National Vehicle Emission GIS Mapping

THE TRANSPORT AGENCY

National Vehicle Emission Dataset 2016

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Contents

Executive Summary

Estimates of the emissions to air from motor vehicles travelling on all public roads in New Zealand have been produced for the 2016 year.

The vehicle emission estimates have been produced through collation of available input data from the Transport Agency systems into a format that is able to be processed within a spatial framework to calculate and produce a visual representation of total emissions across the highway network.

Most of the input data required for the estimate calculations was sourced from two road network datasets. These datasets have been produced by Core Logic, under contract to the Transport Agency and territorial local authorities (TLAs). These datasets comprise of:

- Core Logic's own routable network, used by the All of Government Emergency Services collective. This dataset includes designated and routable speed attributes.

- A merged road network dataset that incorporates the Transport Agency's Road Asset and Maintenance Management (RAMM) road network along with all the TLA RAMM road networks. These networks have been merged into one dataset, and then spatially aligned with Core Logic's routable network. This dataset includes traffic counts and fleet profile information, as well as tying back to the One Network Road Classification (ONRC) system.

These two datasets have then been taken through a two-step process using the Feature Manipulation Engine (FME) software. The first step transfers the speed information from the routable network to the ONRC network so that all the required parameters can be accessed form the one dataset. The second step then continues on to calculate the emission estimate for each road section by selecting the appropriate emission factor based on the road parameters, and then multiplying by the traffic count. Road gradient and regional temperature averages are taken into account for these calculations.

Great care has been taken to create FME workflows that can be reused on a regular basis. Options have also been introduced into the workflow so that the estimates can be produced for a specific region or sub-region, and not just on the entire country.

As part of this project, the Vehicle Emission Prediction Model (VEPM Version 5.3) emission factors have been produced as separate batch files for each territorial authority to allow for the different annual average air temperatures within the regions. This report is based on 2016 factors and uses a large spreadsheet of emission factors that would need to be updated to allow calculations for emissions in future years.

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to identify the inputs and methodology used in building the National Vehicle Emission Dataset 2016 as well as presenting and reviewing the outputs in accordance with the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

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1. Introduction

Jacobs has been engaged by The Transport Agency to develop a national vehicle emission dataset, as well as a repeatable method of producing further datasets in the future. This dataset is referred to as the National Vehicle Emission Dataset 2016 (NVED2016).

This commission follows on from previous work in 2015 and 2016 that developed a national state highway emission dataset and more recently prototyped the inclusion of local roads by incorporating roads from TLAs. Emissions have been calculated for the key vehicle pollutants:

- Carbon monoxide (CO);
- Oxides of nitrogen(NO_x);
- Nitrogen dioxide (NO_2);
- Particulate matter as $PM_{2.5}$, PM_{10}, PM_{BT} -(ie. particulate matter smaller than 2.5 and 10 microns in diameter and particulate matter from tyre and break wear respectively)

In addition, the study includes reporting of carbon dioxide (CO_2).

The methodology developed in the previous work has been followed for this project where appropriate; however, the introduction of much larger datasets, as well as the decision to calculate emission estimates separately for each territorial authority has led to revisions of the original methodology. This is explained in more detail in Section 2 of this report.

This report outlines the methodology that has been used to create NVED2016. It then discusses the input datasets that have been used along with any specific steps that have been taken to ensure the inputs were suitable. The report then outlines the outputs that have been produced, as well as defining all of the deliverables that have been supplied back to The Transport Agency. The report concludes by providing an overview of how future updates can be made to the NVED.

2. Methodology

The methodology used to develop the NVED2016 dataset for all public roads is very similar to that used to create the state highway NVED2013 dataset. The key to the methodology is being able to gather all of the required emission parameters (traffic count, fleet profile, speed and gradient) into the same road sections. Once a road section contains all the necessary information then the appropriate emission factors can be applied to calculate its emission values. These results are then organised into suitable outputs for further analysis and visualisation.

The methodology can be broken down into three steps:

1) Merging the inputs
2) Calculating the emissions
3) Writing the outputs

The following sections explain these steps in more detail.

2.1 Merging the inputs

Jacobs has used three datasets as inputs for the NVED2016: two road centrelines supplied by Core Logic, and a national Digital Elevation Model (DEM) derived from Land Information New Zealand (LINZ) topographic data.

Core Logic provides a routable road centreline that includes speed information. This dataset is called CoreLogic_Centreline. They also have an ongoing contract to supply the Transport Agency, and the TLAs, with another road centreline dataset that combines the agencies' RAMM centreline data, and spatially aligns it to their own CoreLogic_Centreline dataset. This new road centreline data is referred to as CoreLogic_RAMMCentreline.

While the two centrelines have been spatially aligned, the features themselves often have different start and end points. This is because they have two separate uses; one is a routable network while the other is an asset database. When bringing the speed data across from the CoreLogic_Centreline, care has to be taken to find all the individual CoreLogic_Centreline road sections that overlap an individual CoreLogic_RAMMCentreline road section, and then use a weighted mean calculation to find the speed based on the length of the overlap. This merged road centreline dataset is called the Merged_ONRC.

2.2 Calculating the emissions

The Merged_ONRC is then overlaid over the DEM to determine gradients. Jacobs made the decision to assume all roads were two way roads to reduce the amount of manual intervention that would be required each time the road networks were updated. Currently, this information, as well as road directionality, is not recorded on the two road centreline files supplied to the Transport Agency. The roads are then split into 50 metre lengths, although this can be adjusted by the user if required, and each individual 50m length receives a gradient.

Each 50m length of road section has a speed, and this can be used to look up the appropriate emission factor from the relevant VEPM emission table. Processing is split into TLA areas, which requires the TLA boundaries to be a spatial input to the process. This enables the emission factors to be specific to each TLA. The VEPM table uses a combination of the speed, the ratio of Light Vehicles (LV) to Heavy Vehicles (HV), and the gradient category (-6°, -4°, -2°, 0°, 2°, 4°, 6°) to determine the CO, CO_2, NO_x, NO_2, $PM_{2.5}$ & PM_{BT} emission factors to apply to each road section.

The emissions are calculated independently for LV and HV. The Fleet Profile ratio is applied to the traffic volume to obtain LV and HV traffic volumes. These volumes are then multiplied by the appropriate emission factor to get LV emissions and HV emissions (g/km/day) for each road section. These are then added together to obtain the combined emission rate (g/km/day) for each road section. The PM_{10} emission rate is calculated by adding together the $PM_{2.5}$ and PM_{BT} emission rates.

2.3 Writing the Outputs

Once the emissions have been calculated they are optionally written to the output file prefixed Raw_Emissions, and suffixed with the TLA name. This contains the emission values (g/km/day) for each 50m section of road. It was decided during processing that producing this file for the entire country would create too large a file to be practical. The FME workflow therefore leaves the raw emission output as optional only. This might be a sensible option when running the workflow for only one region.

The individual 50m sections are then aggregated back into the CoreLogic_RAMMCentreline road sections based on their unique RAMM asset identifiers. As they are aggregated the emission values are added together using a weighted mean based on the component lengths. This output file is prefixed ONRC_Emissions, and will be suffixed by either NZ, or the TLA name.

2.4 Using FME

The above steps take place in workflows created in FME. Workflows can be created in FME that allow the user to fully automate the processes involved with calculating the emissions. As well as the workflow being very flexible and fully repeatable, it is a graphical tool that clearly illustrates, and documents, the process that is taking place.

The FME workflows have been built so that, within certain constraints, the input datasets can be exchanged easily. These constraints mainly relate to the attribute names that the FME workflow is expecting to find in the input data. There is also an expectation that the two input road datasets can be meaningfully spatially matched.

The calculation process has been split into two separate FME workflows.

1) NVED_CombineRoadCentrelines.fmw
   this model merges the speed data from the CoreLogic_Centreline dataset on to the CoreLogic_RAMMCentreline dataset.
   It uses a series of spatial and table joins, and then assigns the speeds using a weighted mean. The output of this model is the Merged_ONRC dataset, and this is effectively a replica of the CoreLogic_RAMMCentreline dataset with the addition **of** the speed attribute.

2) NVED_AssignEmissionsToRoads.fmw
   this model transforms the Merged_ONRC dataset into two outputs, the Raw_Emissions (optional) and the ONRC_Emissions.
   The roads are clipped into TLA areas, and processing is then run independently for each TLA area. Each road is overlaid over the DEM to assign gradients, and then the appropriate emission factors are obtained from the VEPM table for the relevant TLA based on the speed, gradient and fleet profile breakdown. The emissions for each road are then calculated by multiplying the emission factors with the traffic counts to produce the Raw_Emissions. The Raw_Emissions are then aggregated to produce the ONRC_Emissions dataset.

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3. Inputs

3.1 Spatial Data

To calculate vehicle emissions using VEPM we require four pieces of information from the road network. These are traffic counts, fleet profile, average speed and road gradient.

This information has been gathered from three different data sources obtained from The Transport Agency, as outlined in Table 1.

Table 1 Input data for NVED2016

Parameter	Source	Database layer	Database field used	Date	Notes
Traffic Count	Core Logic	CoreLogic_RAMMCentreline	trafficVolume	2016	This attribute is provided from Core Logic's RAMM_ONRC dataset, but is brought directly through from the Transport Agency or TLAs own RAMM databases. It represents the average daily traffic count of a particular road section.
Fleet Profile	Core Logic	CoreLogic_RAMMCentreline	hvyVehicleVolume	2016	This attribute is provided from Core Logic's RAMM_ONRC dataset, but is brought directly through from the Transport Agency or TLAs own RAMM databases. It represents the average daily traffic count for heavy vehicles of a particular road section, and is used in conjunction with the trafficVolume attribute to calculate the light/heavy vehicle ratio.
Speed	Core Logic	CoreLogic_Centreline	routableSpeed	2016	This attribute is provided from Core Logic's Road Network dataset. It represents a realistic speed that a vehicle can traverse the road segment, and incorporates speed constraints such as surface type, intersections, roundabouts etc.
Gradient	LINZ	Nidem_25nztm.img and Sidem_25nztm.img	*derived*		This is a raster dataset that has an elevation value every 25 metres. The road centrelines are overlaid over this elevation surface to derive the gradient of a particular road section.
TLA Boundaries	Statistics NZ	TLABoundaries	Region	2015	These boundaries are used to divide the processing into TLA areas (ie regional council and unitary authorities).

The input datasets are further illustrated in Appendices G – I of this report.

3.2 VEPM

Jacobs has created a table that has emission rate values for CO, CO_2, NO_x, NO_2, $PM_{2.5}$ and PM_{BT} for every combination of speed, fleet profile and gradient using the Vehicle Emissions Prediction Model (VEPM) version 5.3. We have used the batch run functionality within the model to produce a separate table for each TLA. Each TLA is represented on a separate worksheet within the resulting VEPM spreadsheet. There are sixteen worksheets as a result.

PM_{10} values have been calculated by adding together the values for $PM_{2.5}$ & PM_{BT}.

The parameters used in the VEPM emission rate calculations are shown in Table 2. The minimum and maximum speeds are set by the VEPM model and values outside this range are corrected to either the minimum or maximum value allowed.

Table 2 Input parameters used in VEPM to develop emission factors

Year	Minimum Speed	Maximum Speed	Speed step size	Average trip length
2016	10 km/h	100 km/h	1 km/h	9.1 km

The average trip length of 9.1 km used in the VEPM calculations is taken from the Household Travel Survey 2010 produced by the Land Transport Safety Authority (LTSA).

Separate tables have been produced for each TLA to enable a different annual average air temperature to be used in the emission factor calculations. The temperatures used for each TLA are shown in Table 3. These temperatures have been derived from a combination of NIWA and YR web sites. These web sites contain annual average figures for several monitoring stations within each TLA area. Values from these stations have been averaged, with an emphasis placed on higher population areas that contain higher traffic volume. These figures are not exact, but are deemed representative of the TLA and sufficient for the requirements of this project.

Table 3 Annual average temperatures used for TLAs

Territorial Local Authority	Annual Average Temperature °C
Northland	15.5
Auckland	15.4
Waikato	13.5
Bay of Plenty	14.5
Gisborne	14.2
Hawke's Bay	13.5
Taranaki	13.0
Manawatu-Wanganui	12.9
Wellington	12.8
Marlborough	12.9
Nelson	12.7
Tasman	12.5
West Coast	11.7
Canterbury	11.8
Otago	10.7
Southland	10.1

All other VEPM optional inputs except the gradient have used the VEPM defaults.

The fleet profile used in the calculations is VEPM's default profile for 2016, and is shown in Table 4.

Table 4 VEPM fleet profile

Light Vehicle	Car petrol	66.9%
	Car diesel	7.7%
	Car hybrid	0.7%
	Light commercial petrol	3.3%
	Light commercial diesel	14.0%
	Light commercial hybrid	0.0%
Heavy Vehicle	Bus	0.60%
	Heavy commercial 3.5-7.5 tonne	1.3%
	Heavy commercial 7.5-12 tonne	0.7%
	Heavy commercial 12-15 tonne	0.2%
	Heavy commercial 15-20 tonne	0.3%
	Heavy commercial 20-25 tonne	1.0%
	Heavy commercial 25-30 tonne	1.3%
	Heavy commercial >30 tonne	1.8%

4. Outputs

There are two output spatial datasets created as part of the NVED2016. The first of these, the Merged_ONRC dataset, is a working dataset that has been created by merging the two input datasets provided by Core Logic. This merged dataset is then used to create the final output datasets, ONRC_Emissions and optionally the Raw_Emissions.

Appendices A – F of this report illustrate the ONRC_Emissions outputs as maps.

4.1 Merged_ONRC

Figure 1 shows an example of the Merged ONRC output in Nelson. This dataset is in effect a replica of the CoreLogic_RAMMCentreline input dataset, with the unnecessary attributes being removed and the speed attribute added.

Figure 1 Example of Merged ONRC output

Table 5 summarises the attribute definitions for the Merged_ONRC output.

Table 5 Merged_ONRC output attribute definitions

Field Name	Field Type	Description
assetCarriageWayID	Long Integer	RAMM ID that represents the road section uniquely for each authority
assetRoadID	Long Integer	RAMM ID that represents the road uniquely for each authority
ControllingAuthority	Text	Road Controlling Authority
ONRCClass	Text	One Network Road Classification, e.g. primary collector, arterial, low volume
hvyVehicleTrafficVolume	Double	Average Daily Traffic count for heavy vehicles (from RAMMS)
trafficVolume	Double	Average Daily Traffic count (from RAMMS)
WeightedMeanSpeed	Long Integer	Average speed in km/hr
HeavyPercentage	Double	Ratio of heavy vehicle traffic count to total traffic count

4.2 Raw_Emission

Figure 2 shows an example of the Raw Emission output in Nelson. This output represents a separate emission value at the spatial resolution at which the actual calculations have been made. The default resolution is set at 50 metres, but this can be changed by the user. This output can produce a very large file, and is not recommended when running for the entire country. It is therefore left as an optional output.

Figure 2 Example of Raw_Emission output

Table 6 summarises the attribute definitions for the Raw_Emission output.

Table 6 Raw_Emission output attribute definitions

Field Name	Field Type	Description
assetCarriageWayID	Long Integer	RAMM ID that represents the road section uniquely for each authority
assetRoadID	Long Integer	RAMM ID that represents the road uniquely for each authority
ONRCClass	Text	One Network Road Classification, e.g. primary collector, arterial, low volume
ControllingAuthority	Text	
TerritorialAuthority	Text	
traffcVolume	Double	Average Daily Traffic count (from RAMMS)
Gradient	Double	Gradient of road section in degrees (derived from 25m DEM)
HV_ADT	Double	Heavy Vehicle Average Daily Traffic count
LV_ADT	Double	Light Vehicle Average Daily Traffic count
Speed	Small Integer	Average speed in km/hr
CO_g_km_day	Double	CO emission rate in grams/kilometre/day
CO2_g_km_day	Double	CO_2 emission rate in grams/kilometre/day
NOx_g_km_day	Double	NO_x emission rate in grams/kilometre/day
NO2_g_km_day	Double	NO_2 emission rate in grams/kilometre/day

PM25_g_km_day	Double	$PM_{2.5}$ emission rate in grams/kilometre/day
PMBT_g_km_day	Double	PM Brake/Tyre emission rate in grams/kilometre/day
PM10_g_km_day	Double	PM_{10} emission rate in grams/kilometre/day
CreatedDate	Date	Date that vehicle emission estimation tool created this output

4.3 ONRC_Emissions

Figure 3 shows an example of the ONRC emission output in Nelson. This output represents an emission value for each ONRC road section. The emission output has been aggregated from the more granular Raw_Emission dataset.

Figure 3 Example of ONRC_Emission output

Table 7 summarises the attribute definitions for the ONRC_Emission output.

Table 7 ONRC_Emission output attribute definitions

Field Name	Field Type	Description
assetCarriageWayID	Long Integer	RAMM ID that represents the road section uniquely for each authority
assetRoadID	Long Integer	RAMM ID that represents the road uniquely for each authority
ONRCClass	Text	One Network Road Classification, e.g. primary collector, arterial, low volume
ControllingAuthority	Text	Road Controlling Authority
TerritorialAuthority	Text	Regional Council or Unitary Authority that road falls in
trafficVolume	Double	Average Daily Traffic count (from RAMMS)
hvyVehicleTrafficVolume	Double	Average Daily Traffic count for heavy vehicles (from RAMM)
WeightedMeanSpeed	Double	Average speed in km/hr
CO_total_g_day	Double	CO emission rate for total road section length in grams/day
CO2_total_g_day	Double	CO_2 emission rate for total road section length in grams/day

NOx_total_g_day	Double	NO_X emission rate for total road section length in grams/day
NO2_total_g_day	Double	NO_2 emission rate for total road section length in grams/day
PM25_total_g_day	Double	$PM_{2.5}$ emission rate for total road section length in grams/day
PMBT_total_g_day	Double	PM Brake/Tyre emission rate for total road section length in grams/day
PM10_total_g_day	Double	PM_{10} emission rate for total road section length in grams/day
CO_g_km_day	Double	CO emission rate in grams/kilometre/day
CO2_g_km_day	Double	CO_2 emission rate in grams/kilometre/day
NOx_g_km_day	Double	NO_x emission rate in grams/kilometre/day
NO2_g_km_day	Double	NO_2 emission rate in grams/kilometre/day
PM10_g_km_day	Double	PM_{10} emission rate in grams/kilometre/day
PM25_g_km_day	Double	$PM_{2.5}$ emission rate in grams/kilometre/day
PMBT_g_km_day	Double	PM Brake/Tyre emission rate in grams/kilometre/day
PM10_g_km_day	Double	PM_{10} emission rate in grams/kilometre/day
CreatedDate	Date	Date that vehicle emission estimation tool created this output

5. Data Deliverables

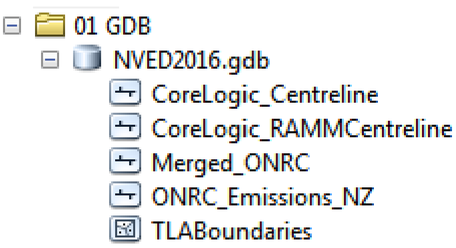
There are three components to the data that is delivered as part of this project. These are:

- the NVED2016 database
- the FME workflows
- the VEPM2016 spreadsheet

5.1 NVED2016 database

The NVED2016 database is stored as an Environmental Systems Research Institute (ESRI) File Geodatabase. It contains five feature classes. Three of these are inputs, and two are outputs. Figure 4 shows the storage structure of the geodatabase when viewed from within the ArcCatalog software.

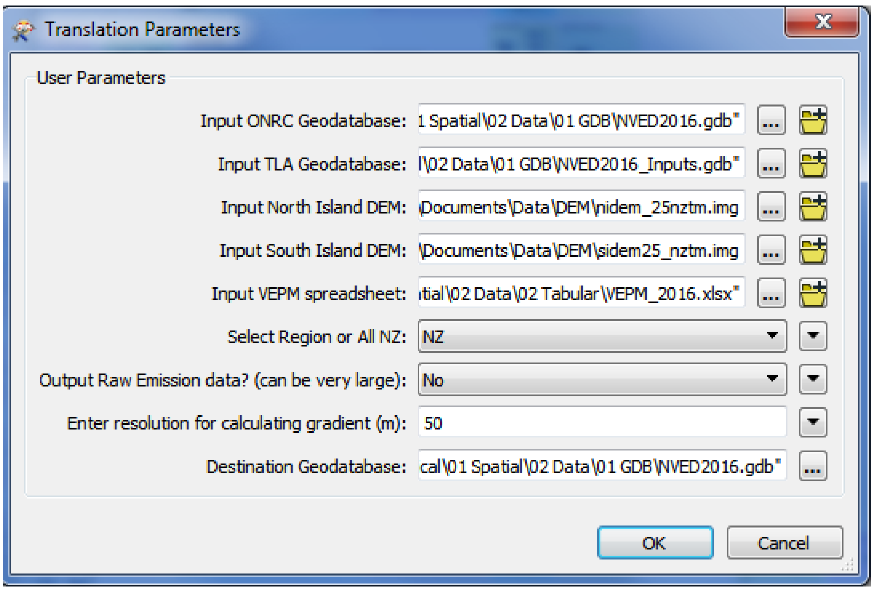
Figure 4 LAVED Prototype Geodatabase storage structure



5.2 FME workflows

The FME workflows are provided as two FME Workbench files (.fmw). These can be opened and run in FME versions 2015 and later. Initially the inputs will be set up according to the Jacobs' project directory structure, but these can be changed very easily to the Transport Agency's structure when running the model in 'Prompt and Run' mode  or  for the first time as shown in Figure 5.

Figure 5 FME parameter dialog



Illustrations of the FME models are provided in Appendices J & K of this report.

5.3 VEPM2016 spreadsheet

The VEPM2016 spreadsheet supplied in the deliverables of this project is a data only version of the batch outputs derived from the VEPM calculation spreadsheet. It combines both LV & HV calculations, and has some revised field names that enable more reliable direct reading and processing by the FME workflow. This spreadsheet has been stripped of all formatting and macros.

It contains a separate worksheet for each TLA.

6. Future Updates

The design of the two FME workflows allows regular updates to be applied when new input data becomes available, or as strategy dictates.

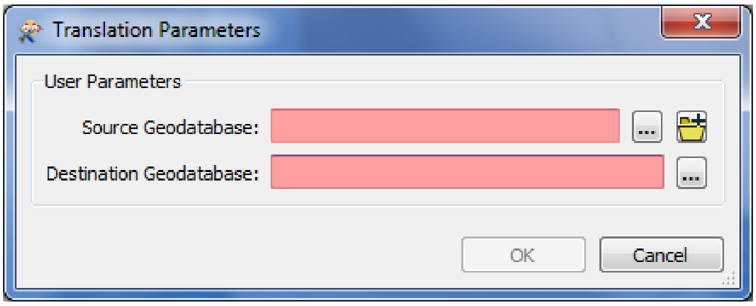
The FME workflows have been designed to be run with the 64 bit version of FME, but will happily run in 32 bit. Because the design is in 64 bit the readers and writers cannot use the ESRI ArcObjects model, and instead use the ESRI API model. The only ramification of this is that these workflows will not write to a feature dataset, which is actually good practice as they would impact performance anyway.

Minor modifications will need to be made to the workflows to ensure they run correctly in the Transport Agency environment. This mainly involves making sure the input and output datasets are selected correctly, and that the input datasets contain the correct attribute information in them. The following is a more thorough explanation of what is required for the two FME workflows.

6.1 Combine Road Centrelines

The ***CombineRoadCentrelines*** FME workflow allows the user to specify the source and destination geodatabases, as shown in Figure 6.

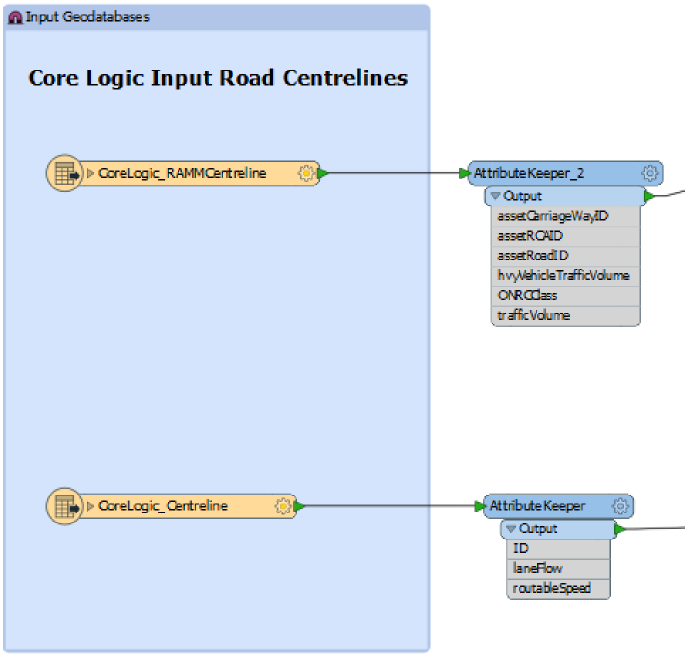
Figure 6 User Parameters for Combine Road Centrelines FME workflow



The Source Geodatabase must contain the two input feature classes required for the process. These feature classes must be called *CoreLogic_RAMMCentreline* and *CoreLogic_Centreline.* Core Logic provides updates of these two feature classes regularly to NZTA, and it is likely that the names of these feature classes will remain the same. If there is a requirement to change the name of the feature classes, then the workflow will need to be opened in FME workbench, and edited.

Inside these feature classes there are several key attribute fields that the workflow relies on to do its job properly. If these fields do not exist then the workflow is likely to error, or produce unreliable results. Figure 7 shows an extract from the FME workflow illustrating the attribute fields that are required.

Figure 7 FME workflow showing attribute fields required in the input datasets



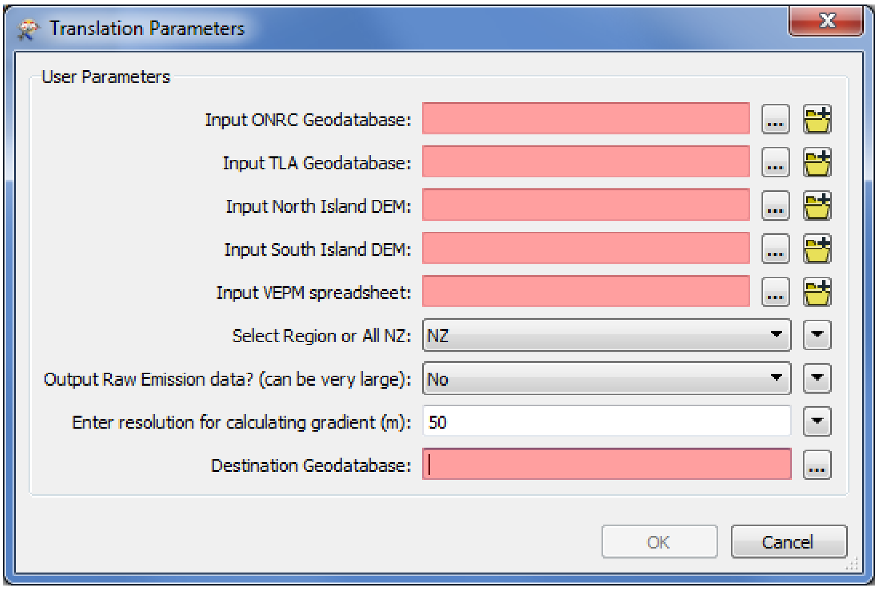
These attributes have not been modified in any way since the original supply from the Transport Agency, so it is likely that no changes will be necessary for future updates.

The Destination Geodatabase can be saved anywhere. It can be a new or an existing geodatabase. It is completely acceptable for the source and destination geodatabases to be the same. In fact it is probably good practice, as this is a good way to store all of the inputs and outputs in the same place. There is only one output feature class created during this workflow, and this is called *Merged_ONRC*.

6.2 Assign Emissions to Roads

The ***AssignEmissionsToRoads*** FME workflow allows the user to specify a much larger range of inputs and settings, as shown in Figure 8.

Figure 8 User Parameters for Assign Emissions to Roads workflow



The Input ONRC Geodatabase is the Destination geodatabase from the Combine Road Centrelines workflow. This geodatabase must contain the *Merged_ONRC* feature class.

The Input TLA Geodatabase should contain a feature class called *RegionalBoundaries*, and this feature class must contain an attribute field named *Region*. This field should contain the TLAs name without any council extensions, i.e. it should be 'Northland' rather than 'Northland Region'.

There are two input DEM datasets in the parameter dialog. There are separate North and South Island files due to the large size of the DEM at the 25 metre resolution that has been used in this project. The two DEMs that are used in the current workflow are Earth Resources Data Analysis System (ERDAS) Imagine files, and the FME workbench would need to be edited if another raster format was to be used for the DEM.

The Input VEPM spreadsheet is a data only spreadsheet that has been derived from a separate batch VEPM run for each TLA. Each TLA is represented by a separate worksheet in the spreadsheet. Further information about this spreadsheet is found in the next section.

The Destination Geodatabase can be saved anywhere. It can be a new or an existing geodatabase. It is completely acceptable for the source and destination geodatabases to be the same. In fact it is probably good practice, as this is a good way to store all of the inputs and outputs in the same place.

The user is also presented with three other options when running this workflow:

- The user has the option of running this workflow on the entire country, or on an individual TLA area. It is worth noting that the processing time for the entire country can be up to 10 hours, depending on the resolution used to calculate the gradient. It will also attempt to use all of the memory that is available to it. It is recommended that the machine running this workflow should have a minimum of 16Gb of RAM.

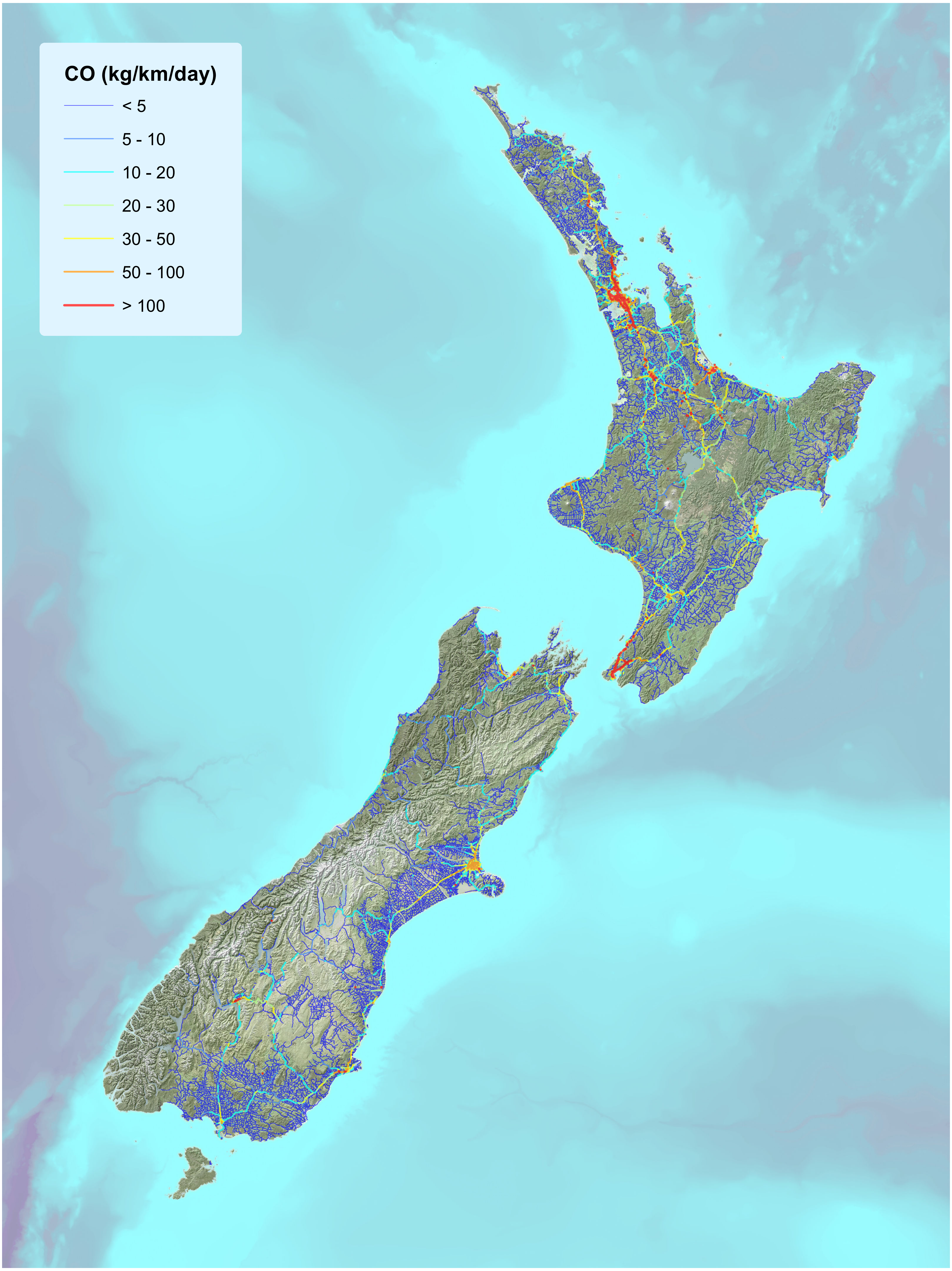
- The user has the option of outputting the raw emission data as well as the ONRC emission data. The raw emissions split the ONRC roads into lengths based on the resolution set by the user. Each individual section has a gradient assigned to it, and the emissions are calculated before aggregating back into the output ONRC roads. The raw emission dataset will typically be considerably larger than the ONRC emissions, unless a very large resolution is set. It is not recommended outputting a raw emission dataset when running the workflow for the entire country.

- The user has the option of setting the resolution of the calculations. For this project this resolution has been set at 50 metres. Reducing the resolution will increase the processing time, and the amount of memory that is used. There is also no point in reducing the resolution below the resolution of the input DEM.

6.3 Updating the VEPM Spreadsheet

The VEPM spreadsheet used for this project has been derived from many VEPM batch runs for each TLA area. Each area has also had a separate Light Vehicle and Heavy Vehicle batch run. An example VEPM spreadsheet for Auckland Light Vehicles has been included in the data delivery of this project to enable the user to better understand how the final VEPM_2016 spreadsheet was produced. The Bulk Input and Bulk Output worksheets contain all the information that is necessary. Unfortunately there is a lot of copy and pasting from the individual VEPM TLA spreadsheets into the final VEPM_2016 spreadsheet, to get it in a format suitable for processing. To use in future years, this spreadsheet will need to be updated to reflect the factors for a new study year.

Appendix A. Daily Vehicle Emissions CO



J:\IE\Projects\02_New Zealand\IZ013700\06 Technical\01 Spatial\01 MXD\OutputCO.mxd

1:4,500,000

Date: 1/02/2017

N
W E
S

Calculated Daily CO emissions

NVED 2016 Dataset

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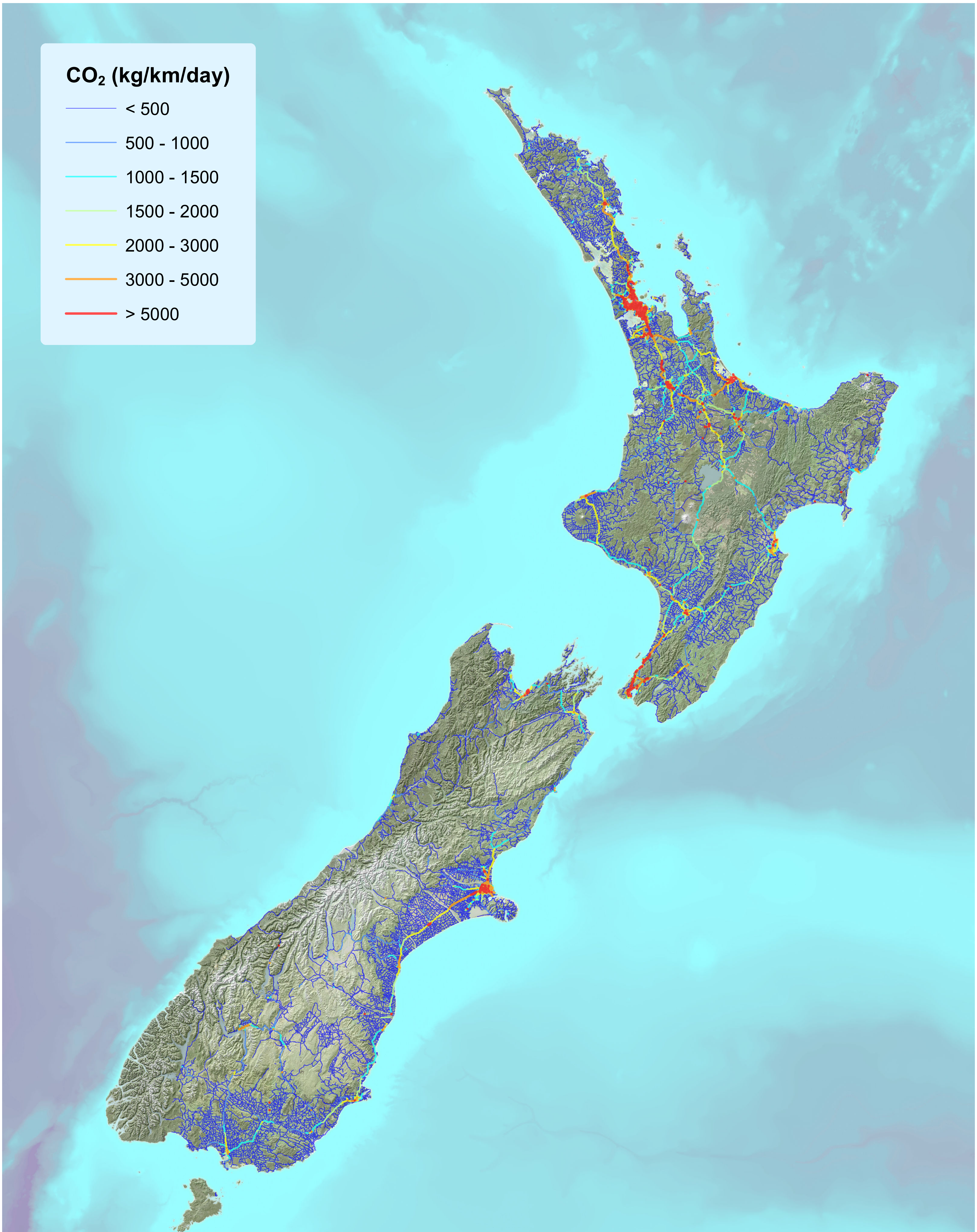
Appendix B. Daily Vehicle Emissions CO_2



J:\IE\Projects\02_New Zealand\IZ013700\06 Technical\01 Spatial\01 MXD\OutputCO2.mxd

1:4,500,000

Date: 30/01/2017

N
W E
S

Calculated Daily CO_2 emissions

NVED 2016 Dataset

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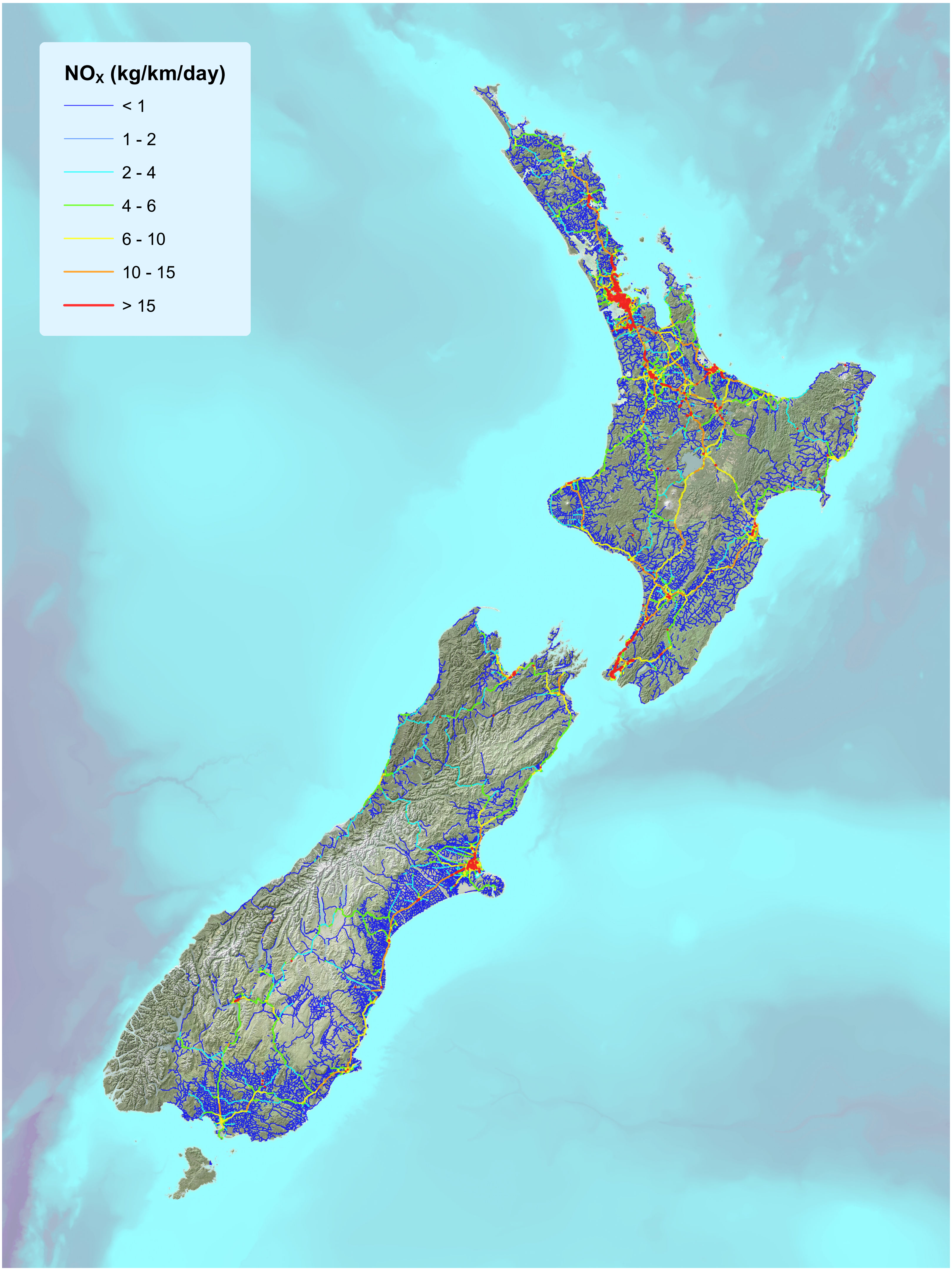
Appendix C. Daily Vehicle Emissions NO_x



J:\IE\Projects\02_New Zealand\IZ013700\06 Technical\01 Spatial\01 MXD\OutputNOx.mxd

1:4,500,000

Date: 1/02/2017

N
W E
S

Calculated Daily NO_X emissions

NVED 2016 Dataset

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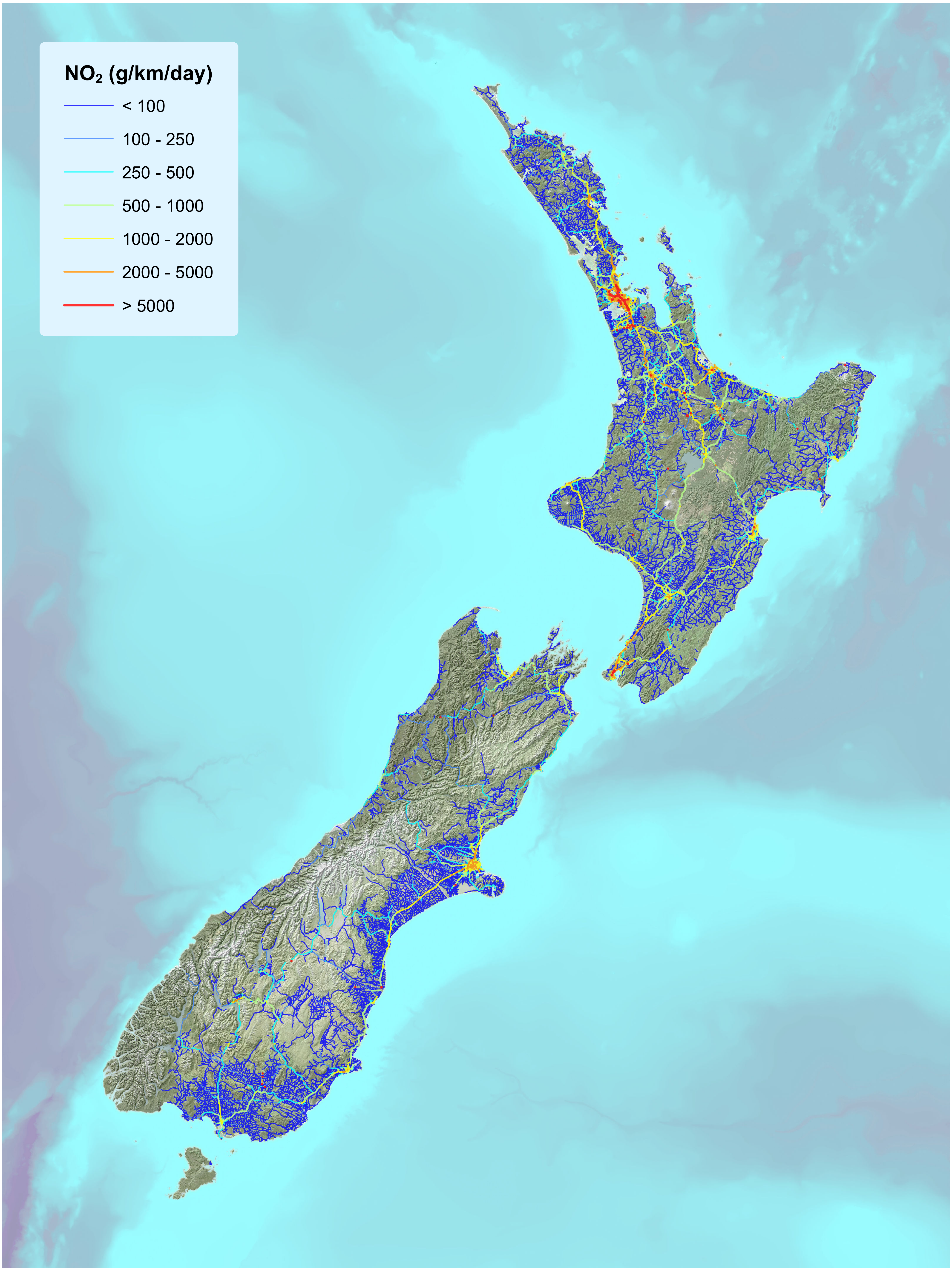
Appendix D. Daily Vehicle Emissions NO_2



J:\IE\Projects\02_New Zealand\IZ013700\06 Technical\01 Spatial\01 MXD\OutputNO2.mxd

1:4,500,000

Date: 1/02/2017

N
W E
S

Calculated Daily NO_2 emissions

NVED 2016 Dataset

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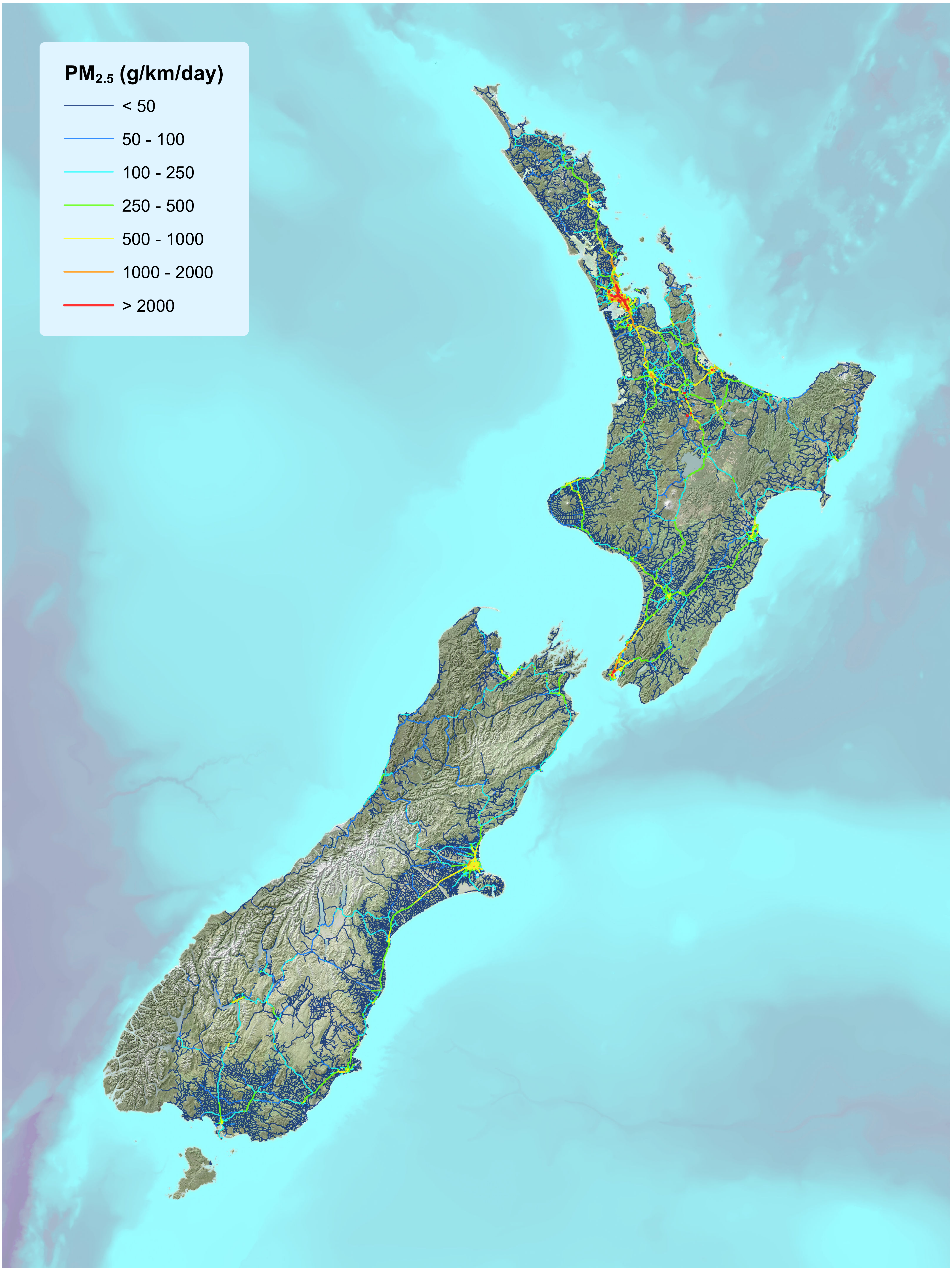
Appendix E. Daily Vehicle Emissions $PM_{2.5}$



1:4,500,000

Date: 7/09/2018

N
W E
S

Calculated Daily $PM_{2.5}$ emissions

NVED 2016 Dataset

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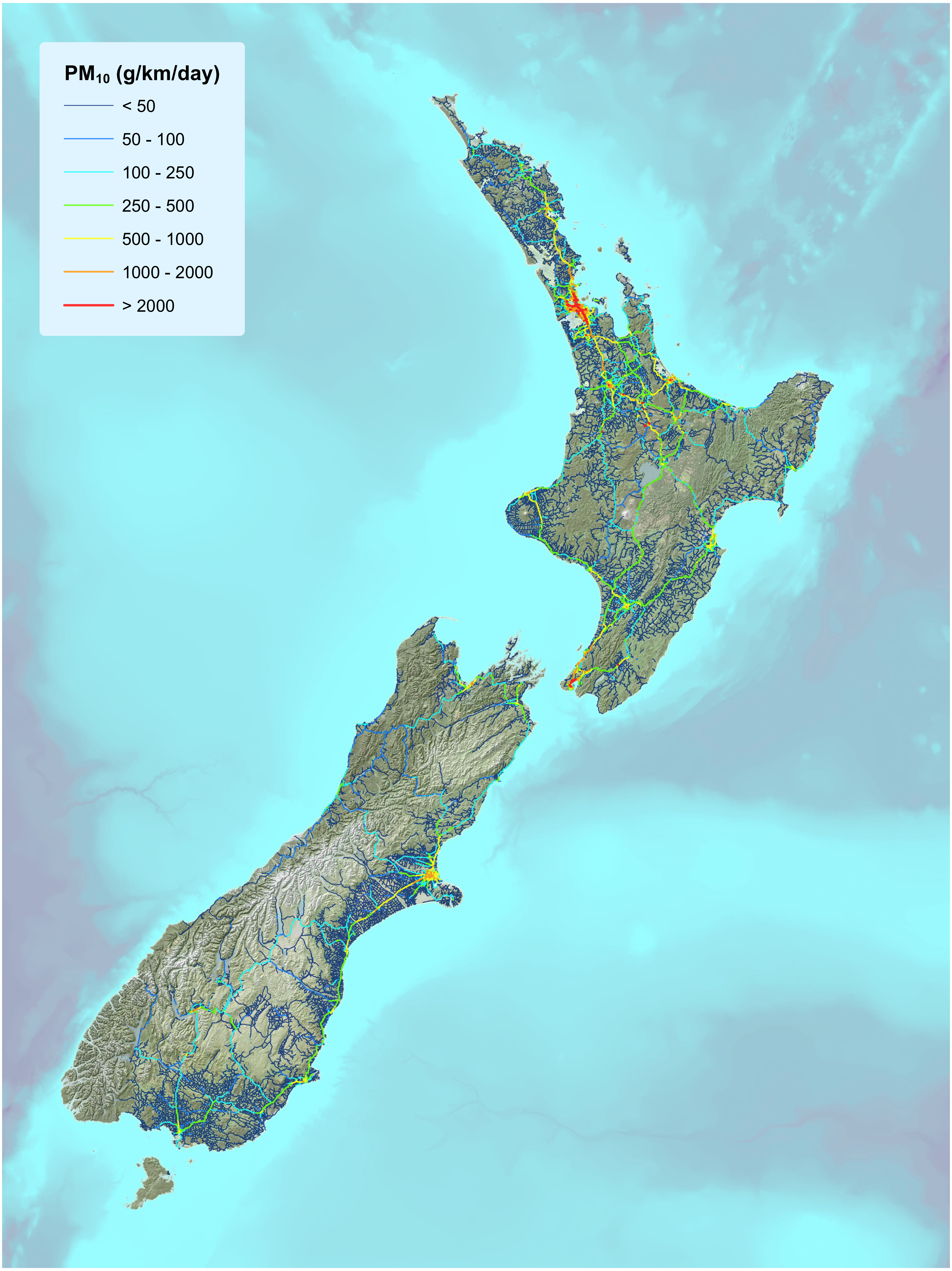
J:\IE\Projects\02_New Zealand\IZ013700\06 Technical\01 Spatial\01 MXD\OutputPM25.mxd

Appendix F. Daily Vehicle Emissions PM_{10}



J:\IE\Projects\02_New Zealand\IZ013700\06 Technical\01 Spatial\01 MXD\OutputPM10.mxd

1:4,500,000

Date: 7/09/2018

N
W E
S

Calculated Daily PM$_{10}$ emissions

NVED 2016 Dataset

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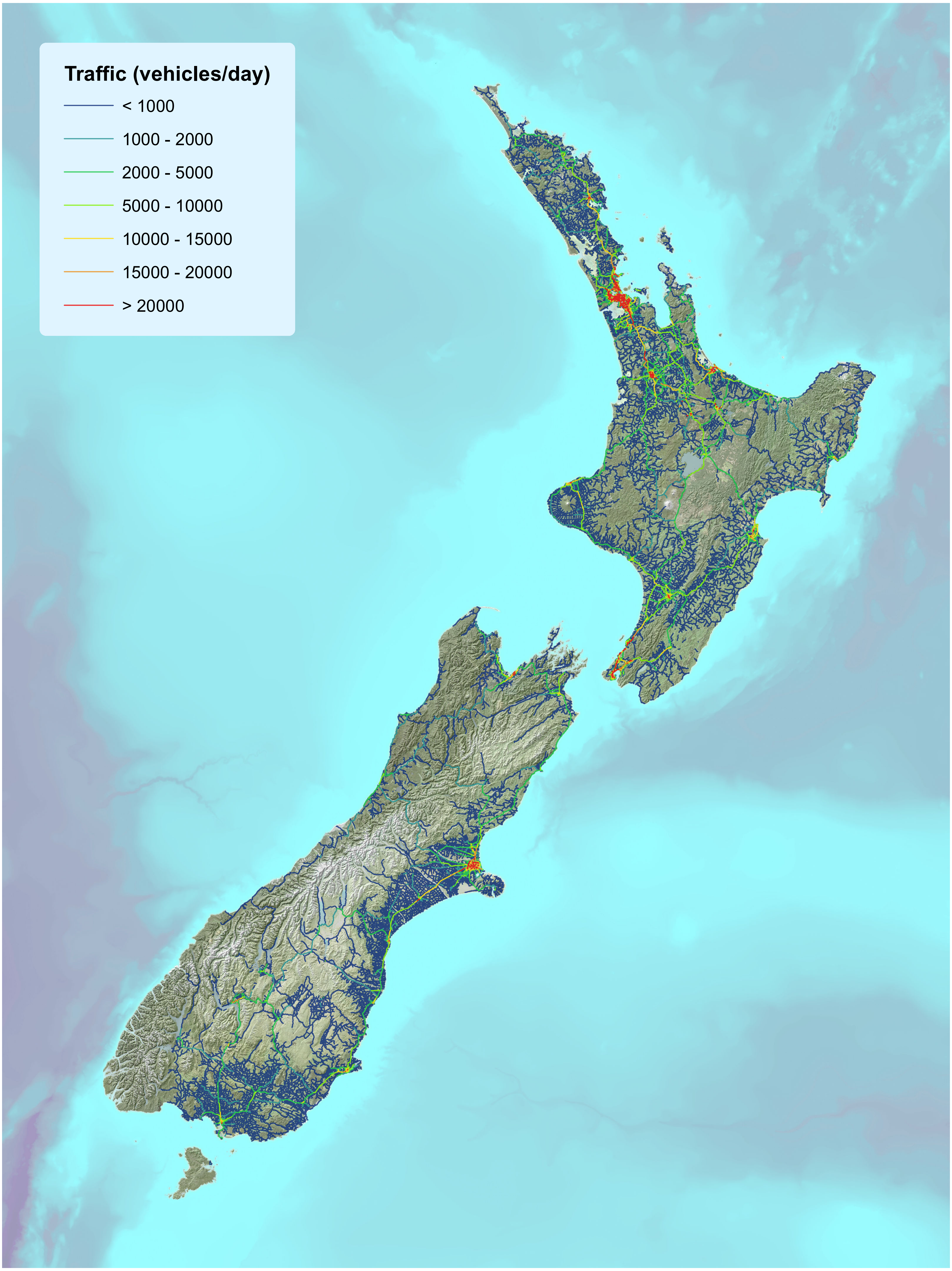
Appendix G. Average Daily Traffic Input



J:\IE\Projects\02_New Zealand\IZ013700\06 Technical\01 Spatial\01 MXD\InputTraffic.mxd

1:4,500,000

Date: 1/02/2017

N
W E
S

Average Daily Traffic

NVED 2016 Input Data

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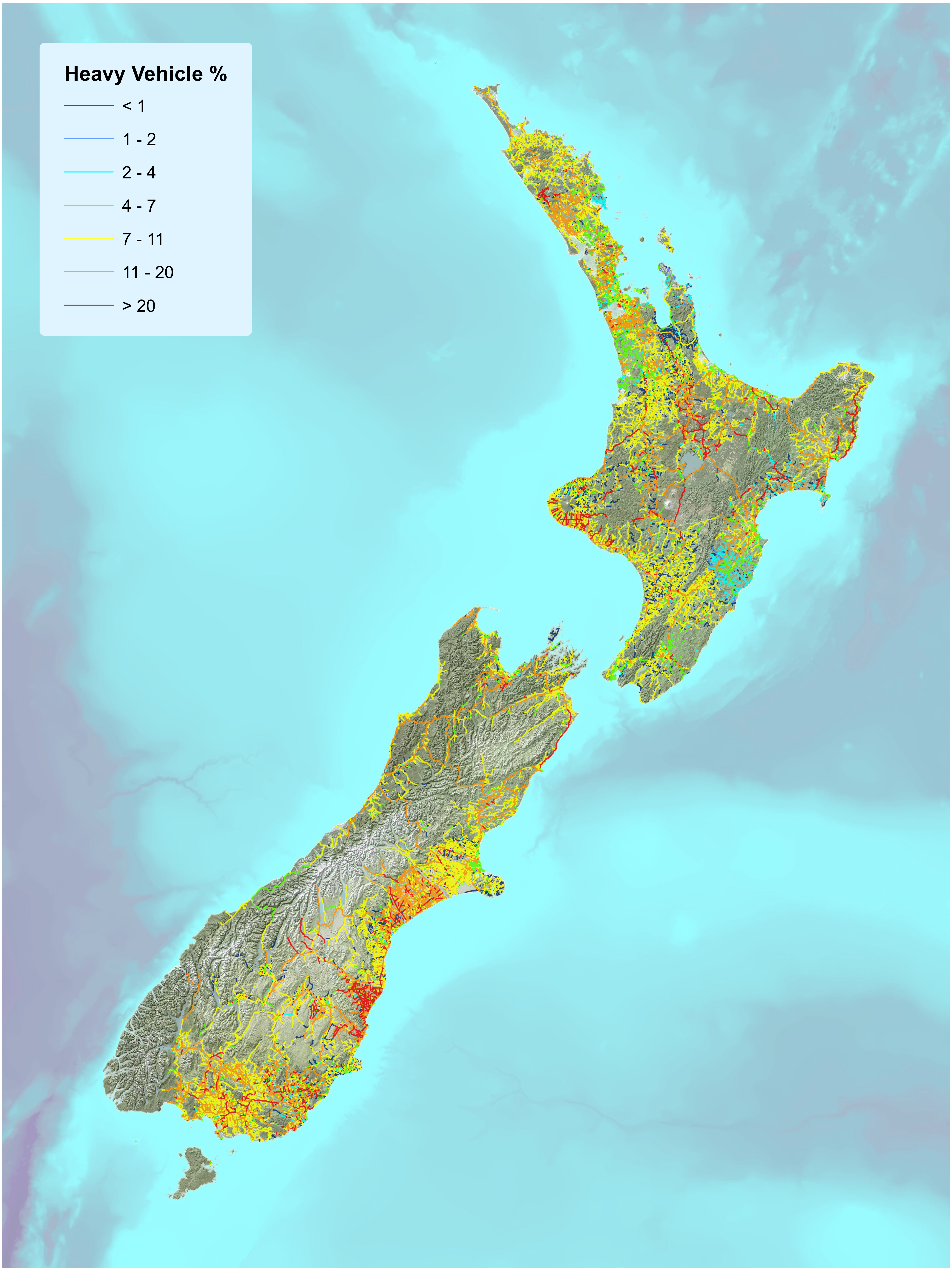
Appendix H. Fleet Profile Input



1:4,500,000

Date: 1/02/2017

N
W E
S

Fleet Profile

NVED 2016 Input Data

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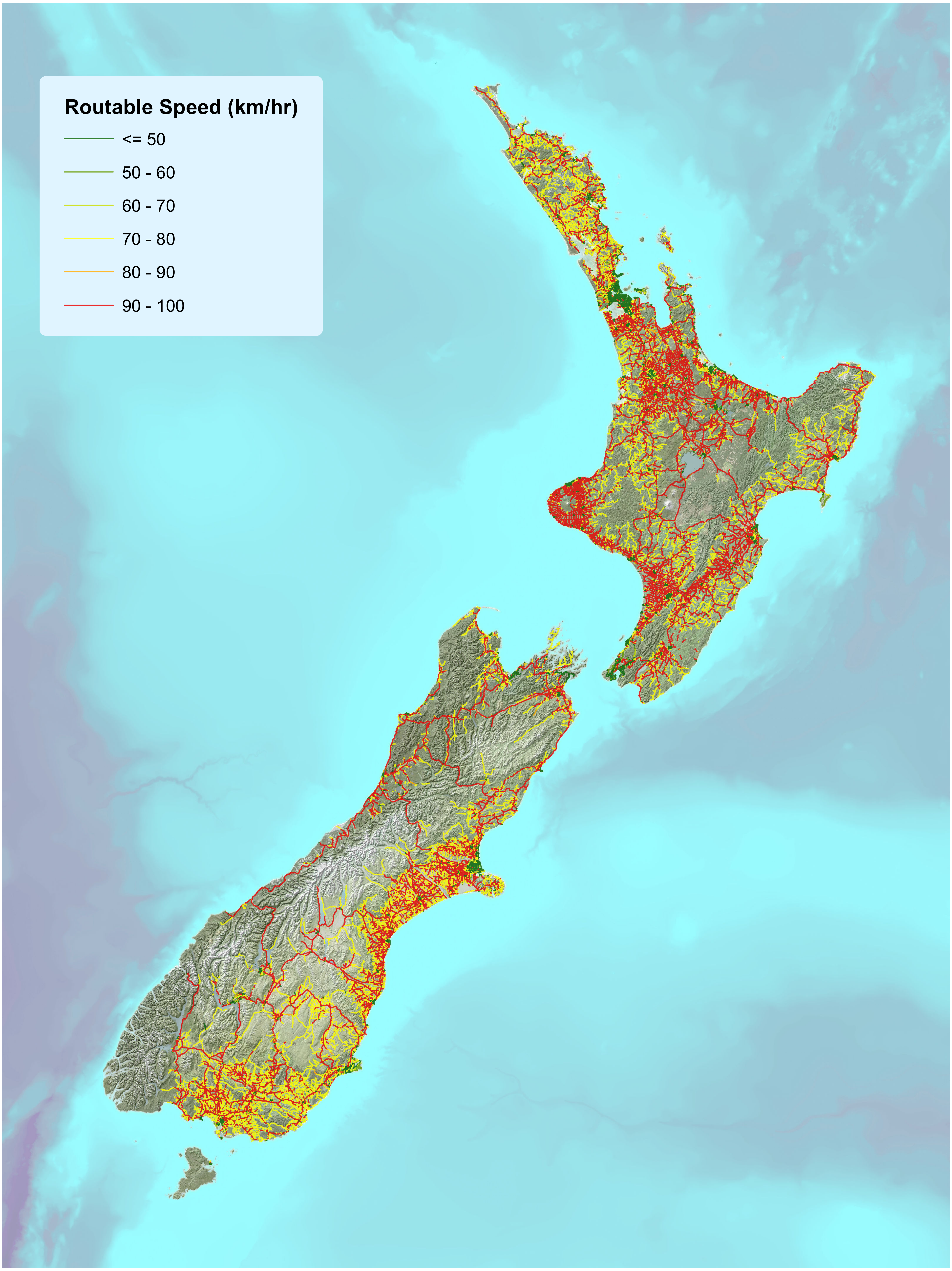
J:\IE\Projects\02_New Zealand\IZ013700\06 Technical\01 Spatial\01 MXD\InputFleetProfile.mxd

Appendix I. Speed Input



J:\IE\Projects\02_New Zealand\IZ013700\06 Technical\01 Spatial\01 MXD\InputSpeed.mxd

1:4,500,000

Date: 1/02/2017

N
W E
S

Routable Speed

NVED 2016 Input Data

NZ TRANSPORT AGENCY
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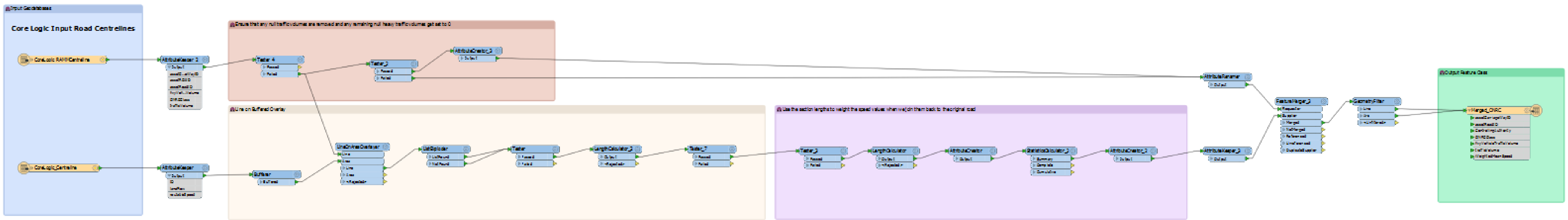
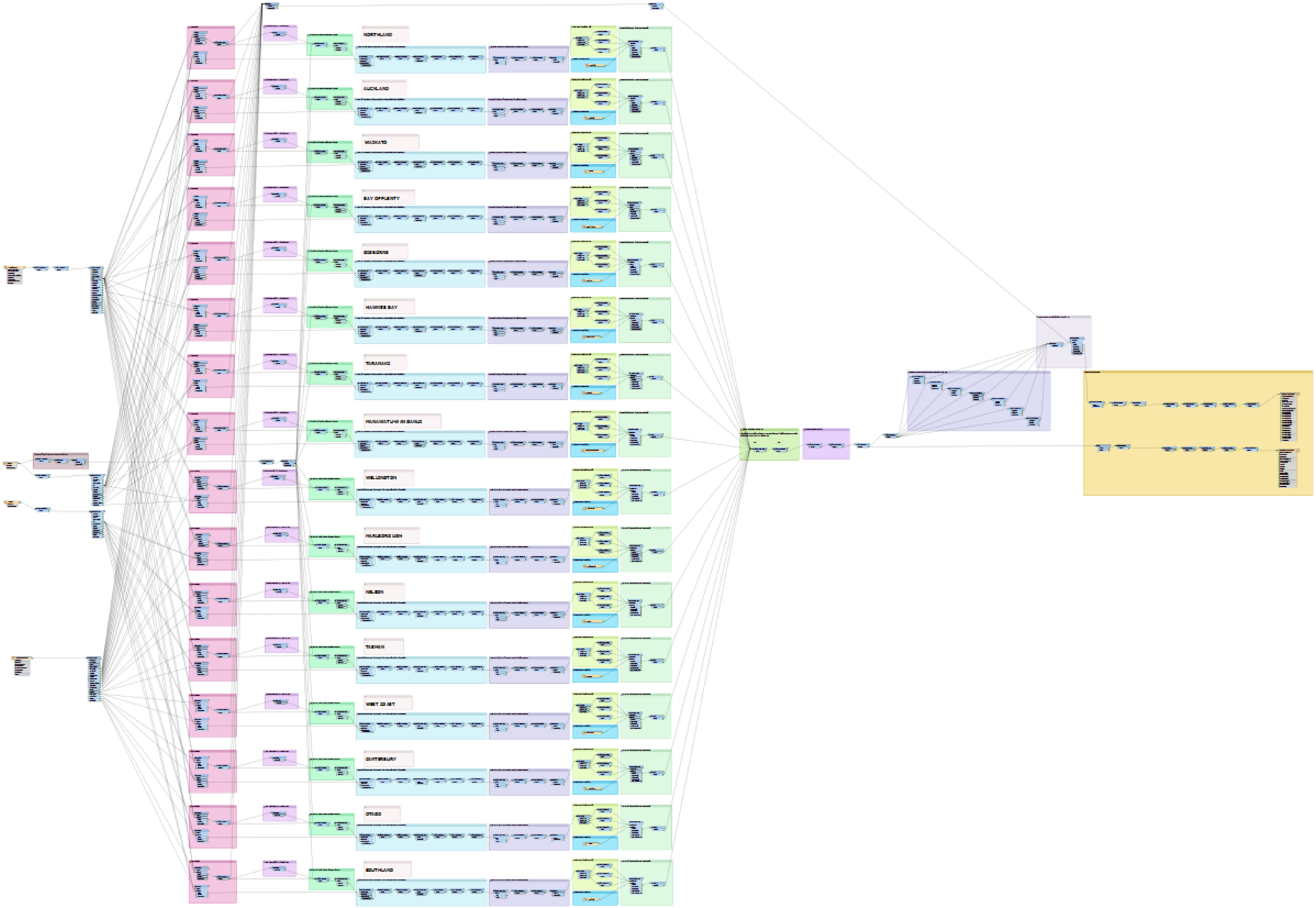
Appendix J. FME Model 1 – Combine Road Centrelines



FME Model 1 - Combine Road Centrelines

Appendix K. FME Model 2 – Assign Emissions To Roads



FME Model 2 - Assign Emissions to Roads