenline counts. The magnitude of the trips was considered negligible overall;
- In the PM peak, there were too many trips from sector 2 to sector 1 in the sample compared with the screenlines (following factoring of other movements) and a negative expansion factor resulted. This equated to trying to remove 47 trips for this movement. The trips were not removed and an expansion factor of one was adopted for this movement. This means there will be slightly more trips across screenline 5 in the PM peak. Again, this discrepancy was not considered major.

Intra-sector expansion factors of 4.9, 1.8, and 6.2 were calculated and applied for the AM, interpeak and PM peaks respectively using traffic engineering trip rates to estimate the total number of likely trips in each peak period. As noted in the previous section, the daily trip rates suggested too much traffic in the overnight period – inconsistent with the traffic counts. The intra-sector trips were not further factored in the overnight period, with the sample retained unadjusted. No further analysis was undertaken as it is not planned to utilise the overnight matrix in WTSM.

The overnight period is therefore not discussed specifically in terms of the calculated expansion factors.

The resulting sector factors were applied to the zoned sample matrices so that zone origin-destination pairs within the same origin and destination sectors have the same factor applied for each time period. For example for an origin zone within sector 2 and a destination zone within sector 3, the trips between this zonal origin and destination would be factored by the expansion factor for sector 2 to sector 3. Another origin in sector 2 and destination in sector 3 will have the same expansion factor applied.

The expanded 2013 commercial vehicle matrices represent the same time periods of the counts, which were:

- AM Peak Period: 07:00 – 09:00
- Interpeak Period: 11:00 – 13:00
- PM Peak Period: 16:00 – 18:00

An estimated overnight period was also produced, which represents 13 hours from 18:00 to 07:00, so that combined with the other three periods, an observed daily 24 hour matrix was available (following factoring the interpeak from two to seven hours).

The expanded sample matrices are provided in Appendix C by sector for each of the four time periods.

5. Output Matrix Analysis

After the expanded 2013 observed commercial vehicle matrices were created, a series of analyses were undertaken to ensure validity of the matrices, which are discussed in this section.

5.1 Matrix Summary

The table below shows the total trips in the sample and the expanded 2013 matrices.

Matrix Summary	AM (0700-0900)	IP (1100-1300)	PM (1600-1800)
Sample	1,050	4,065	682
Full	7,902	8,593	6,325

Table 6: Sample and Expanded Matrix Totals

5.2 Matrix Trip Rate Comparison

The daily expanded trips were calculated by summing the AM, PM and overnight periods with the interpeak factored by 2/7 (to convert the average two hour interpeak to a seven hour duration). Daily trip rates by sector were calculated for the expanded matrix to determine if this indicated any sector-based outliers. Trip rates are provided in the following table for 2013 total employment and for the 2013 HCV-related employment (as specified in WTSM). Note that the “HCV employment” relates to the 2001, 2006, and 2011 based models and this will be revised as part of the development of the new 2013 based commercial vehicle model. Nevertheless, it provides a good indicator, relating commercial vehicle trips to the likely land use drivers.

		EMPLOYMENT & DAILY TRIP RATE BY SECTOR													
Job Category	**Trip Category**	**1**	**2**	**3**	**4**	**5**	**6**	**71**	**72**	**73**	**80**	**91**	**92**	**101**	**102**
Total Emp		12,511	9,155	2,763	77,930	19,013	11,651	12,952	4,153	12,255	27,979	10,976	11,596	5,287	17,540
HCV Emp		7,815	7,583	2,141	62,341	15,392	7,902	9,096	2,709	7,248	19,547	7,240	8,091	3,470	11,848
All Jobs	Origin	0.32	0.23	0.37	0.11	0.31	0.34	0.34	0.64	0.34	0.24	0.17	0.16	0.27	0.25
	Destination	0.27	0.39	0.36	0.10	0.32	0.38	0.35	0.60	0.31	0.24	0.19	0.17	0.21	0.24
HCV Jobs	Origin	0.52	0.28	0.48	0.14	0.39	0.50	0.48	0.99	0.58	0.35	0.26	0.23	0.42	0.38
	Destination	0.44	0.47	0.46	0.13	0.39	0.55	0.50	0.92	0.53	0.35	0.29	0.24	0.33	0.36

Table 7: Daily Trip Rates by Sector

The trip rates for total HCV-related employment are shown graphically in the following figure.

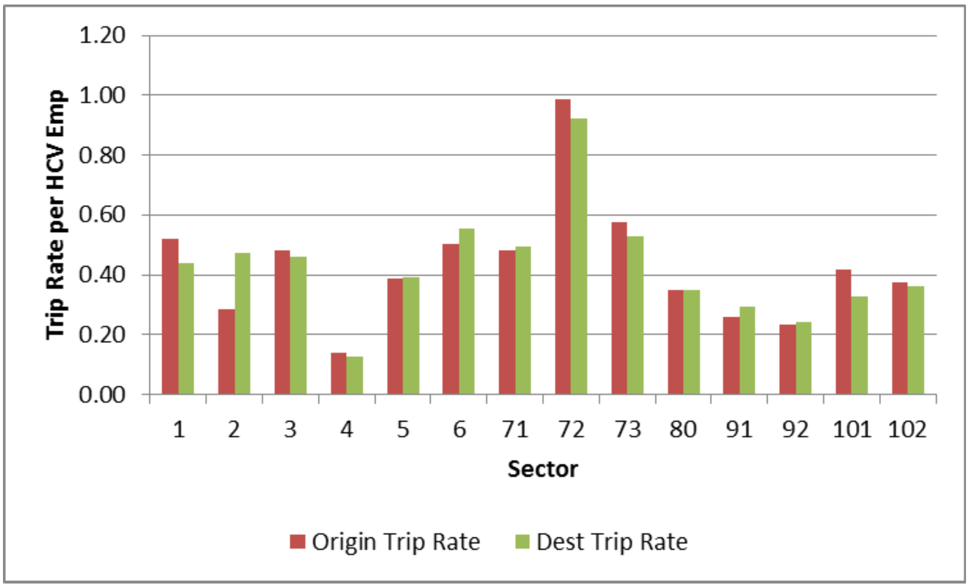

Figure 5: Daily Trip Rates by Sector for the Expanded Sample Matrix

The trip rates are notably low in sector 4, which is the Wellington CBD. This is likely due to the high number of jobs in the services industry, which do not generate/attract equivalent proportions of commercial vehicle trips compared with other areas.

There is a particularly high trip rate for sector 72, which covers the Tawa area. There was a significant expansion factor for the overnight period in this area – but a check of the daytime trips (i.e. excluding overnight) also indicates a higher relative trip rate for this area. A comparison of the number of expanded commercial vehicle trips in sector 72 with the adjacent sector 71 (Porirua) shows that the actual volume of trips to/from sector 72 is much lower (58% for Tawa/Porirua). The HCV-related employment follows a very different pattern (ratio of 29%), however, with a high number of jobs in the services industry in Porirua and significantly less in Tawa. It is likely that the synthetic equations will underestimate trips to/from the Tawa area compared with the expanded sample – and thorough checks of the modelled volumes compared with observed will be required, particularly in this area.

5.3 WTSM Assignment Results

The 2013 expanded commercial vehicle matrices were assigned in WTSM. A full four stage model run was conducted using 2013 Census data to produce light vehicle trips with the expanded observed 2013 commercial vehicle trips input.

At individual count sites, the modelled outputs were unlikely to match the counts because of route choice in the model, but at validation screenline level, the modelled outputs should correspond well with the counts because of the expansion process adopted.

Note that the validation screenlines are different from those used for the matrix expansion. The counts used to produce the screenlines are the same, but the validation screenlines capture major movements, such as the CBD, and are not always watertight on their own.

The comparison of assignment results confirmed that the expanded commercial vehicle matrices reflected the traffic counts, with good correspondence at screenline level. Below is a table listing the comparison results by various evaluation criteria.

Evaluation Criteria			Target	Medium and Heavy Screenline Comparison Summary					
				AM (07:00-09:00)		IP (11:00-13:00)		PM (16:00-18:00)	
				Abs.	(%)	Abs.	(%)	Abs.	(%)
GEH	<=	5	60%	33	(87%)	35	(92%)	32	(84%)
	<=	10	95%	5	(100%)	3	(100%)	5	(97%)
	<=	12	100%	0	(100%)	0	(100%)	1	(100%)
	<=	Max	0%	0	(100%)	0	(100%)	0	(100%)
% Difference Less Than	10%		-	14	(37%)	14	(37%)	13	(34%)
	20%		-	22	(58%)	21	(55%)	19	(50%)
R^2			-	0.93		0.92		0.89	

Table 8: Modelled vs Observed Comparison

6. Conclusion

The 2013 expanded commercial vehicle matrix was concluded as being sufficient for the next stage, which is developing synthetic equations to represent commercial vehicle travel.

Several issues were noted which are worth summarising.

The sample was found to vary over the network and hence simple expansion was not possible. The expansion was therefore by time period and by screenline, which meant that an expansion factor had to be estimated from trip rate data for intra-sector movements that did not cross any screenlines. These intra-sector expansion factors cannot be checked further but were considered an appropriate order of magnitude.

At daily level, the sample generally ranged from 5% to 20% compared with traffic counts at screenlines. This is a significant sample compared with other travel data sources for model development (household travel surveys typically sample 1 to 2%). However, for some movements, a considerably lower sample was obtained resulting in large expansion factors. Some positive expansion factors with values less than one (i.e.: reducing the sample) were calculated for a few movements. These related to numerically small numbers of trips and hence no further action was taken, with the calculated expansion factor applied. In two instances, expansion factors less than zero resulted. While these also related to small numbers of trips, a value of one was adopted in these cases and it was accepted that the expanded matrix would be marginally high compared to counts for a few movements.

The TDG and NZTA sample travel pattern datasets were sourced from different suppliers and analysis subsequently showed that each dataset had a different geographic focus. This confirms that obtaining as much data as possible, from different sources, is important to minimise any bias in the travel pattern data.

Appendix A

Sample Matrix at Sector Level

AM	1	2	3	4	5	6	71	72	73	80	91	92	101	102	111	112	Total
1	32	9	1	7	2	2	0	1	1	1	0	0	0	0	0	0	57
2	14	35	2	13	2	4	0	2	0	1	0	0	0	0	0	0	74
3	0	1	12	3	1	2	0	0	0	0	0	0	0	0	0	0	20
4	11	8	2	46	6	8	1	2	3	2	0	0	0	0	0	0	88
5	2	2	1	8	23	7	1	2	2	3	1	1	0	0	3	0	57
6	5	3	1	19	11	36	5	5	4	7	1	2	0	0	3	1	104
71	1	0	0	4	1	6	62	4	2	2	5	2	1	0	1	0	92
72	2	2	0	4	2	8	3	23	3	5	1	0	0	0	2	0	56
73	2	1	0	9	2	7	1	1	19	16	2	2	0	0	1	0	63
80	2	2	0	6	10	8	2	1	14	79	1	6	1	1	2	1	136
91	0	0	0	2	1	2	9	1	2	3	32	1	4	0	3	0	60
92	0	0	0	2	4	2	1	3	4	10	0	23	0	1	0	0	52
101	0	0	0	0	1	1	1	0	0	1	3	0	8	0	6	0	21
102	0	0	0	0	2	0	0	0	0	2	0	1	0	124	0	5	135
111	0	0	0	0	4	1	2	2	1	5	3	0	7	0	3	1	28
112	0	0	0	0	1	0	0	0	0	0	0	0	0	5	1	1	8
Total	70	62	19	123	75	94	89	48	56	136	51	38	21	132	25	11	1050

Table A1: AM Peak Period Sample Matrix

IP	1	2	3	4	5	6	71	72	73	80	91	92	101	102	111	112	Total
1	191	44	3	49	9	15	2	4	3	4	0	0	0	0	0	0	324
2	39	98	2	34	6	7	1	3	2	2	0	0	0	0	0	0	195
3	3	4	61	11	8	7	1	2	1	1	0	0	0	0	0	0	99
4	54	44	11	232	35	45	6	8	16	8	1	1	0	0	0	0	460
5	11	9	7	41	109	38	6	4	6	14	4	3	1	2	5	1	261
6	15	12	8	50	41	167	15	19	15	25	6	16	1	1	5	1	397
71	1	1	1	4	4	20	304	18	5	11	25	4	1	0	2	0	402
72	3	5	2	9	6	21	15	74	11	15	3	2	1	1	3	2	172
73	4	3	1	18	10	17	4	4	84	60	3	9	0	0	1	0	219
80	7	4	1	13	37	26	6	5	51	292	4	22	1	2	2	1	475
91	1	1	0	1	6	8	31	4	5	6	90	5	13	0	11	0	181
92	0	0	0	2	7	9	4	2	12	33	1	90	0	4	0	0	166
101	0	0	0	0	2	1	2	1	0	2	10	0	47	0	16	1	84
102	0	0	0	0	8	2	1	0	1	6	0	5	0	464	0	16	503
111	0	0	0	1	16	9	3	5	3	14	10	1	21	0	12	3	97
112	0	0	0	0	1	1	0	2	0	2	0	0	0	17	3	4	29
Total	329	224	98	466	305	393	400	154	216	494	158	159	87	492	60	30	4065

Table A2: Interpeak Period Sample Matrix

PM	1	2	3	4	5	6	71	72	73	80	91	92	101	102	111	112	Total
1	12	4	0	5	1	2	1	1	0	1	0	0	0	0	0	0	28
2	3	8	0	4	0	2	1	1	1	2	0	0	0	0	0	0	22
3	0	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	10
4	5	4	3	34	6	17	7	3	6	7	2	3	0	0	0	0	98
5	1	1	1	4	19	10	1	2	1	3	2	0	0	0	3	0	49
6	1	1	2	8	9	28	5	3	4	4	1	3	0	0	2	0	72
71	0	0	0	1	1	3	35	2	1	1	4	1	0	0	0	0	51
72	0	1	1	1	3	5	4	13	1	2	1	1	0	0	1	0	32
73	1	0	0	3	1	2	2	1	14	16	1	3	0	0	0	0	44
80	1	0	0	2	6	6	1	2	11	63	1	2	0	1	1	0	99
91	0	0	0	0	1	1	3	0	1	0	14	1	1	0	1	0	24
92	0	0	0	1	1	1	1	0	2	5	0	20	0	1	0	0	34
101	0	0	0	0	1	0	0	0	0	1	1	0	3	0	3	0	10
102	0	0	0	0	1	0	0	0	0	1	0	1	0	67	0	3	73
111	0	0	0	0	2	4	1	2	1	4	2	0	4	0	6	1	27
112	0	0	0	0	0	1	0	0	0	0	0	0	0	4	1	1	8
Total	26	19	16	64	53	84	62	31	42	110	29	37	10	73	18	6	682

Table A3: PM Peak Period Sample Matrix

ON	1	2	3	4	5	6	71	72	73	80	91	92	101	102	111	112	Total
1	42	10	0	9	2	3	1	1	1	2	1	0	0	0	0	0	73
2	8	24	1	10	1	2	0	1	0	1	0	0	0	0	0	0	50
3	0	1	5	4	2	4	0	0	0	1	0	0	0	0	0	0	19
4	14	11	5	160	17	18	2	3	3	3	0	2	0	0	0	0	240
5	2	1	2	22	129	31	2	3	3	20	4	4	1	2	10	1	236
6	5	3	2	22	40	144	10	10	11	15	4	6	1	1	6	2	281
71	1	1	0	6	2	14	59	8	3	5	5	2	0	0	1	0	107
72	2	1	1	5	7	13	9	44	4	8	3	2	1	0	7	1	107
73	1	0	0	4	5	15	1	1	52	30	1	7	0	1	1	0	122
80	3	2	1	9	26	24	4	5	29	205	3	13	1	1	7	2	335
91	1	0	0	2	2	7	6	2	3	6	38	1	5	0	9	1	84
92	0	1	0	3	8	8	1	0	7	19	1	68	0	2	1	0	120
101	0	0	0	0	2	4	1	3	1	4	7	0	16	0	9	1	49
102	0	0	0	0	8	2	0	0	1	6	0	5	0	172	0	12	207
111	0	0	0	1	17	15	3	9	5	24	6	2	18	0	35	8	143
112	0	0	0	0	1	2	1	1	0	2	1	0	2	10	8	19	49
Total	80	55	17	258	270	308	100	94	123	351	74	112	46	190	97	47	2222

Table A4: Overnight Period Sample Matrix

Appendix B

Matrix Expansion Screenline Definition

The table below shows the screenlines developed and used for the matrix expansion.

Expansion Screenline ID	Screenline Description	Count ID	Count Location
7A	North of Ngauranga, SH1 corridor	22	Middleton Rd
		23	Churton Park - Grenada Interchange
7B	North of Ngauranga, SH2	24	SH2 N of Nga
6	South of Ngauranga	20	Hutt Rd
		21	SH1 south of Ngauranga
		42	Waikowhai St
21	Externals via SH1	40	Manakau - Nth of Waitohu River Bridge
22	Externals via SH2	41	Mt Bruce
11	South of Wellington City	8	Mt Vic Tunnel - Patterson St (Sth of Basin Reserve)
		9	Hawker St
		10	Oriental Pde
		11	Ohiro Rd
		12	Brooklyn Rd
		13	Taranaki St
		14	Tasman St
		15	Adelaide Rd Nth
5	South of Newtown	8	Mt Vic Tunnel - Patterson St (Sth of Basin Reserve)
		9	Hawker St
		10	Oriental Pde
		47	Crawford Rd
		48	Manchester St
		49	Mt Albert Rd
		50	Adelaide Rd
		51	Happy Valley Rd
90	East of Karori	18	Chaytor St
		19	Birdwood St
121	North of Wellington CBD	1	Waterloo Quay
		2	Featherston St
		3	Molesworth St
		4	Bowen St

Expansion Screenline ID	Screenline Description	Count ID	Count Location
		5A	The Terrace Interchange - Tinakori - NB Off Ramp
		5	The Terrace Interchange - Hawkestone Interchange mainline
82	North of Upper Hutt on SH2 corridor	46	Rimutaka Hills
81	North of Paraparaumu	52	Kebble Drive - Nth of Lindale
		53	Elizabeth Street
102	South of Mana	43	Mana Bridge - Paremata Bridge
		37	SH58
103	North of Lower Hutt	25	SH2 Sth of 58
		36	Eastern Hutt Rd
100	West of Lower Hutt	27	Kennedy Good Bridge
		28	Melling bridge
		29	Ewen bridge
		30	Waione St
		36	Eastern Hutt Rd
14	South of Porirua	38	Main Road
		39	Linden - Tawa College

Appendix C

Expanded Sample Matrices

AM	1	2	3	4	5	6	71	72	73	80	91	92	101	102	111	112	Total
1	156	167	15	92	22	15	1	5	7	6	0	1	0	0	0	0	487
2	179	168	28	161	30	23	1	7	4	6	0	1	0	0	0	0	609
3	6	8	57	85	36	13	0	0	4	2	0	0	0	0	0	0	212
4	153	115	5	226	245	47	3	6	29	23	0	1	0	0	0	0	854
5	24	23	3	582	114	46	5	5	16	30	4	7	1	3	10	3	876
6	47	27	11	193	115	175	16	18	37	66	4	24	1	4	10	12	759
71	3	1	0	10	3	16	304	95	6	5	57	18	7	1	4	0	531
72	5	6	1	10	6	20	81	112	7	12	14	4	3	0	13	4	298
73	13	8	3	72	20	53	3	4	93	314	8	23	0	0	2	0	616
80	13	18	1	45	80	61	7	4	390	384	4	74	2	1	8	1	1094
91	0	0	0	5	2	6	65	5	5	7	156	6	49	0	20	0	327
92	2	3	0	17	36	20	7	27	31	70	2	110	1	1	1	0	327
101	0	0	0	0	1	2	12	3	1	4	55	3	37	0	34	0	153
102	0	0	0	0	18	2	2	0	0	2	0	1	0	604	0	4	634
111	0	0	0	0	11	3	8	9	2	13	13	2	35	0	0	0	96
112	0	0	0	0	5	0	0	3	0	1	0	0	0	18	0	0	28
Total	602	543	124	1498	744	505	514	301	634	945	318	275	138	633	102	25	7902

***Table C1: AM Peak Period Expanded Sample Matrix*[2]**

[2] Note zone 85 was incorrectly included in Sector 71 instead of Sector 72. This was updated during the model build – so the expanded matrices have slightly different trip numbers for Sectors 71 and 72 reported in Technical Note 4.

IP	1	2	3	4	5	6	71	72	73	80	91	92	101	102	111	112	Total
1	336	149	8	110	20	31	2	5	8	12	0	1	0	0	0	0	682
2	35	172	6	78	13	15	1	3	6	5	1	1	0	0	0	0	334
3	8	10	108	14	10	13	1	2	4	2	0	0	0	0	0	0	173
4	132	108	33	410	311	91	6	9	49	26	1	4	0	0	0	0	1179
5	26	21	23	347	192	77	7	5	19	43	4	10	1	6	5	3	790
6	13	10	6	42	34	294	17	21	46	77	7	48	1	3	6	5	629
71	1	1	1	3	3	15	536	116	4	8	58	12	8	1	6	0	773
72	2	4	2	7	4	16	142	131	8	11	7	6	4	2	9	6	359
73	10	8	3	44	26	43	5	4	148	368	3	12	0	0	1	0	676
80	17	10	2	33	91	65	7	6	330	515	4	30	1	2	2	1	1118
91	0	0	0	0	4	6	26	3	4	5	158	4	77	0	30	0	320
92	0	1	0	4	18	23	9	5	19	49	3	160	0	4	1	0	297
101	0	0	0	0	2	1	16	10	0	1	87	4	82	0	45	1	250
102	0	0	0	0	21	4	2	1	1	6	0	5	0	817	0	22	880
111	0	0	0	0	12	6	4	10	2	10	17	2	38	0	0	0	102
112	0	0	0	0	2	3	0	4	0	2	0	0	0	18	0	0	30
Total	581	493	191	1093	763	704	782	334	648	1141	352	299	212	856	106	39	8593

Table C2: Interpeak Period Expanded Sample Matrix[3]

[3] Note zone 85 was incorrectly included in Sector 71 instead of Sector 72. This was updated during the model build – so the expanded matrices have slightly different trip numbers for Sectors 71 and 72 reported in Technical Note 4.

PM	1	2	3	4	5	6	71	72	73	80	91	92	101	102	111	112	Total
1	71	232	6	84	19	20	3	3	2	6	0	2	0	0	0	0	449
2	3	51	6	58	8	19	1	2	6	14	1	2	0	0	0	0	171
3	9	12	47	18	4	5	1	0	3	0	0	0	0	0	0	0	100
4	183	130	35	213	355	179	18	9	51	55	4	26	0	0	0	0	1258
5	21	18	9	349	118	103	4	4	12	27	6	4	1	3	7	1	687
6	13	8	18	65	78	170	14	9	31	34	3	29	0	1	4	1	479
71	1	0	0	3	2	9	216	35	3	4	60	8	10	0	6	0	358
72	1	1	1	3	8	13	75	80	2	4	17	9	6	0	10	0	231
73	9	1	1	16	9	14	4	2	85	404	2	42	0	0	0	0	588
80	5	1	0	13	35	38	4	5	352	391	3	30	0	3	4	3	887
91	0	0	0	0	3	4	16	1	1	1	83	4	35	0	21	1	173
92	2	0	0	8	4	8	6	0	23	50	4	125	0	3	1	0	235
101	0	0	0	0	2	1	12	18	0	2	41	12	20	0	35	1	146
102	0	0	0	0	4	1	1	0	1	6	0	3	0	413	1	26	456
111	0	0	0	0	5	11	5	14	3	10	13	2	24	0	0	0	86
112	0	0	0	0	2	3	0	2	0	1	0	0	1	13	0	0	22
Total	318	454	124	831	657	598	380	185	574	1011	238	296	99	437	90	32	6325

***Table C3: PM Peak Period Expanded Sample Matrix*[4]**

[4] Note zone 85 was incorrectly included in Sector 71 instead of Sector 72. This was updated during the model build – so the expanded matrices have slightly different trip numbers for Sectors 71 and 72 reported in Technical Note 4.

ON	1	2	3	4	5	6	71	72	73	80	91	92	101	102	111	112	Total
1	42	505	3	114	21	16	2	4	3	12	2	1	0	0	0	0	726
2	6	24	11	119	17	9	1	4	2	6	1	0	0	0	0	0	201
3	12	21	5	29	15	17	1	2	0	6	0	0	0	0	0	0	110
4	333	265	25	160	1367	85	7	10	17	16	2	11	1	0	0	0	2300
5	43	21	8	1087	129	147	7	12	17	96	13	21	2	10	36	4	1653
6	9	5	4	40	73	144	33	34	52	73	13	28	3	3	22	8	544
71	2	1	0	11	5	25	59	591	5	10	74	8	1	0	7	1	799
72	3	2	2	10	13	24	666	44	6	14	41	8	3	0	52	4	892
73	7	2	1	20	28	88	5	4	52	343	5	53	1	1	5	1	616
80	15	13	5	54	151	138	12	17	179	205	9	106	4	1	25	5	938
91	1	1	0	3	4	13	46	17	5	11	38	8	24	0	70	3	245
92	1	3	0	18	46	46	5	2	14	36	18	68	1	2	8	0	269
101	0	0	0	0	3	7	16	45	1	8	101	2	16	0	72	3	274
102	1	0	0	0	43	14	1	0	1	6	0	5	0	172	4	36	282
111	0	0	0	1	31	26	14	48	8	44	29	9	95	2	0	0	309
112	2	0	0	0	5	13	4	9	0	3	2	1	4	17	0	0	59
Total	477	863	65	1667	1951	814	879	842	366	888	348	328	155	209	300	66	10217

Table C4: Overnight Period Expanded Sample Matrix[5]

[5] Note zone 85 was incorrectly included in Sector 71 instead of Sector 72. This was updated during the model build – so the expanded matrices have slightly different trip numbers for Sectors 71 and 72 reported in Technical Note 4.