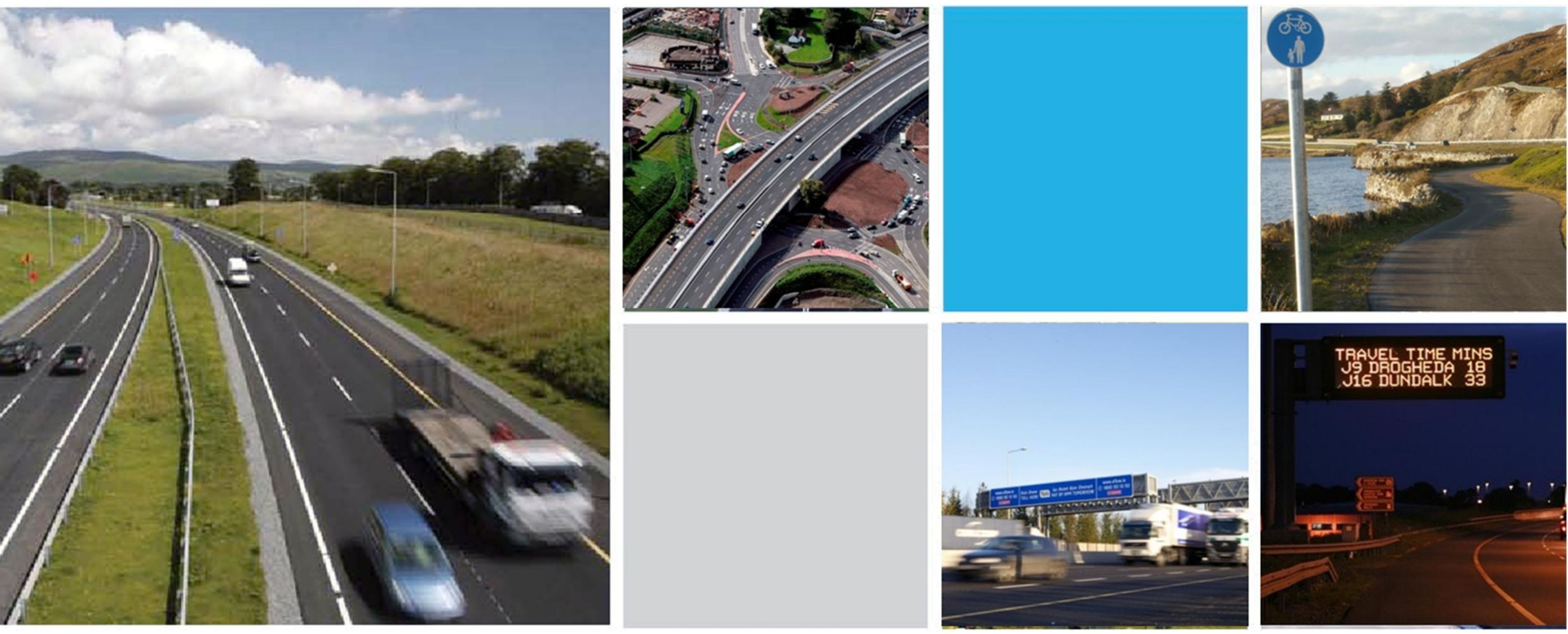
Mid West National Road Design Office

Traffic Modelling Report

Foynes to Limerick Road Improvement Scheme



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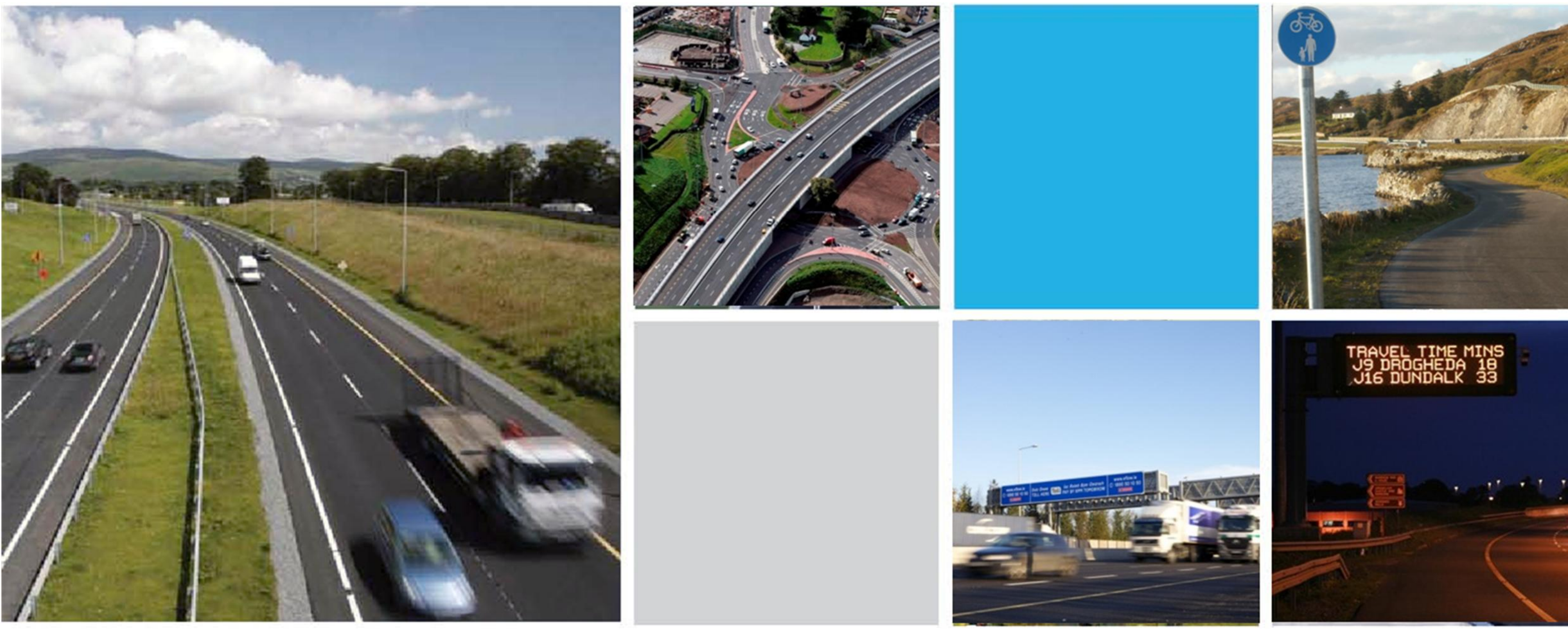


1. Introduction

1.1 Overview

This Traffic Modelling Report (TMR) outlines the development, calibration & validation and traffic forecasting process for a local area traffic model. The traffic model has been developed to assess the impact from a traffic point of view of the route corridor options identified as part of the Phase 2 Route Selection process for the Foynes to Limerick Road Improvement Scheme. The traffic model study area for the proposed scheme is illustrated in Figure 1.1.

The proposed route options identified as part of the Phase 2 Route Selection process have been modelled and appraised in accordance with the NRA[1] Project Management Guidelines (PMG) 2010 and NRA Project Appraisal Guidelines (PAG) 2011. These guidelines are in compliance with the Department of Transport's Common Appraisal Framework for Transport Projects and Programmes (2009).

Figure1.1 - Traffic Model Study Area

1.2 The Project Appraisal Guidelines

This Traffic Modelling Report forms one individual PAG deliverable required under the NRA Project Appraisal Guidelines (PAG) (2011) as part of the appraisal process for major schemes. The full set of PAG deliverables for major schemes as part of the Phase 2 Route Selection process is as follows:

- Project Brief;

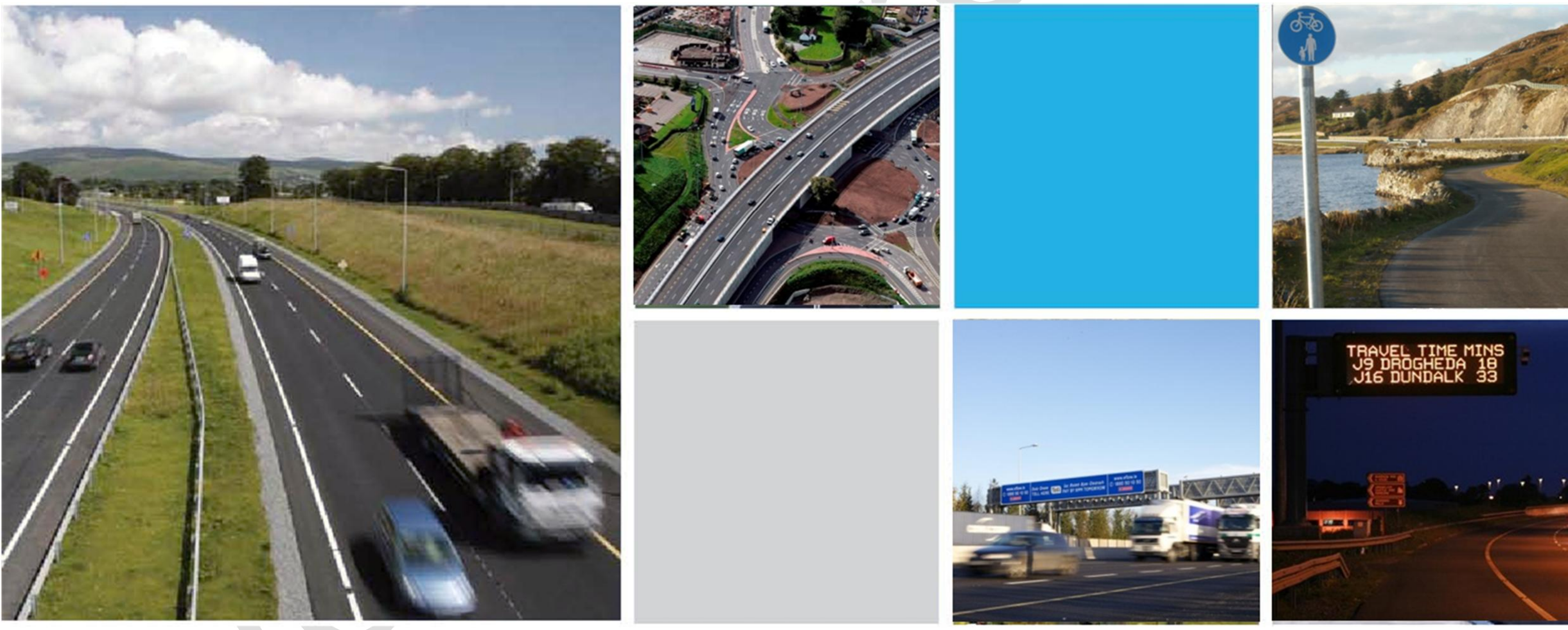
[1] On the 1st August 2015 the National Road Authority (NRA) merged with the Railway Procurement Agency (RPA) to form Transport Infrastructure Ireland (TII). However, in relation to existing guidance/standards documents, reference is still made to the NRA throughout this document.

- Traffic Modelling Report;
- Cost Benefit Analysis;
- Project Appraisal Balance Sheet; and
- Preliminary Business Case.

1.3 Project Background

The proposed scheme arises from the European Union (EU) Trans European Transport Network (TEN-T) requirement to provide a road that meets the standard defined by the TEN-T regulations in order to integrate the Core Port of Shannon-Foynes with the Core transport network in Ireland and the European Union. In practical terms this will be achieved by connecting Foynes to the existing motorway network in the vicinity of Limerick City.

Chapter 2
Data Collection



2 Data Collection

2.1 Introduction

In order to develop a Traffic Model, a significant level of traffic data is required to ensure that the model can replicate existing traffic patterns and volumes. This section of the TMR describes the collation of data for the construction of the Base Year (2014) Local Area Model (LAM).

2.2 National Transport Model

The starting point for the development of the Base Year LAM was the 2013 Base Year National Transport Model[2] (NTpM), which was developed by the National Roads Authority (NRA), who are now part of Transport Infrastructure Ireland (TII). The NTpM is a strategic multi-modal variable demand model used by the TII to assess the impact of infrastructure or policy changes at national, regional and local level. Within the NTpM there are four modules, which are as follows:

- National Traffic Model (NTM);
- National Rail Model (NRM);
- National Bus Model (NBM); and
- Variable Demand Model (VDM)

The three assignment models (NTM, NRM & NBM) are used to assign the demand for travel represented by the demand matrices to the network, generating travel costs (e.g. time, distance, tolls, fares) for each mode. A brief overview of the Variable Demand Model is provided in the following section.

2.2.1 Variable Demand Modelling

The role of the Variable Demand Model (VDM) is to assess, if required, the impact of a change in the transport network or change in the cost of travel (e.g. fuel costs, fares) upon the demand for travel (mode switching, induced demand etc.). Table 5.2.1 of *PAG Unit 5.2: Construction of Transport Models* provides guidance on when variable demand modelling is required.

The VDM operates at a national level as it requires the full cost of a trip between an origin and destination; therefore any assessment of potential demand responses arising from the Foynes to Limerick Road Improvement scheme is undertaken with the NTpM and not the LAM. However, any demand responses identified as a result of the proposed scheme will be incorporated into the LAM using demand matrix adjustment techniques during the ensuing project phase (Phase 3 Design).

2.3 National Traffic Model

The NTM is a strategic (macroscopic) traffic model developed using the transportation modelling software VISUM[3] and forms the road traffic element of the NTpM as outlined above. The model covers the entire national and regional road network and is used by TII as a tool in the appraisal of potential road schemes, land-use and policy changes. The NTM provides demand data for

[2] NRA National Transport Model documentation - http://www.nra.ie/policy-publications/national-transport-model/
[3] VISUM - **V**erkehr **I**n **S**tadten **UM**legung (Urban Transport Assignment)

Light Vehicles (Car & Light Goods Vehicles) and Heavy Vehicles (Other Goods Vehicle 1, Other Goods Vehicle 2 and Buses/Coaches) for the following time periods[4]:

- Average AM Peak Hour (average hour between 07:00 – 09:00); and
- Average Inter Peak Hour (average hour between 12:00 – 14:00).

The model provides both the initial highway network and demand matrices for the LAM. The NTM is high level strategic traffic model and though it is suitably refined to test impacts on a national scale it is not detailed enough to assess local impacts on the network.

2.4 Traffic Surveys

A summary of the traffic survey data that was collated to inform the development of the Base Year (2014 LAM) is outlined below in Table 2.1. Figures 2.1 to 2.8 illustrate the location of the traffic surveys.

Table 2.1 - Traffic Survey Data

Survey Type	Description
Origin – Destination (OD)	Automatic Number Plate Recognition (ANPR) surveys were carried out on Tuesday 20th May 2014 at 17 sites between 07:00-19:00. Additional ANPR surveys were also carried out at these same sites on Wednesday 4th June 2014 between 06:00 – 08:00 & 15:30 – 20:00.
	A Roadside Interview (RSI) style questionnaire was given to HGV drivers at Foynes Port on Thursday 22nd May 2014.
Traffic Count	Automatic Traffic Counts (ATC) surveys were carried out at 13 of the ANPR sites along with an additional 3 sites between 19th May and 1st June 2014.
	Junction Turning Counts (JTC) surveys were carried out at 27 locations on Tuesday 20th May 2014 between 07:00-19:00.
	Traffic data from 13 Transport Infrastructure Ireland (TII) Traffic Monitoring Units (TMU).
Journey Time	Journey time survey data was collected as part of the ANPR surveys and through the use of Bluetooth tracking devices at Adare.

[4] The NTM does not model the PM Peak Hour. However a standard process is in place to generate a PM Peak Hour model for the proposed scheme and is discuss in Chapter 3.

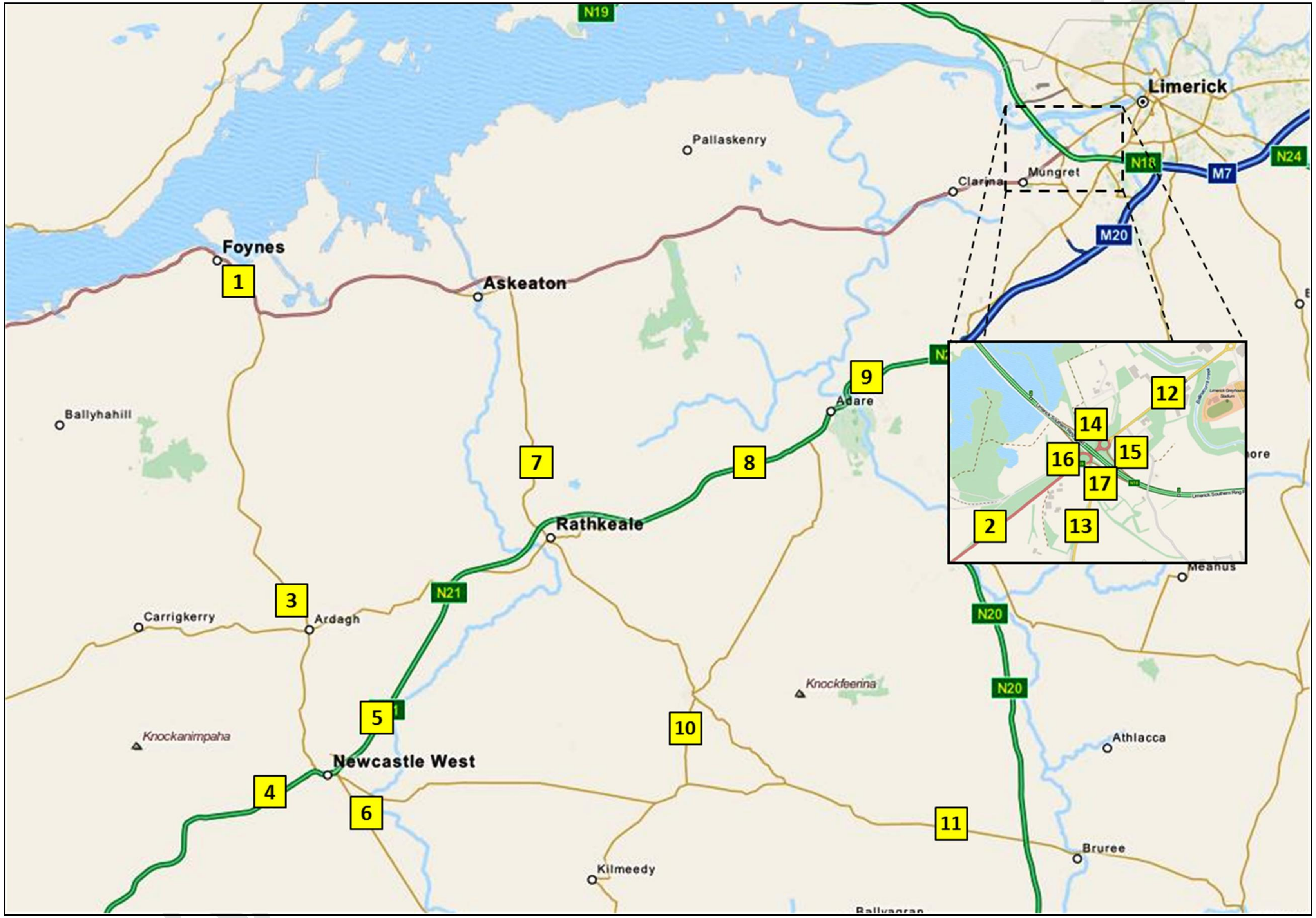


Figure 2.1 – Overview of ANPR Survey Locations

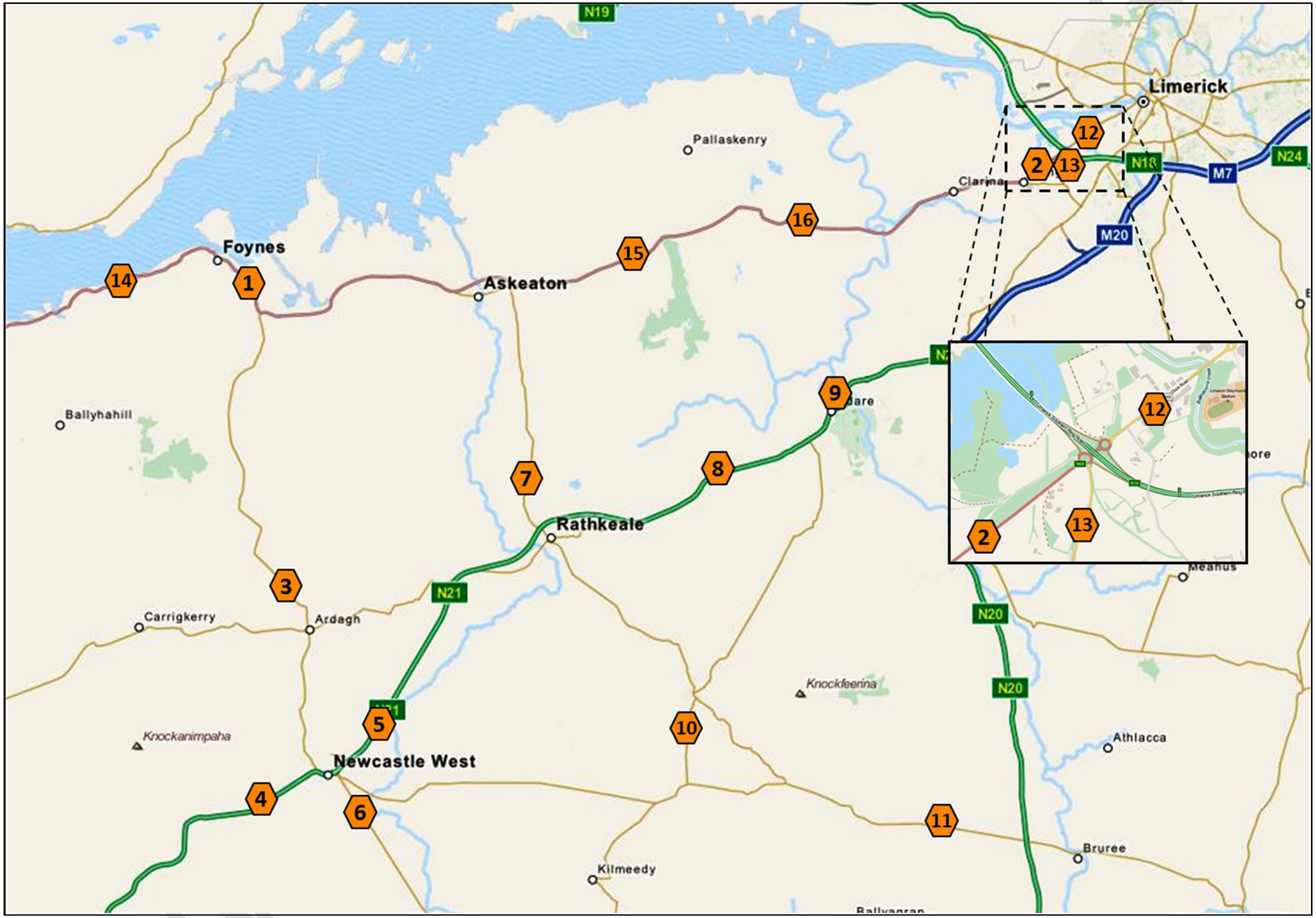


Figure 2.2 - Overview of ATC Survey Locations

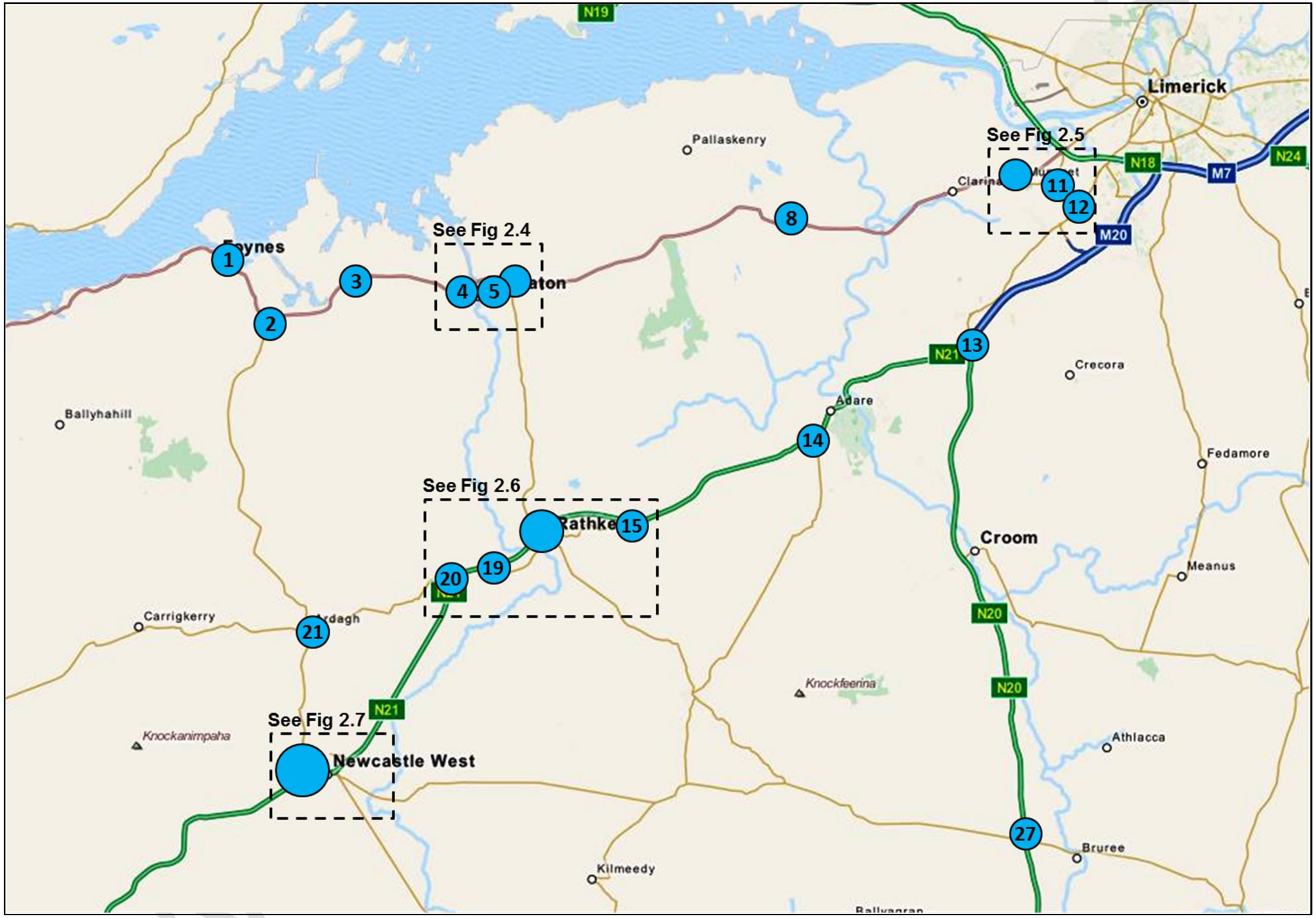


Figure 2.3 - Overview of JTC Survey Locations

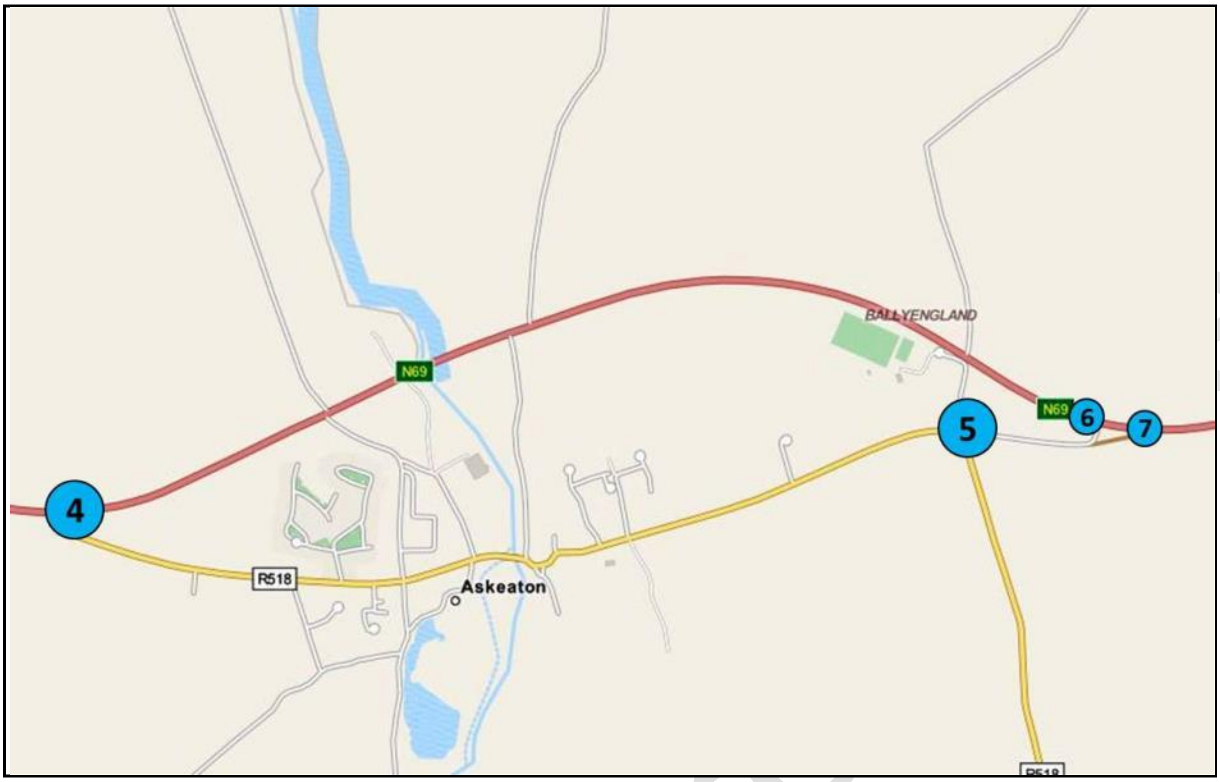


Figure 2.4 – JTC Survey Locations in vicinity of Askeaton

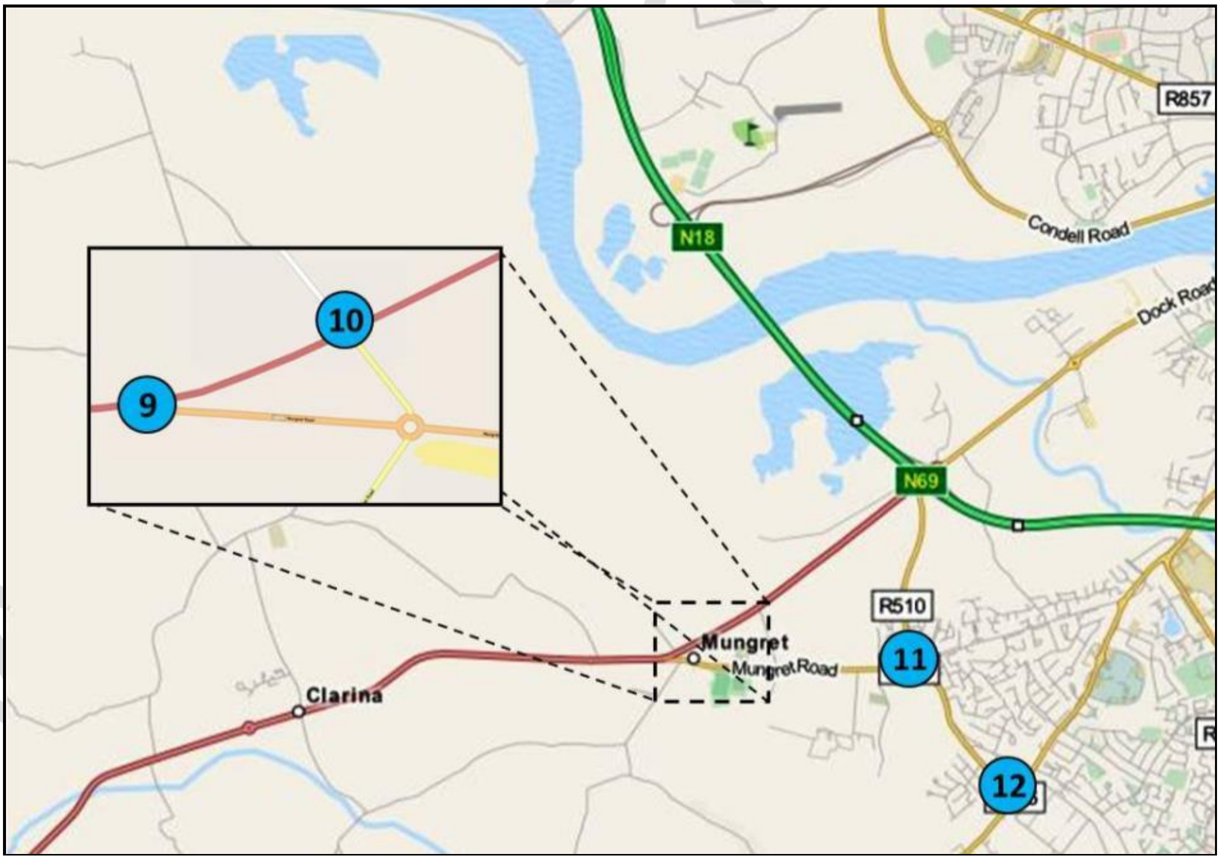


Figure 2.5 - JTC Survey Locations in vicinity of Mungret

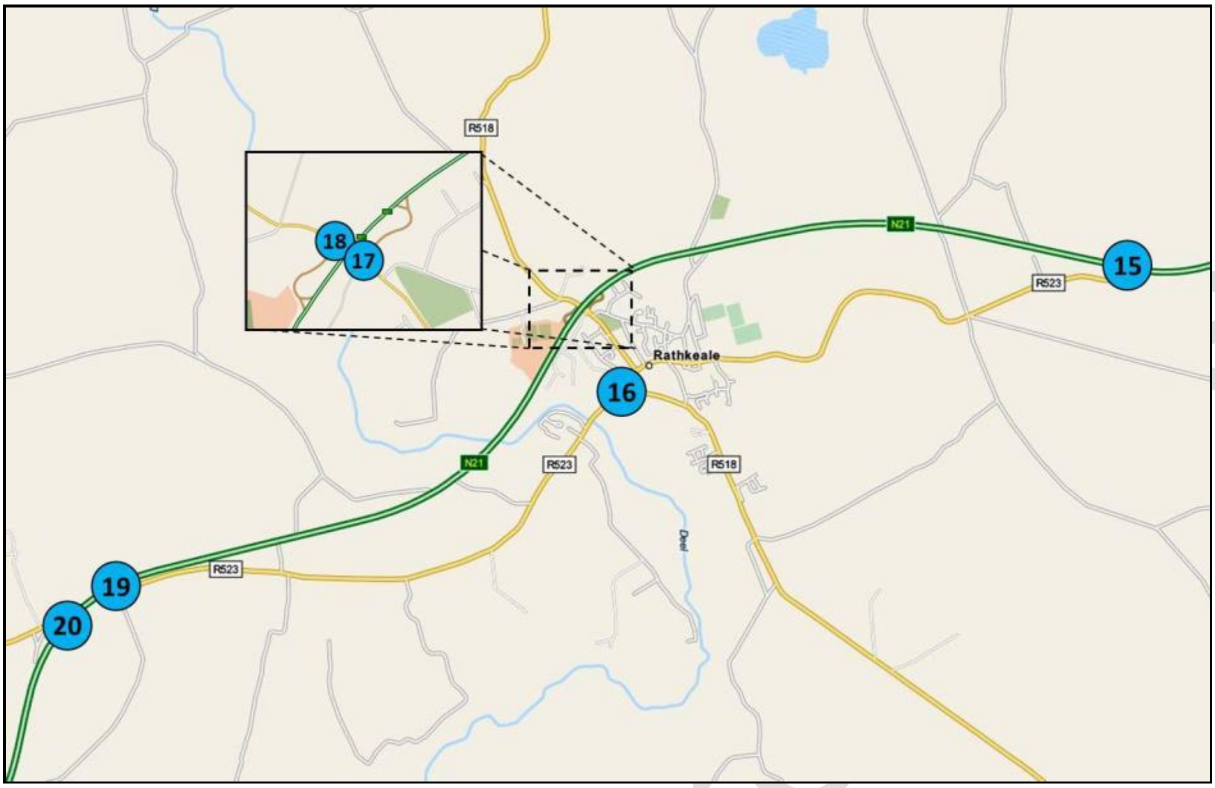


Figure 2.6 - JTC Survey Locations in vicinity of Rathkeale

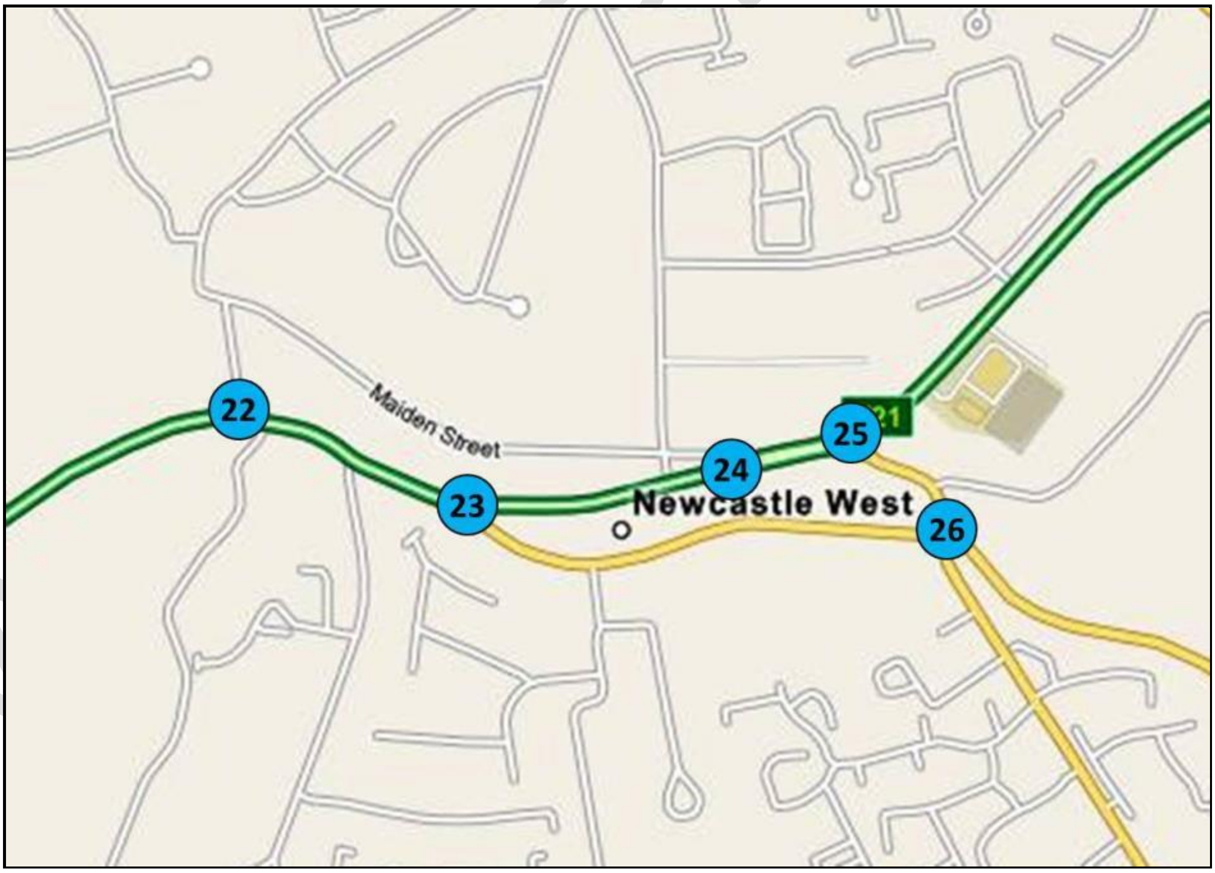


Figure 2.7 - JTC Survey Locations in vicinity of Newcastle West

Figure 2.8 – TII Traffic Monitoring Units within the Study Area

2.4.1 Automatic Traffic Counter

An ATC captures the flow passing a given point on a road and classifies the flow into different vehicle classifications, for example Cars, Light Goods Vehicles (LGV) and Heavy Goods Vehicles (HGV). Traffic flow data extracted from the 16 ATC surveys undertaken over a 14 day period in May 2014 is presented in Table 2.2 below for the following time periods:

- AM Peak (08:00 – 09:00);
- Average Inter Peak (average hour between 12:00 – 14:00); and
- PM Peak (17:00 – 18:00).

Table 2.2 also provides annual average estimates of both weekday (Mon – Fri) and 7 day traffic flow. In order to estimate annual data, seasonality factors have been developed from the TII TMUs within the study area and applied to the survey data. The following estimates are provided:

- 2014 Annual Average Weekday Traffic (AAWT); and
- 2014 Annual Average Daily Traffic (AADT).

Table 2.2 - Automatic Traffic Counter Data 2 Way Flow (2014)

Site No.	Location	Vehicles Per Hour			Vehicles Per Day	
		AM	IP	PM	AAWT	AADT*
1	N69 - 900m west of N69/R521 Jct.	291	314	444	5512	5287
2	N69 - 400m southwest of N18 Jct.	725	552	853	9699	9303
3	R521 - 900m north of Ardagh	163	164	202	2819	2704
4	N21 - 450m west of N21/R521 Jct.	763	800	973	12619	12104
5	N21 - 1km northeast of N21/R522 Jct.	899	858	1099	14482	13890
6	R522 - 1km south of N21	325	290	395	5116	4907
7	R518 - 500m north of N21	119	97	147	1823	1749
8	N21 - 1km West of N21/R519 Jct.	985	821	1071	13899	13331
9	N21 - 500m east of River Maigue Bridge	1310	1077	1224	17821	17094
10	R519 - 600m south of R519/R518 Jct.	85	65	81	1119	1074
11	R518 - 1km West of N20/R518 Jct.	206	146	218	2665	2556
12	Dock Rd - 200m northeast of N18 Jct.	1481	1163	1498	18690	17927
13	R510 - 300m south of N18 Jct.	1048	771	1067	12560	12048
14	N69 - 2.5km west of Foynes	145	227	305	3623	3460
15	N69 at Ballyvogue 4 km east of R518 Jct.	453	389	608	7201	6907
16	N69 - 2.2 km west of River Maigue Bridge	729	512	895	9876	9473

**- HGV percentages are provided in Figure 2.9 alongside the AADT flows.*

2.4.2 Junction Turning Counts

A JTC captures the number of vehicles turning at a junction and observes which turn they take. As with the ATCs they classify the traffic into different vehicles categories. JTC surveys were undertaken at 27 junctions on Tuesday 20th May 2014 between 07:00-19:00. Traffic flow was classified by vehicle type and recorded in 15min time intervals. The following junctions were surveyed (refer to Figures 2.3-2.7):

- Junction 1: N69 Junction with Foynes Port Access Road;
- Junction 2: N69/R521 Junction east of Foynes;
- Junction 3: N69 Junction with local road into Aughinish Alumina Plant (RUSAL);
- Junction 4: N69/R518 Junction west of Askeaton;
- Junction 5: Junction along R518 east of Askeaton;
- Junction 6: N69/R518 Junction east of Askeaton;
- Junction 7: N69/R518 Junction east of Askeaton;
- Junction 8: N69 Junction with staggered crossroads in Kildimo;
- Junction 9: N69/R859 Junction in Mungret;
- Junction 10: N69 Junction with Local Road east of Mungret;
- Junction 11: R859/R510 Quinn's Cross Roundabout at Gouldavoher;
- Junction 12: R526/R510 Raheen Roundabout;

- Junction 13: M20/N20/N21 Interchange at Attyflin;
- Junction 14: N21/R519 Junction west of Adare;
- Junction 15: R523/N21 Junction east of Rathkeale;
- Junction 16: R523/R518 Junction west of Rathkeale;
- Junction 17: N21 slip road junction with R518 South of N21 at Rathkeale;
- Junction 18: N21 slip road junction with R518 North of N21 at Rathkeale;
- Junction 19: N21/R523 Junction east of Reens;
- Junction 20: N21/R523 Junction west of Reens;
- Junction 21: R521/R523 crossroads at Ardagh;
- Junction 22: N21/L1340 Junction on South Quay at Newcastle West;
- Junction 23: N21/R522 Junction on St Mary's Road at Newcastle West;
- Junction 24: N21/L1343 Junction at Newcastle West;
- Junction 25: N21/R520 Junction at Newcastle West;
- Junction 26: R522/R520 Roundabout at Newcastle West; and
- Junction 27: N20/R518 Junction at Newcastle West.

A graphical summary of the AADT presented in Table 2.2, rounded to the nearest 100, is shown below in Figure 2.9 as well as estimated 2014 AADT from the JTC and AADT data from the TII TMUs. The percentage of Heavy Goods Vehicles (HGVs) at each of the locations is also shown.

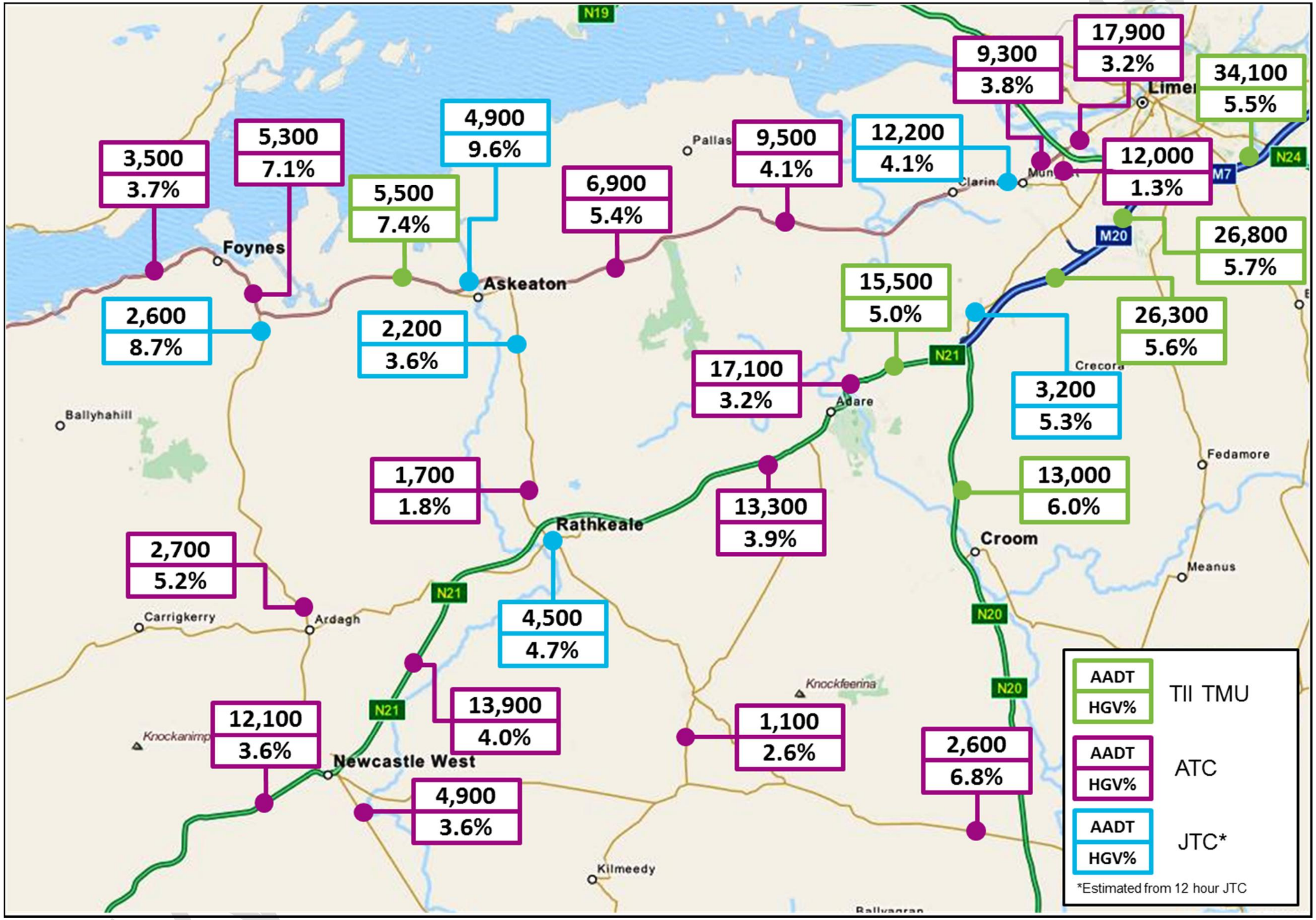


Figure 2.9 – 2014 Estimated AADT & Percentage HGV Summary

2.4.3 Automatic Number Plate Recognition (ANPR) Surveys

In order to ensure a robust representation of current traffic patterns, ANPR surveys were undertaken. ANPR surveys are used to provide Origin-Destination data over a wide area and also provide extensive journey time information. ANPR cameras are placed on the roadside at key locations, capturing vehicle registration plates as they pass and time stamping the registration plate. The data is stored for each unit and the registration is 'tracked' as it passes through different sites. The time stamps allow vehicles which make several prolonged stops to be removed from the data.

By 'tracking' the registration plates ANPR surveys can capture the origin and destination of a given vehicle within a study area. A number of sites were strategically set up throughout the study area to form a closed cordon and data was recorded over a 13 hour period on a typical weekday. The survey data was presented on a 'first seen-last seen' basis, whereby the survey data records the first site and last site the vehicle was seen at. The vehicle's origin and destination within the study area is then considered to be the first and last site it is seen at.

Data was collated at 17 locations within the study area and is shown in detail in Figure 2.1 above. These locations were chosen to ensure a closed cordon was developed to establish traffic pattern information in the area.

The Origin-Destination dataset has been divided into seven sectors as shown in Figure 2.10. This is for the purpose of presenting a high level summary of the data; a more detailed analysis was used in the calibration and validation of the model. The results of the HGV questionnaire and POWSCAR analysis outlined in Sections 2.4.4 and 2.5 respectively were also incorporated into the analysis.

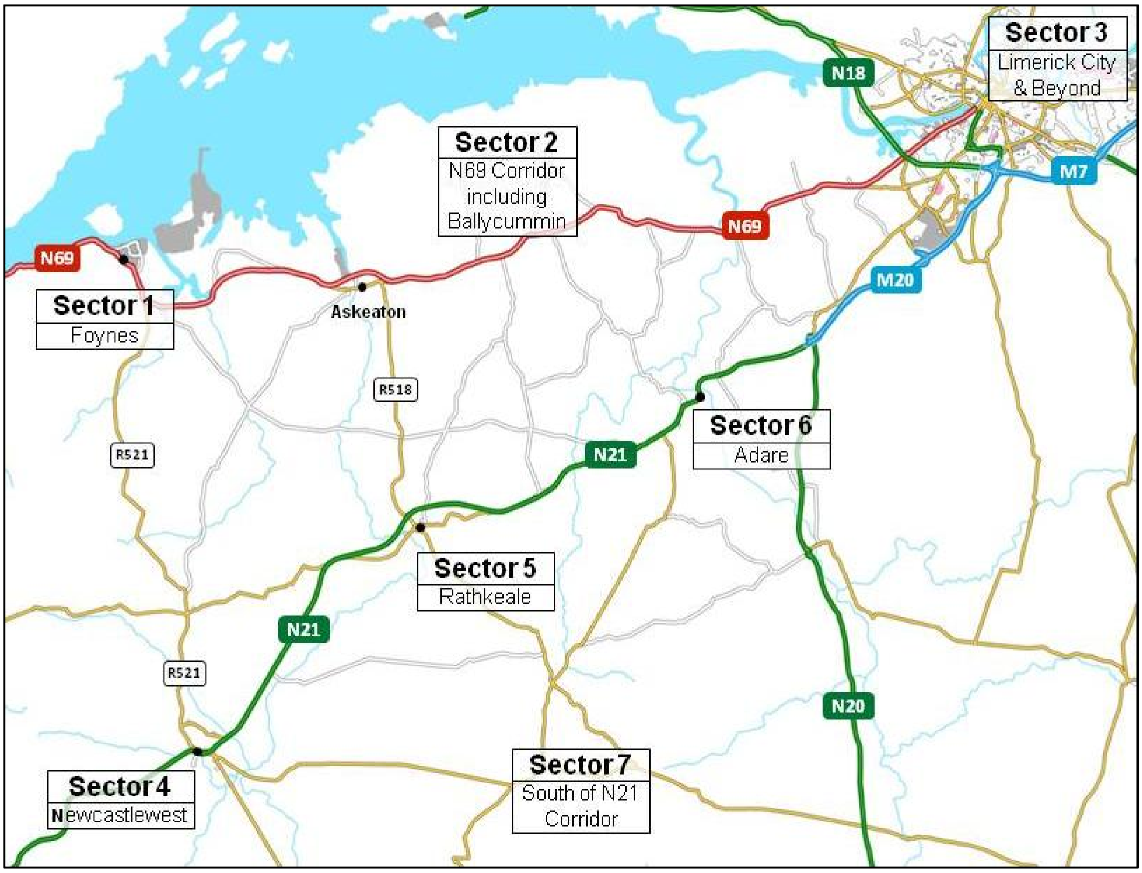


Figure 2.10 – ANPR Sectors

It should be noted that traffic travelling to/from the N18/M7 has been included in Sector 3 traffic, and traffic travelling further southwest along the N21 and R522 past Newcastle West has been included in sector 4. Sector 2 covers the length of the N69 from Foynes to Mungret and includes Ballycummin. The data is presented (expressed as proportions) for AM, IP and PM peak periods for light and heavy vehicles below in Tables 2.3 - 2.8.

The vertical column of row labels represents the sector at which vehicles were first observed within the network. The horizontal row labels represent the sector at which vehicles were last seen. Therefore, the tables outline the Origin of a vehicle (the first time a vehicle is captured within the network) and the Destination (as the last time a vehicles is captured).

Same site flows (i.e. first seen at Site 2 and last seen at Site 2) and vehicles only seen once in the network (i.e. seen at only one site) have all been considered and are included into the data. For example in Table 2.3 for Sector 2, 29% of traffic is considered local traffic as it is not seen at any other ANPR site. Therefore this traffic has an origin and destination between zones within Sector 2.

Table 2.3 - AM Peak Light Vehicle O-D Results

		Destination Sector						
AM LV		1	2	3	4	5	6	7
Origin Sector	1	1%	63%	29%	5%	1%	1%	0%
	2	15%	29%	48%	5%	1%	1%	1%
	3	0%	14%	60%	11%	10%	5%	0%
	4	1%	3%	44%	48%	0%	2%	2%
	5	0%	6%	20%	29%	9%	36%	0%
	6	0%	0%	71%	3%	1%	25%	0%
	7	0%	3%	0%	4%	8%	6%	79%

Table 2.4 - AM Peak Heavy Vehicle O-D Results

		Destination Sector						
AM HV		1	2	3	4	5	6	7
Origin Sector	1	0%	13%	63%	15%	3%	3%	3%
	2	10%	26%	48%	13%	0%	3%	0%
	3	0%	18%	55%	14%	9%	4%	0%
	4	3%	8%	64%	16%	1%	1%	7%
	5	0%	4%	24%	41%	12%	19%	0%
	6	0%	0%	36%	55%	0%	9%	0%
	7	0%	13%	0%	19%	0%	0%	68%

Table 2.5 – Inter Peak Light Vehicle O-D Results

		Destination Sector						
IP LV		1	2	3	4	5	6	7
Origin Sector	1	2%	65%	19%	10%	1%	3%	0%
	2	13%	59%	21%	5%	1%	1%	0%
	3	0%	14%	57%	11%	11%	6%	1%
	4	0%	3%	20%	68%	2%	5%	2%
	5	0%	5%	13%	41%	8%	33%	0%
	6	0%	0%	61%	5%	1%	33%	0%
	7	0%	2%	0%	6%	8%	4%	80%

Table 2.6 – Inter Peak Heavy Vehicle O-D Results

		Destination Sector						
IP HV		1	2	3	4	5	6	7
Origin Sector	1	0%	14%	63%	15%	0%	4%	4%
	2	12%	27%	38%	18%	0%	5%	0%
	3	0%	13%	47%	21%	13%	6%	0%
	4	0%	4%	72%	6%	4%	8%	6%
	5	0%	2%	35%	28%	16%	17%	2%
	6	0%	8%	31%	30%	8%	23%	0%
	7	0%	0%	0%	18%	0%	9%	73%

Table 2.7 - PM Peak Light Vehicle O-D Results

		Destination Sector						
PM LV		1	2	3	4	5	6	7
Origin Sector	1	6%	68%	20%	6%	0%	0%	0%
	2	26%	39%	26%	6%	1%	1%	1%
	3	4%	15%	57%	12%	5%	7%	0%
	4	1%	3%	10%	75%	3%	7%	1%
	5	0%	5%	6%	59%	10%	20%	0%
	6	0%	1%	69%	17%	2%	11%	0%
	7	0%	1%	0%	5%	4%	0%	90%

Table 2.8 - PM Peak Heavy Vehicle O-D Results

		Destination Sector						
PM HV		1	2	3	4	5	6	7
Origin Sector	1	0%	20%	58%	15%	0%	0%	7%
	2	22%	22%	42%	11%	0%	0%	3%
	3	6%	13%	68%	6%	6%	1%	0%
	4	0%	8%	26%	19%	22%	22%	3%
	5	0%	0%	14%	68%	16%	2%	0%
	6	0%	0%	43%	29%	14%	14%	0%
	7	8%	9%	0%	0%	0%	0%	83%

The analysis of the Origin/Destination patterns of traffic as revealed from the ANPR surveys (from the AM and PM peak hours) are summarised in the following sections. The vehicular movements were analysed for both Light Vehicle travel patterns and Heavy Vehicle travel patterns.

2.4.3.1 Light Vehicle Travel Patterns (AM Peak)

During the AM peak hour (08:00 to 09:00) a strong desire line between Sector 1 (Foynes) and Sector 2 (the N69 corridor) was noted. Indeed 63% of traffic originating at Sector 1 has a destination along the N69 corridor. A strong desire line was also noted from Sector 1 to Sector 3 (Limerick City and beyond) with 29% of traffic originating at Sector 1 being last seen in Sector 3. The balance of traffic from Sector 1 was dispersed across the remaining sectors in the study area.

From Sector 2 (the N69 corridor) the strongest desire line was to Sector 3, with 48% of traffic originating in Sector 2 having a destination in Sector 3. After Sector 3 the second highest level of demand was seen for destinations within Sector 2 itself, with 29% of traffic originating in Sector 2 also having a destination in Sector 2 (the N69 corridor).

From Sector 3 (Limerick City and beyond) there was a reasonable connection with Sector 2 (the N69 corridor), with 14% traffic originating in Sector 3 having its destination in Sector 2. From Sector 3 there is also a strong connection with the N21 corridor (Sectors 4, 5 and 6), and indeed 26% of traffic originating in Sector 3 had a destination along the N21 corridor. However the bulk of traffic (60%) originating in Sector 3 remained with the Sector 3 cordon.

From the N21 corridor (Sectors 4, 5 and 6) a strong desire line was noted with Sector 3, particularly from Sector 6 (Adare) which showed 71% of traffic having a destination within Sector 3. A reasonable level of interconnectivity was also noted between Sectors 4 and 5, with 29% of traffic originating in Sector 5 (Rathkeale) having a destination in Sector 4 (Newcastle west).

2.4.3.2 Heavy Vehicle Travel Patterns (AM Peak)

For HGV traffic during the AM peak hour (08:00 to 09:00) a strong desire line between Sector 1 (Foynes) and Sector 3 (Limerick City and beyond) was noted with 63% of traffic originating at Sector 1 having a destination in Sector 3.

Sector 1 also has a strong connection with Sector 2 and Sector 4, with 13% and 15% respectively of traffic originating in Sector 1 having a destination in these Sectors. Sector 4 has a strong connection with Sector 3, with 64% of traffic originating in Sector 4 having a destination in Sector 3.

A strong desire line between Sector 6 (Adare) and Sector 3 (Limerick City) and Sector 4 (Newcastle west) was also revealed in the OD patterns emphasising the strategic importance of the N21 corridor.

A strong desire line was also noted from Sector 3 to Sectors 2 and 4 (the N69 corridor and Newcastle west) with 18% and 14% respectively of HGV traffic originating in Sector 3 having a destination in these sectors during the AM peak hours.

2.4.3.3 Light Vehicle Travel Patterns (PM Peak)

During the PM peak hour (17:00 to 18:00) a strong desire line between Sector 1 (Foynes) and Sector 2 (the N69 corridor) was again noted. Of the traffic originating in Sector 1, 68% had a destination along the N69 Corridor (Sector 2) with 20% having a destination in Sector 3 (Limerick City and beyond). The remaining traffic from Sector 1 was dispersed across the remaining sectors in the study area.

From Sector 2 (the N69 corridor), the strongest desire line during the PM peak hour was to Sectors 1 and 3. From Sector 3 (Limerick City and beyond), there was a reasonable connection with Sector 2 (the N69 corridor), 15% of traffic, and Sector 4, 12% of traffic. Again however the bulk of traffic (57%) originating in Sector 3 remained within the Sector 3 cordon.

From the N21 corridor (Sectors 4, 5 and 6) a strong desire line was noted with Sector 4 and Sector 3. Indeed the strongest desire line noted in the PM peak hours is between Sector 6 and Sector 3, with 69% of traffic first seen at Adare having a destination in Sector 3 (Limerick City and beyond).

2.4.3.4 Heavy Vehicle Travel Patterns (PM Peak)

For HGV traffic during the PM peak hour (17:00 to 18:00) a strong desire line between Sector 1 (Foynes) and Sector 3 (Limerick City and beyond) was noted with 58% of traffic originating at Sector 1 having a destination in Sector 3.

Sector 1 also has a strong connection with Sector 2 and Sector 4, with 20% and 15% respectively of traffic of traffic originating in Sector 1 having a destination in these sectors.

The connection between Sector 4 and Sector 3 is less notable in the PM peak hours, with 26% of HGV traffic originating in Sector 4 having a destination in Sector 3. More HGV traffic from Sector 4 was noted having a destination within Sector 4 itself (19% of HGV traffic from Sector 4) and in Sector 5 (22% of HGV traffic from Sector 4) during the PM peak hours.

A strong desire line for HGV Traffic between Sector 6 (Adare) and Sector 3 (Limerick City) and Sector 4 (Newcastle west) was again also revealed in the PM peak OD patterns emphasising the strategic importance of the N21 corridor.

A strong desire line was also noted from Sector 3 to Sector 2 (the N69 corridor) with 13% of HGV traffic originating in Sector 3 having a destination in Sector 2 sectors during the PM peak hours. Less HGV traffic is attracted to the N21 corridor destinations during the PM peak hours.

2.4.4 Foynes Port HGV Questionnaire

In addition to the ANPR surveys a questionnaire was given to HGV drivers in Foynes Port itself to form a better understanding of the Origin-Destination movements of just HGVs using Foynes Port. The information was collected on Thursday 22nd of May between 07:00 & 19:00 and contained questions relating to data on the following:

- Origin & Destination;
- Weekly Frequency of Journey;
- Goods carried;
- Route to/from the Shannon Foynes Port;
- Vehicle Type; and
- Journey Purpose.

Of the 109 HGV drivers interviewed, 59 stated that they began their journey (origin) within County Limerick. The next highest origin recorded was within County Cork with 12, followed by County Kerry with 9. Overall the most popular destination was Limerick County with 54 trips, followed by Cork with 16 and Kerry with 10.

Within Limerick County there were 47 internal trips, of those trips 62% were made 4 times or more per week and a further 17% made 1-3 times per week. A total of 62% of these trips were travelling to and from Limerick City with more than half specifying a destination on Dock Road.

Of the 109 trips recorded, over 90% were using the N69 with the remaining trips using the N21 via Rathkeale or Newcastle West to travel to destinations in Counties Limerick, Cork and Kerry.

Both the ANPR surveys and the questionnaire showed a strong desire line between Foynes and the Dock Road junction with the N18. It should be noted however that the ANPR includes HGVs generated along the N69 west of Foynes and any HGV traffic from Foynes village itself.

2.4.5 Journey Times

Journey time information was also collated from the ANPR data in order to ensure that the travel time on existing roads was properly reflected within the base models, thereby ensuring that a robust assignment could be undertaken. A cap was placed on the recorded journey times from the ANPR data in order to ensure trips with short stops were excluded. Analysis was also undertaken to remove statistical outliers from the data. The journey times represent an average of journey time surveys captured on Tuesday 20th of May 2014.

Traffic delays and congestion through the village of Adare are regularly reported. In order to capture the delay through Adare across an extended period (2 weeks), additional journey time surveys were undertaken in October 2015. These surveys were undertaken using Bluetooth tracking devices which capture the Bluetooth signal emanating from mobile phones and car kits in vehicles travelling along a selected route.

The ANPR and Bluetooth data was used to validate the base year models against a total of 12 journey time sections which are illustrated below in Figures 2.11 and 2.12. The selected route along the N21 through Adare was from the N21/L1424 roundabout (Lantern Lodge) east of Adare to the N21/R519 junction (Murphy's Cross) west of Adare.

Details of the resultant journey times and average speeds for the AM, Inter and PM Peak periods are presented in Table 2.9.

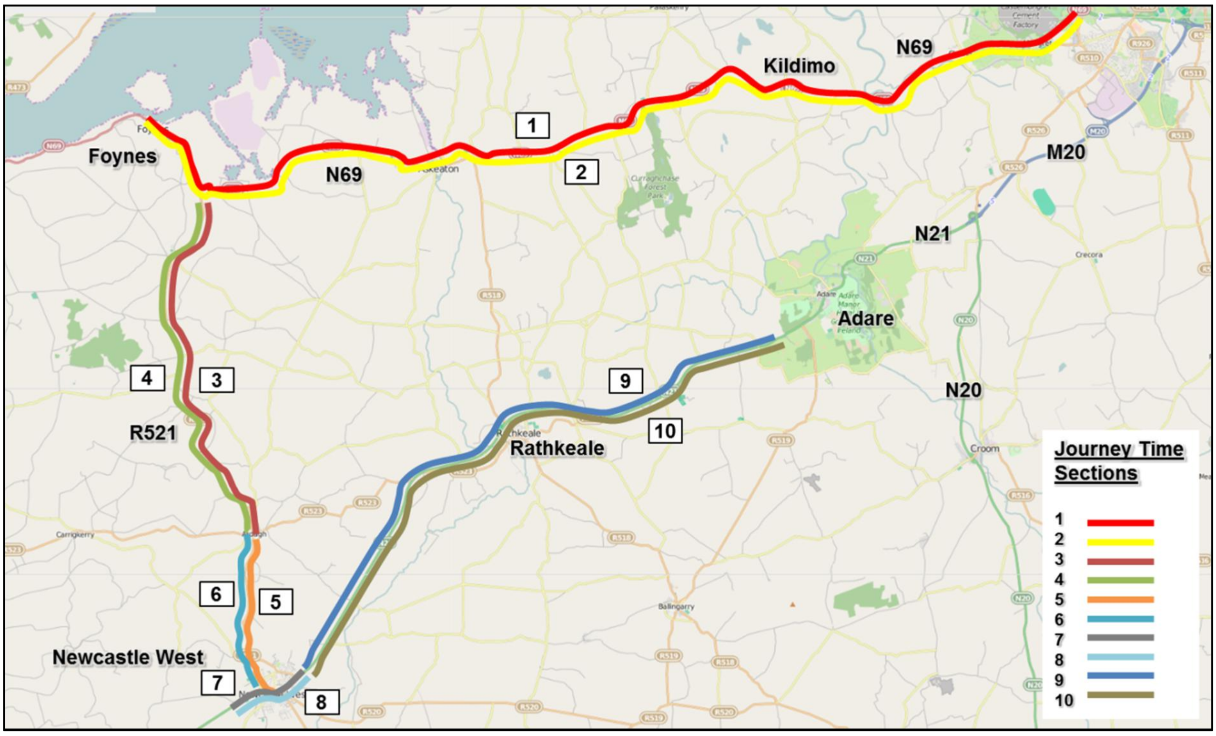


Figure 2.11 – Journey Time Sections (ANPR)

Figure 2.12 – Adare Journey Time Sections (Bluetooth)

Table 2.9 - Average Journey Times & Speeds during Peak Hours

Route No.	Section	Direction	Distance (km)	Average Journey Times (min:sec)			Average Speeds (kph)		
				AM	IP	PM	AM	IP	PM
1	N69 Foynes to Limerick	EB	32.3						
2		WB	32.3						
3	R521 Foynes to Ardagh	SB	13.5						
4		NB	13.5						
5	R521 Ardagh to Newcastle West	SB	7.4						
6		NB	7.4						
7	N21 through Newcastle West Town	EB	2.1						
8		WB	2.1						
9	N21 East of Newcastle West to West of Adare	EB	20.0						
10		WB	20.0						
11	N21 Through Adare Village	EB	2.5						
12		WB	2.5						

2.5 POWSCAR Analysis

As part of the Irish Census (2011), the CSO produced the Place of Work, School or College Census of Anonymised Records (POWSCAR) database. The POWSCAR dataset provides detailed data on the journey to work/education at Electoral Division (ED) level, this data includes:

- Origin (residence) and destination (place of work/education);
- Time of departure; and
- Travel mode.

In order to further understand the commuting patterns within the study area the journey to work and education trip patterns for a total of 41 Electoral Divisions (ED) located along the N69 and N21 corridors were assessed. Figure 2.12 shows the EDs which were included in the assessment.

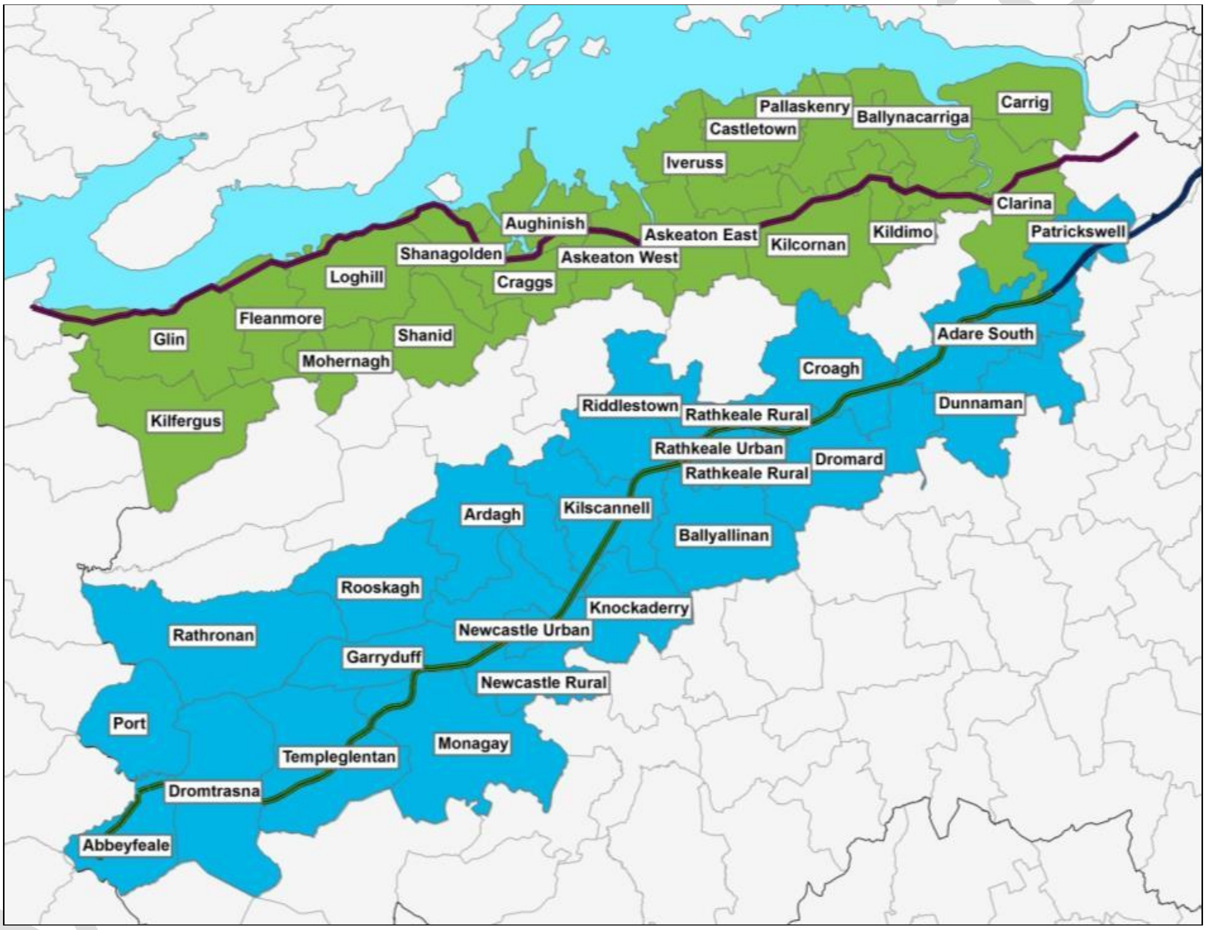


Figure 2.12 – Electoral Divisions for POWSCAR Analysis

It was found that on average 81% of all journeys to work and education trips were made by a private mode either as driver or passenger. The remaining 19% was split into public transport (10%) and 'green' modes (9%) such as walking or cycling.

Of the trips made by a private mode, the vast majority had a destination either within Limerick County or City. Table 2.10 summarises the top five county destinations for all private mode trips for EDs along both the N69 and N21 Corridors.

Table 2.10 – POWSCAR Top Five County Destinations

N69 Top Destination Counties		N21 Top Destination Counties	
County	**No. of Trips**	**County**	**No. of Trips**
Limerick	4135	Limerick	7239
Kerry	127	Kerry	403
Clare	112	Cork	210
Cork	53	Clare	112
North Tipperary	13	Dublin	31

Of the 4,135 trips originating along the N69 corridor with a destination in Limerick County the top five most popular destinations were located along the N69 itself or within Limerick City. A similar situation was found along the N21.

Table 2.11 summarises the most popular destinations within Limerick County by ED; the EDs in Limerick City have been combined to form one destination.

Table 2.11 – POWSCAR Top Five ED Destinations

N69 Top Destination EDs		N21 Top Destination EDs	
County	**No. of Trips**	**County**	**No. of Trips**
Limerick City	858	Newcastle West Urban	1645
Ballycummin	531	Limerick City	875
Askeaton West	293	Abbeyfeale	720
Pallaskenry	286	Ballycummin	614
Askeaton East	263	Rathkeale Urban	485

The most popular destination along the N21 for trips originating along the N69 is Newcastle West Urban and for trips originating along the N21 the most popular N69 destination is Askeaton West. However overall there is limited interaction between the two corridors.

2.6 GeoDirectory Data

The GeoDirectory is a database jointly established by An Post and Ordnance Survey Ireland. The dataset is a complete address database of all buildings in Ireland, with each building classified as either commercial, residential or both within the dataset. The data for the study area was utilised to help inform the disaggregation of NTM zones and the placement of zone connectors. Figure 2.13 below shows the GeoDirectory units by type within the study area.

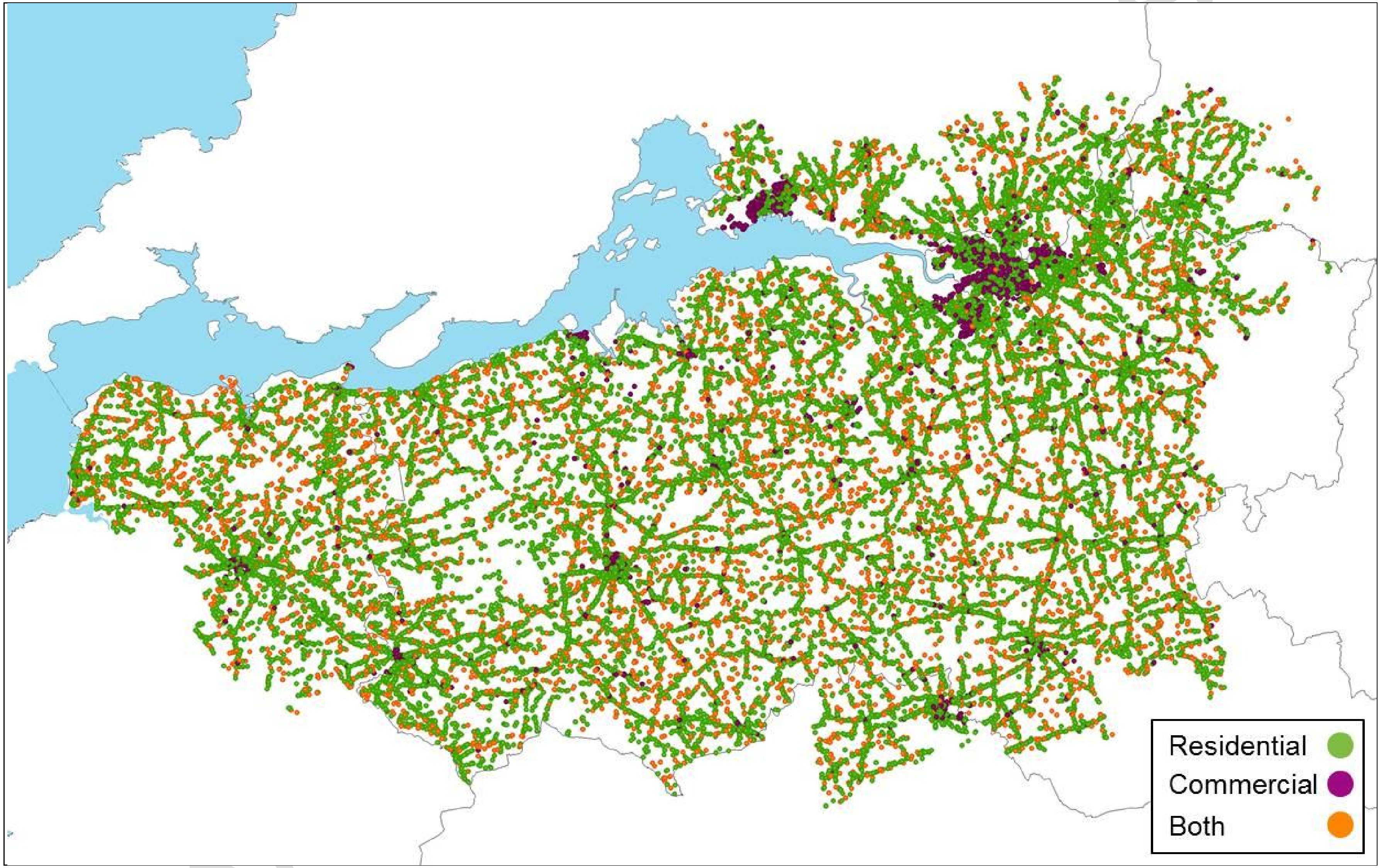
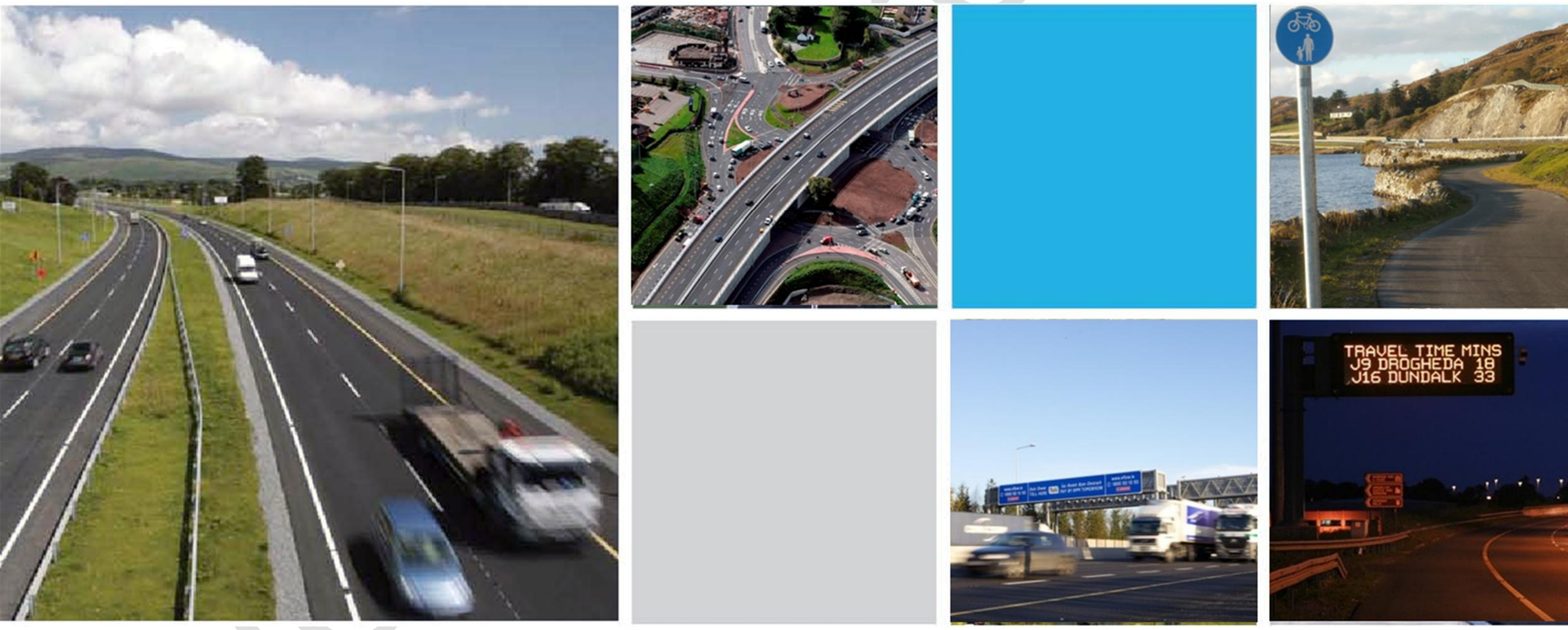


Figure 2.13 – GeoDirectory Points within Traffic Model

Chapter 3
Model Development



3 Model Development

3.1 Overview

This section of the report describes the development, calibration and validation of the 2014 Base Year Local Area Models (LAMs) which have been developed for the following time periods:

- AM Peak Hour (08:00 – 09:00);
- Average Inter Peak Hour (12:00 – 14:00); and
- PM Peak Hour (17:00 – 18:00).

These peak hours were defined following an assessment of the Automatic Traffic Counters (ATCs) within the study area. Traffic flows at each of the ATCs within the study area was aggregated together to reveal the following profile.

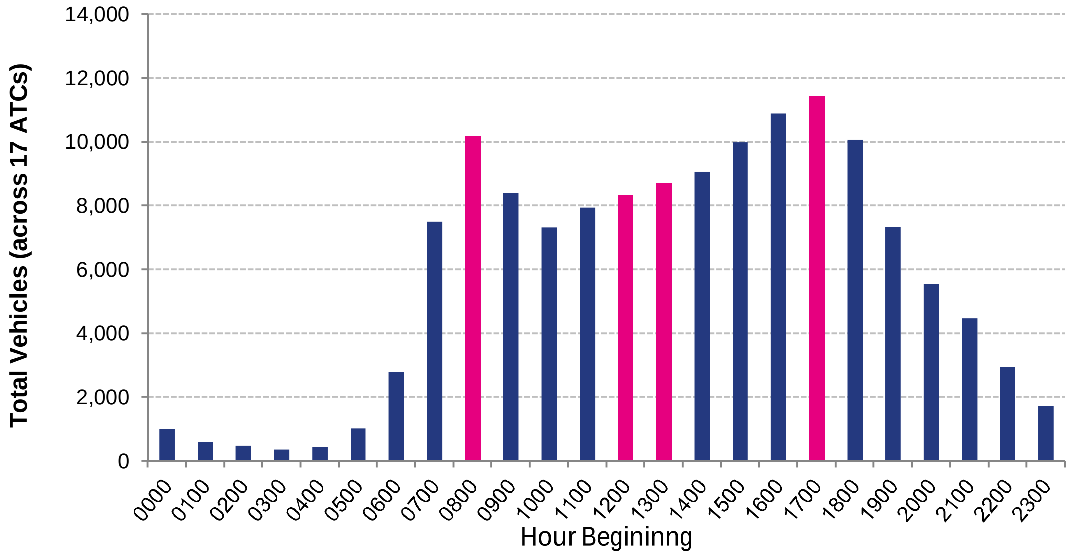


Figure 3.1 – Peak Hour Selection

3.2 Definition of Model Study Area

In order to identify the extent of the study area for the LAM a high level assessment was undertaken using the National Traffic Model (NTM). An indicative route alignment was coded into the future NTM (2050 High Growth) and assessed to establish the extents of the existing road network impacted upon.

The indicative route used in the assessment was based on upgrading the N69 corridor between the N18 Dock Road junction and Foynes. This option was used as it would likely have the most impact on the wider network.

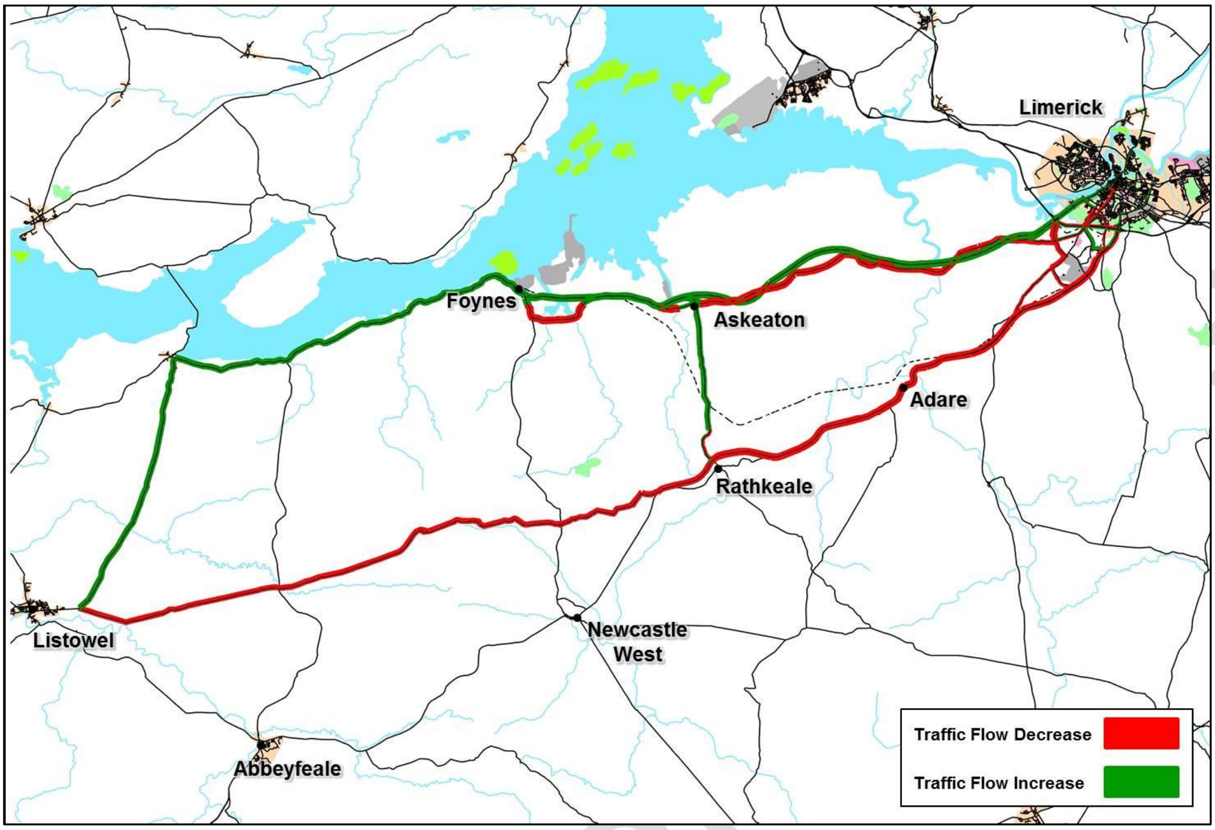


Figure 3.2 – Defining LAM Study Area (Test in 2050 NTM)

As can be seen in Figure 3.2 above, it is anticipated that an upgrade of the N69 will impact upon the M20/N21 corridor to the south. Therefore, it was considered necessary to include Listowel and Abbeyfeale in the study area in order to accurately model the transfer of traffic to any potential route options. This study area was subsequently cordoned out of the NTM Model.

3.3 Network Development

As mentioned previously, the NTM was used as a starting point for developing the 2014 LAMs. Having identified the extent of the study area, the subsequent traffic model area of influence was 'cordoned' out of the 2013 NTM Base model and is shown in Figure 3.3 below.

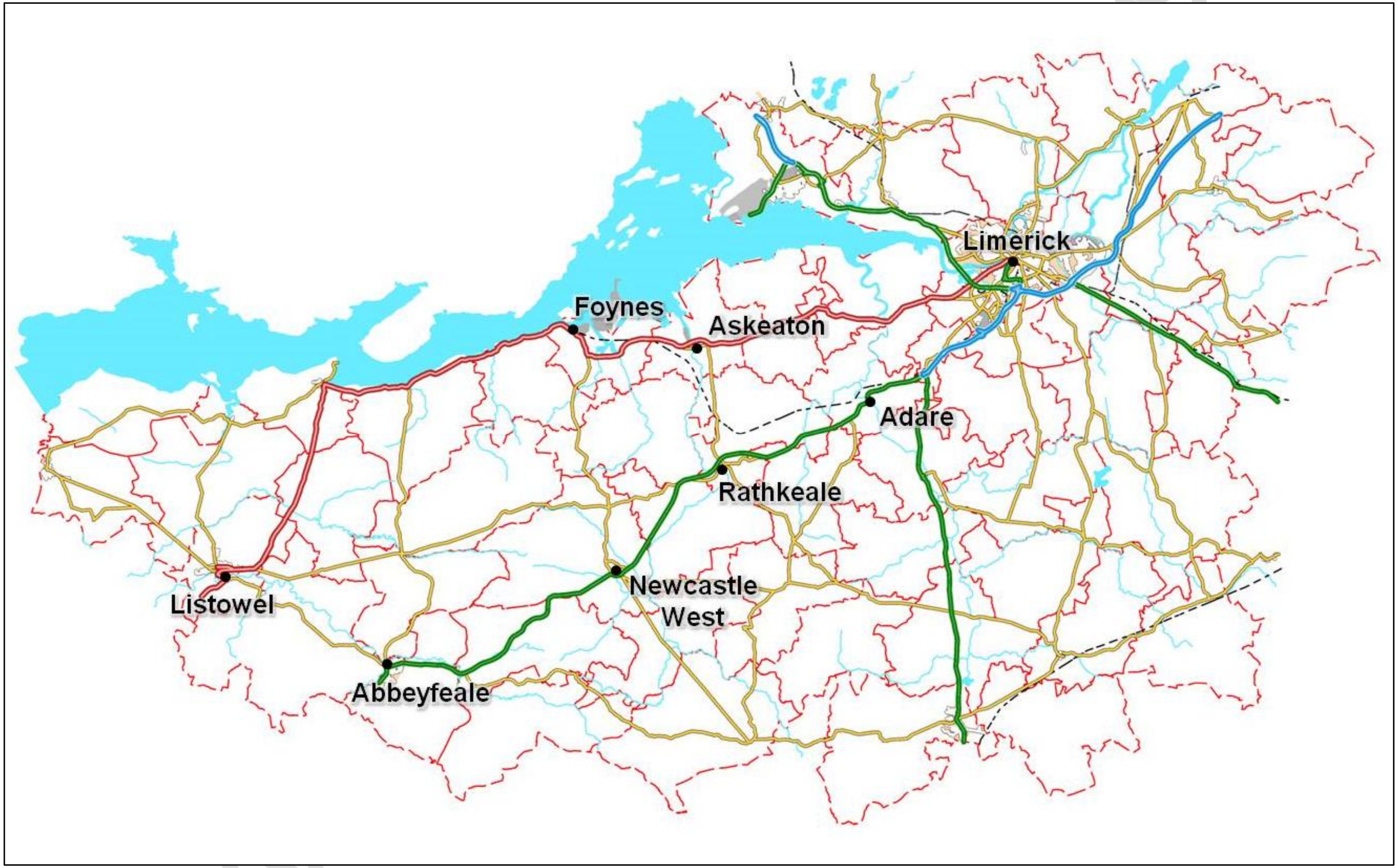


Figure 3.3 – LAM Study Area Cordoned from NTM

3.2.1 Refinement of LAM Road Network

Once the study area had been cordoned from the NTM, the road network was further refined to reflect the 2014 road network conditions (i.e. inclusion of further detail such as refined road capacity, banned turns junction types etc.). This information was collected through site observations and aerial mapping.

A significant number of additional local roads which are not included in the 2013 NTM modelled network were also included in the 2014 LAM as they could be potentially impacted upon by a proposed scheme. The road network in the study area is shown before and after the network refinement in Figures 3.4 & 3.5 respectively.

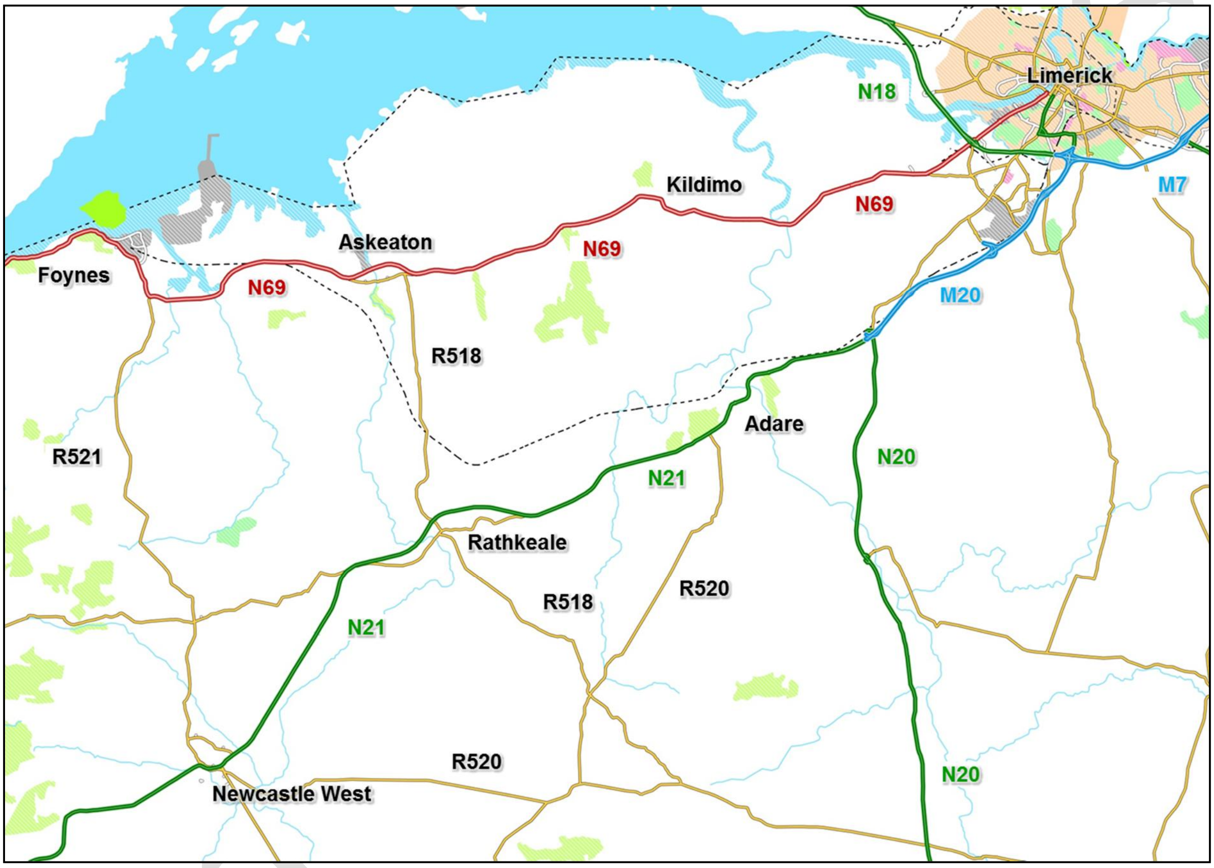


Figure 3.4 – NTM Road Network

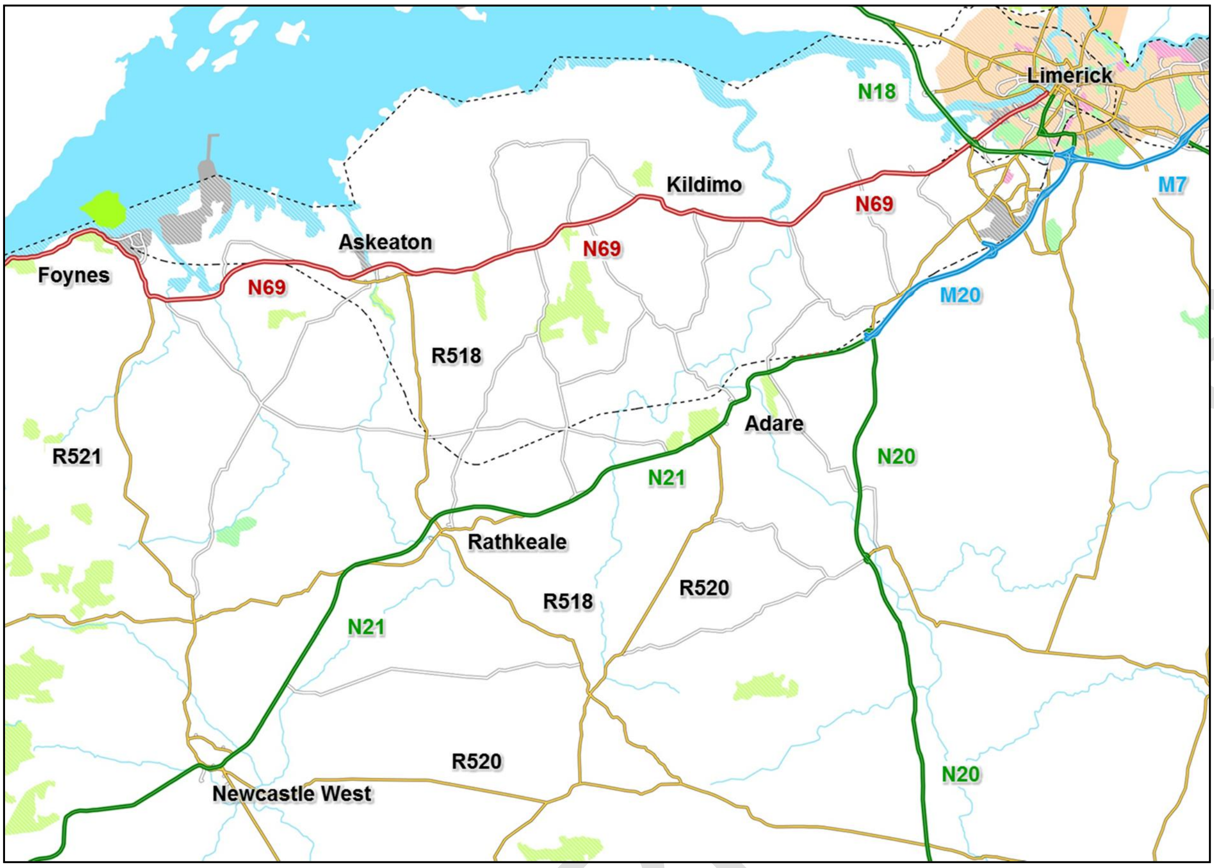


Figure 3.5 - Refined LAM Road Network

3.2.2 Refinement of LAM Zoning System

In order to obtain suitable detail within the LAM, a more detailed zoning system than used in the NTM was required. The NTM zoning system is shown in Figure 3.3 above. The zoning system in the NTM is based on the aggregation of Electoral Divisions (ED's), which is suitable for most zones in the LAM apart from urban areas and excessively large zones. Examples of the urban areas that required further refinement were Foynes, Askeaton, Raheen, Rathkeale, Newcastle West, Adare and Limerick.

The towns & villages mentioned above were each represented by a single zone, in the original NTM zoning system with the exception of Limerick. In order to obtain greater detail and to reflect existing traffic flows and traffic patterns in these key areas, these zones were disaggregated into several sub-zones. The vast majority of zones were split based on ED boundaries where possible.

This zone splitting process was undertaken based on the An Post GeoDirectory database as described in Section 2.6. The trips from the split zones were allocated to the new sub zones based on the proportion of residential and commercial addresses located within the sub zone. Figure 3.6 below highlights in blue the zones which were split.

The original model cordoned from the NTM contained 82 zones, which included 22 external zones (these zones feed traffic into and out of the LAM). The disaggregation of the various zones noted above produced a model containing a total of 110 zones, including 22 external zones.

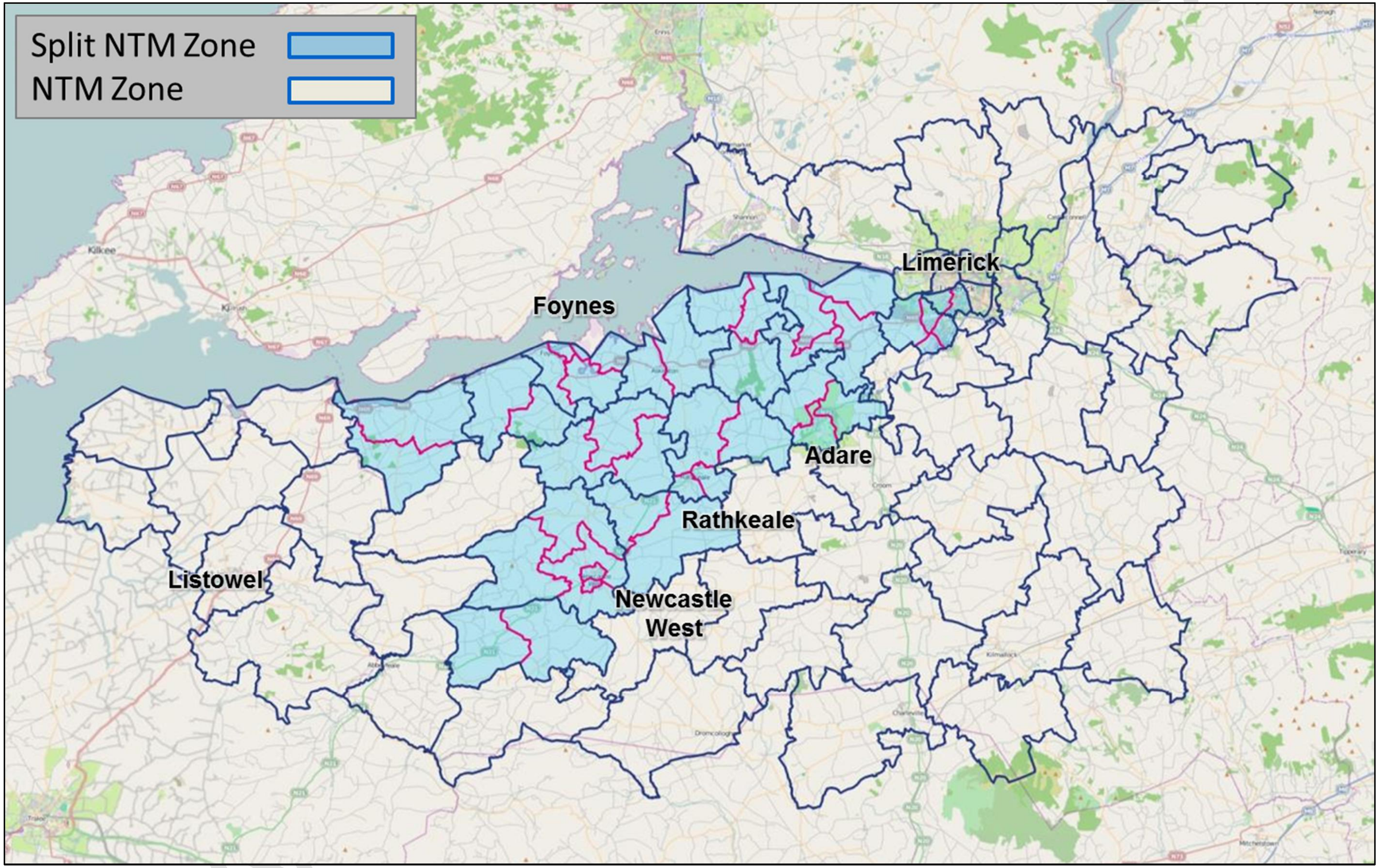


Figure 3.6 - Refined Foynes to Limerick LAM Zoning Structure

3.2.3 Link Travel Times

The total travel time of a trip from origin to destination is a function of both link travel time and junction delay. Link travel times in the network are determined by a predefined Volume-Delay Function (VDF) in VISUM, which describes the relationship between current traffic volumes (q) and the capacity of the link (q_{max}). The VDF used in this model is based on the Bureau of Public Roads 3 (BPR 3) function:

$$t_{cur} = \begin{cases} t0 * (1 + a * sat^{b}) & \text{, if } sat \leq sat_{crit} \\ t0 * (1 + a * sat^{b}) + (q - q_{max}) * d & \text{, if } sat > sat_{crit} \end{cases}$$

where: *t0 = free flow travel time (based on link length (km) and free flow speed (v0))*
$sat = q/(q_{max} * c)$

The VDF function is globally applied to all links in the network as the capacity (q) and free flow speed (v0) of each link (input during network development) feed directly into the VDF. A VDF is applied to each link classification in the model based on adjusted a, b, c and d parameter values which reflect the quality of that road type.

3.4 Matrix Development

The following time periods were required for the LAM:

- Morning peak from 08:00 – 09:00 (AM Peak Hour);
- Average hour in the inter peak period from 12:00 - 14:00 (Inter Peak Period); and
- Evening Peak from 17:00 – 18:00 (PM Peak Hour)

'Prior' AM Peak and Inter Peak hour Light and Heavy vehicle matrices were extracted from the cordoned 2013 NTM. The matrices were disaggregated (split) to provide a more refined LAM zoning system as discussed in Section 3.2.2 above. The process of zone splitting was undertaken using VISUM, whereby origin and destination trip ends were allocated to the sub-zones based on An Post GeoDirectory information whilst maintaining the equivalent distribution of the larger zones.

The resultant 'Prior' matrices were then adjusted during the calibration process using matrix estimation methods to reflect 2014 demand.

As there is no PM Peak Hour NTM, an alternative approach to generate the PM Peak Hour 'Prior' matrices was adopted. The calibrated AM Peak Hour matrices were transposed to give a 'Prior' PM matrix. Each of these matrices were then modified during the calibration process using the 2014 traffic survey data ascertained for each peak, using the select link analysis tool in VISUM.

3.5 Assignment Model

The assignment model applies the demand for travel, represented by the trip matrices, to the supply, in the form of the road network. The 'generalised cost' of a journey, represented by a combination of time, distance and tolls is compared in a route choice algorithm, and a stable output produced, where ideally, all possible routes between an origin and destination have the same 'cost'. Generalised cost is computed as follows:

- Generalised Cost = Value of Time * Time + Vehicle Operating Cost * Distance + Toll[5]

The economic parameters used in the LAM are outlined in Table 3.1. These are fully compliant with parameters set out in the Project Appraisal Guidelines.

Table 3.1 - Generalised Cost Economic Parameters (2014)

Peak Hour	User Class	Value of Time (VoT)*		Vehicle Operating Cost (VOC)	
		Cents/sec	*€/hr*	*Cents/metre*	*€/km*
AM and PM	Light	0.5393	19.41	0.0101	0.101
	Heavy	0.9243	33.27	0.0382	0.382
Inter	Light	0.5272	18.98	0.0101	0.101
	Heavy	0.9538	34.33	0.0370	0.370

**Average 2014 VoT for Working, Commuting & Other Trip Purposes*

For the purpose of the assignment in the VISUM software, a scalar of 1000 is applied to the VoT, VOC and Tolls. Tolls are included in the model in cents.

3.5.1 Assignment Algorithm

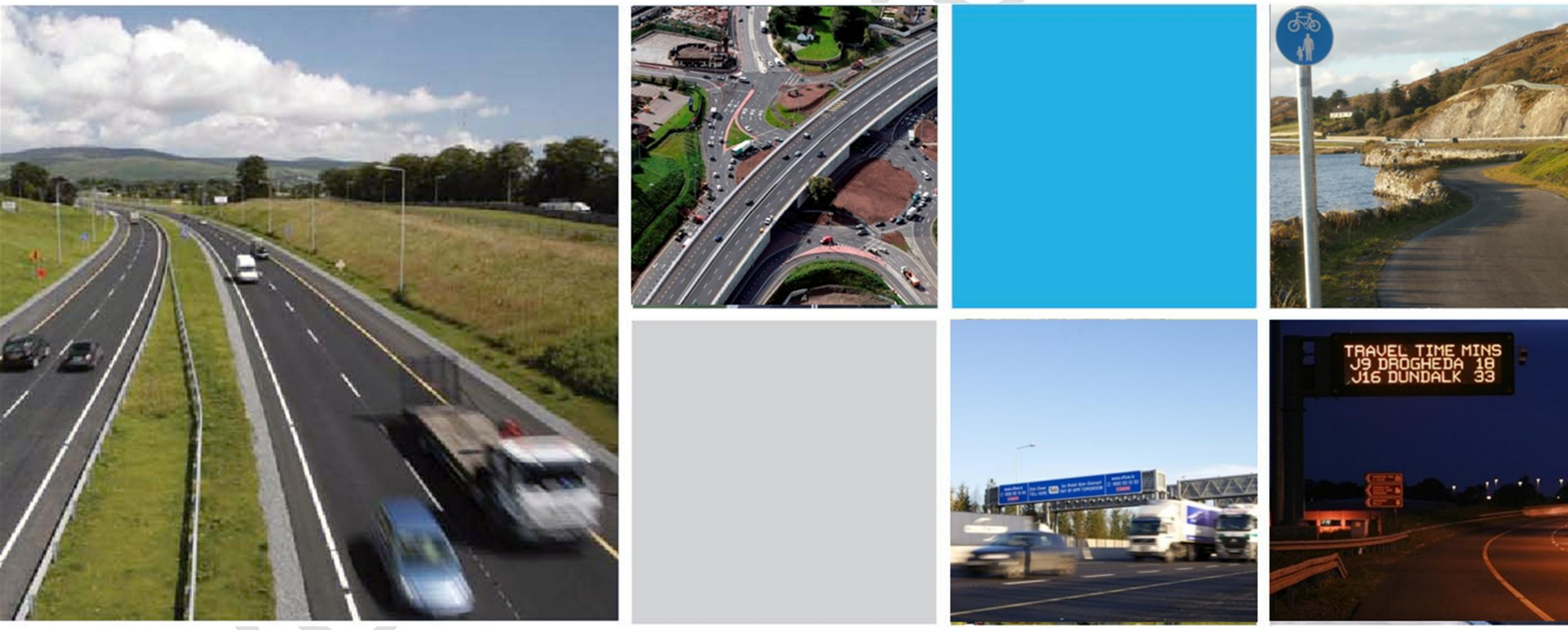
The Route Choice Algorithm selected is based on Equilibrium Lohse. This assignment method models the learning process of road users using the network. The first iteration step is an 'all or nothing' assignment, which means that all trips are assigned onto the lowest impedance route (route with the lowest generalised cost) of the unloaded network. No congestion or delay is taken into account in the route choice for each trip.

In each subsequent iteration step, the new lowest impedance route for each Origin-Destination pair is found. Drivers make use of information gained during their previous trips for the new route search and all known 'shortest' routes are searched for in an iterative process. For the route search the impedance is deduced from the impedance of the current volume and the estimated impedance from the previous iteration step. In other words, the route search estimates delay based on impedance in previous iteration and uses this to inform the new route choice.

The assignment terminates when a stable solution is calculated and user equilibrium is reached. When equilibrium conditions have been reached, no user can further reduce the impedance of their trip by switching route.

[5] The toll travel costs generated by the model refer to the existing N18 Limerick Tunnel toll which is included in the LAM. There are no plans to introduce any additional tolls at this stage.

Chapter 4
Model Calibration



4 Model Calibration

4.1 Introduction

Following the development of the base year models, the process of calibrating and validating the models was undertaken.

4.2 Calibration

The purpose of model calibration is to ensure that the model assignments reflect the existing travel situation. Calibration is an iterative process whereby the model is continually revised to ensure that the most accurate replication of the base year conditions is represented.

4.2.1 Matrix Estimation

Matrix Estimation (ME) is the process in which the number of trips assigned along a model link is adjusted to match an observed total. ME can be undertaken manually through flow bundle analysis or through the "TFlow Fuzzy" matrix estimation tool provided in VISUM. "TFlow Fuzzy" is designed to automatically adjust trip matrices to match modelled volumes to observed volumes along multiple links or turns.

The LAMs were calibrated utilising flow bundle analysis as it allows greater control over the calibration process than "TFlow Fuzzy". Flow bundle matrices were extracted, examined and subsequently adjusted to match observed flows up and downstream of the point at which the flow bundle was taken.

4.2.2 Calibration Criteria

The model calibration process has been undertaken based on the requirements of the NRA PAG *Unit 5.2: Construction of Traffic Models* and with reference to the calibration criteria outlined in Table 5.2.2 of that document. The PAG specify the acceptable values for modelled and observed flow comparisons and suggests how calibration should relate to the magnitude of the values being compared. A summary of these targets is shown in Table 4.1 below.

Table 4.1 - Model Calibration Criteria: Individual Flows

Class Test	Criteria and Measure *Assigned Hourly Flows (e.g. links or turning movements) vs. Observed Flows:*	Guideline
1	Individual flows within 100 vph for flows <700 vph	> 85% of cases
2	Individual flows within 15% for flows 700 – 2700 vph	
3	Individual flows within 400 vph for flows > 2700 vph	

The standard method used to compare modelled values against observations on a link involves the calculation of the Geoff E. Havers (GEH) statistic (Chi-squared statistic), incorporating both relative and absolute errors. The GEH statistic is a measure of comparability that takes account of not only the difference between the observed and modelled flows, but also the significance of this difference with respect to the size of the observed flow. The GEH statistic is calculated as follows:

$$GEH = \sqrt{\frac{(M - 0)^2}{0.5(M + 0)}}$$

Where M = Modelled Flow and O = Observed Flow.

Guidance in the PAG sets out the following criteria in relation to GEH values:

Table 4.2 - Model Calibration Criteria: GEH Values

Criteria and Measures		Requirement
GEH statistic	Individual flows: GEH < 5	> 85% of cases

4.2.2 Calibration Results

A total of 58 links flows and 92 turning flows were used in the calibration process, the results of which are summarised in Tables 4.3-4.6. The results in full can be found in Appendix B of this report. Note: In some instances turning flows of zero were observed for individual movements. These movements are not reported in the tables in Appendix B.

Table 4.3 - Link Calibration Results: Individual Flows

% of Calibration Sites Meeting Individual Flow Criteria				
Time Period	**Link Flows**			**Required**
	Total Traffic	**Lights**	**Heavies**	
AM Peak				>85%
Inter Peak				>85%
PM Peak				>85%

Table 4.4 - Link Calibration Results: GEH Values

% of Calibration Sites with GEH < 5				
Time Period	**Link Flows**			**Required**
	Total Traffic	**Lights**	**Heavies**	
AM Peak				>85%
Inter Peak				>85%
PM Peak				>85%

Table 4.5 - Turn Calibration Results: Individual Flows

% of Calibration Sites Meeting Individual Flow Criteria				
Time Period	**Turning Flow**			**Required**
	Total Traffic	**Lights**	**Heavies**	
AM Peak				>85%
Inter Peak				>85%
PM Peak				>85%

Table 4.6 - Turn Calibration Results: GEH Values

% of Calibration Sites with GEH < 5				
Time Period	**Turning Flow**			**Required**
	Total Traffic	**Lights**	**Heavies**	
AM Peak				>85%
Inter Peak				>85%
PM Peak				>85%

The comparison of modelled and observed flows demonstrates that the AM, Inter and PM Peak period models exceeded the flow criteria for all user classes. Likewise, the GEH results show that the AM Peak, Inter Peak and PM Peak periods models also exceed the criteria for all user classes. The results therefore confirm that the models have been calibrated to a standard compliant with the PAG criteria for all user classes and all time periods.

4.2.3 Trip Length Distribution Check

The output trip matrix from the matrix estimation process must be checked to ensure that the process has not significantly altered trip distribution. It is possible that in seeking to increase the flow along a particular link, the matrix estimation process might add significant numbers of trips between the two zones at either end of the link in question. This could have the effect of creating excessive short distance trips while longer distance trips are unaffected, which in turn would push the trip distance distribution toward short trips.

To check the output of the matrix estimation process, the Trip Length Distributions (TLD) from before (pre) and after (post) matrix estimation are compared. The TLD for each peak hour for Light Vehicles are represented as histograms in Figure 4.1 to 4.3. The TLD figures illustrate that that the TLD has not been significantly altered as a result of matrix estimation.

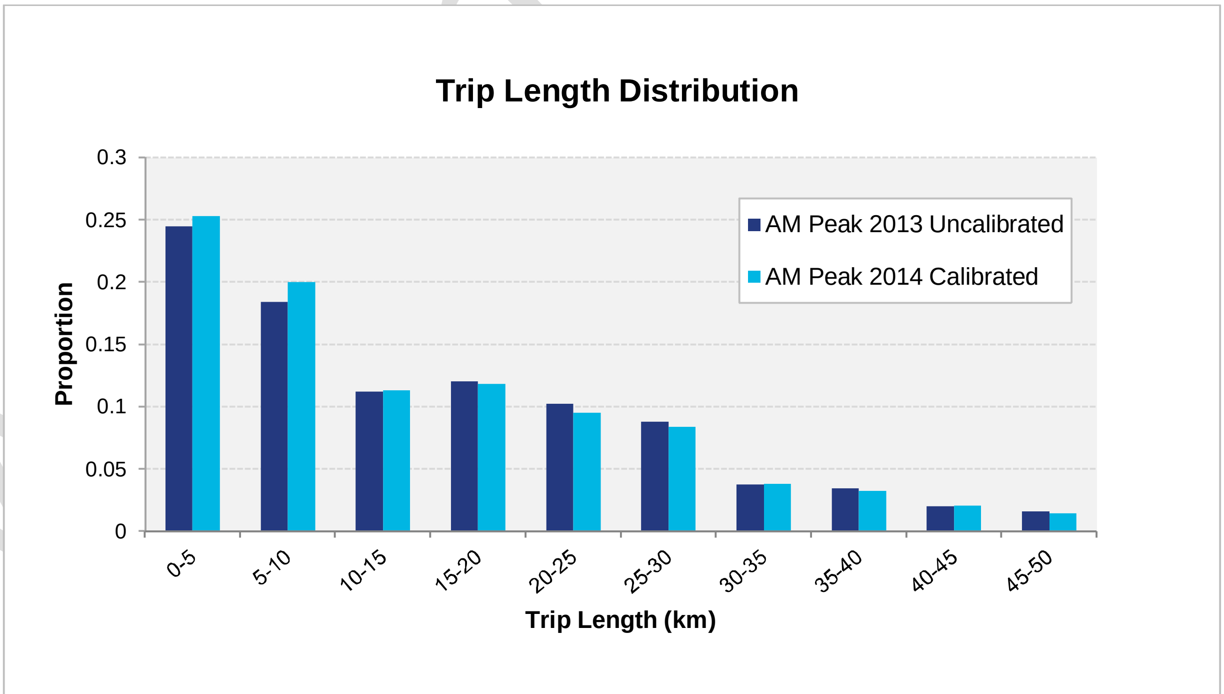


Figure 4.1 - TLD AM Peak Hour (LV)

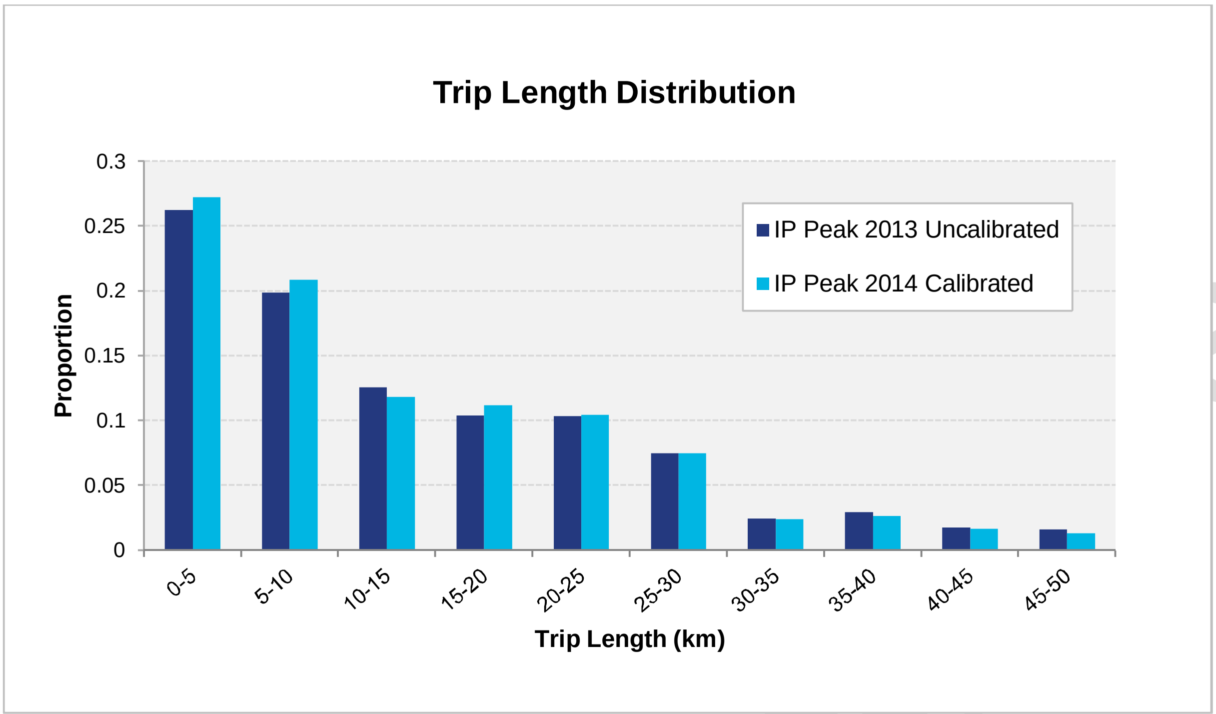


Figure 4.2 - TLD Inter Peak Hour (LV)

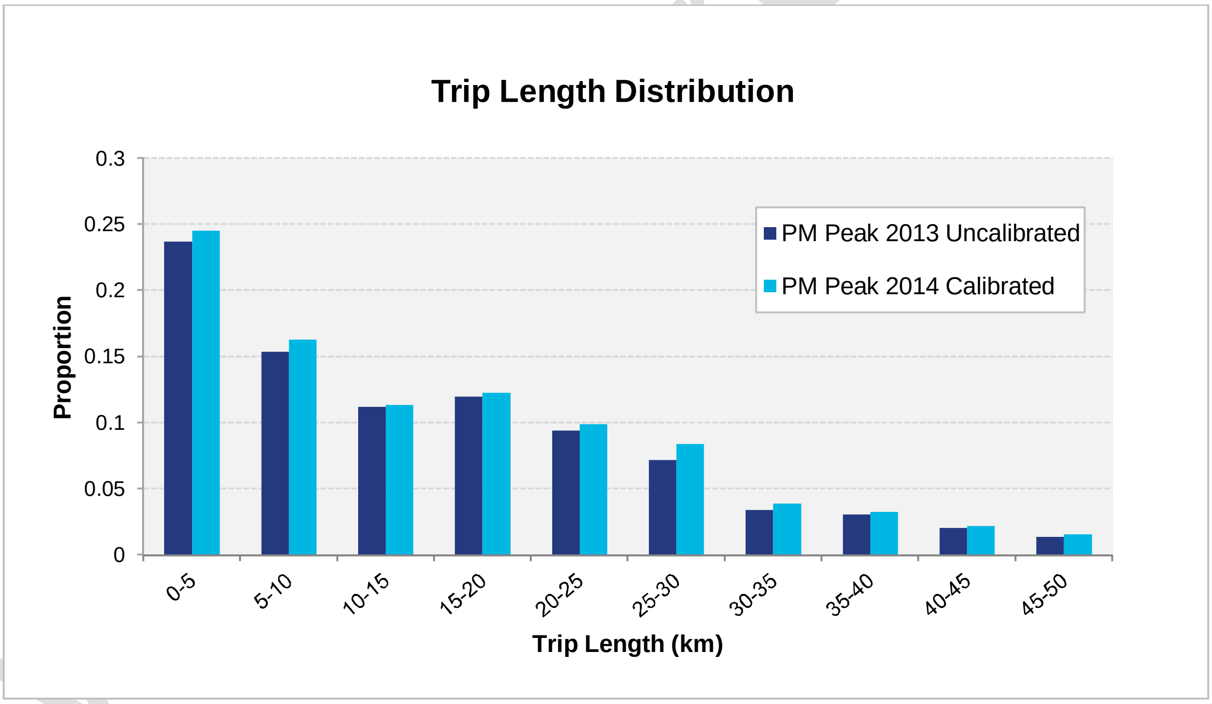


Figure 4.3 - TLD PM Peak Hour (LV)

4.3 Model Validation

Model validation comprises the comparison of calibrated flows against an independent dataset which was not used as part of the calibration process. Validation checks included:

- Additional link flows;
- Turning flow validation; and
- Overall model validation (e.g. journey times)

The model was also checked against the O-D data collected as part of the ANPR though this is not required under PAG guidance.

4.3.1 Validation of Link Flows

A total of 28 observed and modelled link flows were compared at a number of validation sites which were kept exclusive of the calibration data, in accordance with the criteria above. The permissible difference was calculated for each value (based on the observed figure) and compared with that which had been modelled. Validation results are included in Appendix C and are summarised in Tables 4.7 and 4.8 below.

Table 4.7 – Link Validation Results: Individual Flows

% of Validation Sites Meeting Individual Flow Criteria				
Time Period	Link Flows			Required
	Total Traffic	Lights	Heavies	
AM Peak				>85%
Inter Peak				>85%
PM Peak				>85%

Table 4.8 – Link Validation Results: GEH Values

% of Validation Sites with GEH < 5				
Time Period	Link Flows			Required
	Total Traffic	Lights	Heavies	
AM Peak				>85%
Inter Peak				>85%
PM Peak				>85%

A comparison against the validation counts shows that the AM, Inter and PM Peak period models all exceed the PAG requirements for the validation of traffic flow on links. Likewise, all models exceed the GEH criteria of 85%. The results therefore demonstrate that the validation criteria as set out by the NRA PAG are successfully met by all models.

4.3.2 Validation of Turning Flows

A further 48 observed and modelled turning flows were compared at each of the validation sites in accordance with the criteria above. The permissible difference was calculated for each value (based on the observed figure) and compared with that which had been modelled. Validation results are included in Appendix C and are summarised in Tables 4.9 and 4.10 below.

Table 4.9 – Turn Validation Results: Turning Flows

% of Validation Sites Meeting Individual Flow Criteria				
Time Period	**Link Flows**			**Required**
	Total Traffic	**Lights**	**Heavies**	
AM Peak				>85%
Inter Peak				>85%
PM Peak				>85%

Table 4.10 – Turn Validation Results: GEH Values

% of Validation Sites with GEH < 5				
Time Period	**Link Flows**			**Required**
	Total Traffic	**Lights**	**Heavies**	
AM Peak				>85%
Inter Peak				>85%
PM Peak				>85%

A comparison against the validation turning counts shows that all the models exceed the PAG requirements for the validation of traffic flow. Likewise, all models exceed the GEH criteria of 85%. The results therefore demonstrate that the validation criteria as set out by the NRA PAG are successfully met by all models.

4.3.3 Validation of Journey Times

As part of the validation process, the modelled journey times were compared against the surveyed journey times to ensure the model gave a reasonable representation of existing conditions. The results of the journey time validation are presented in Table 4.11 to 4.13 for the AM, Inter and PM peak hours respectively for the sections shown previously in Figure 2.11.

Table 4.11 - AM Peak Modelled/Observed Journey Times

Route	Observed *(min:sec)*	Modelled *(min:sec)*	Absolute Difference *(min:sec)*	% Difference	Validated
1					✓
2					✓
3					✓
4					✓
5					✓
6					✓
7					✓
8					✓
9					✓
10					✓
11					✓
12					✓
Percentage Validated					**100%**

Table 4.12 - Inter Peak Modelled/Observed Journey Times

Route	Observed *(min:sec)*	Modelled *(min:sec)*	Absolute Difference *(min:sec)*	% Difference	Validated
1					✓
2					✓
3					✓
4					✓
5					✓
6					✓
7					✓
8					✓
9					✓
10					✓
11					✓
12					✓
Percentage Validated					**100%**

Table 4.13 - PM Peak Modelled/Observed Journey Times

Route	Observed *(min:sec)*	Modelled *(min:sec)*	Absolute Difference *(min:sec)*	% Difference	Validated
1					✓
2					✓
3					✓
4					✓
5					✓
6					✓
7					✓
8					✓
9					✓
10					✓
11					✓
12					✓
Percentage Validated					**100%**

All models satisfy the PAG requirement that 85% of all modelled journey times are within 15% of observed data or within 1min if higher than 15%. As such the base year models are considered validated to the requirements of *PAG Unit 5.2: Construction of Transport Models* in terms of journey times.

4.4 Comparison of Traffic Patterns

Although not required under PAG guidance, the routing of traffic though the study area was checked against the results from the O-D surveys outlined in Section 2.4.3. The difference between observed and modelled traffic patterns are presented in Tables 4.14 – 4.19 below for both light and heavy vehicles.

Whilst no guidelines exist on the validation of O-D patterns, a target of +/- 15% was used as a target deviation limit. The tables below show that the majority of O-D pairs meet this target during the AM, Inter and PM peak periods. No light vehicle matrices have any OD pairs in excess of this target and very few HV OD pairs exceed this target significantly.

Table 4.14 - Comparison of AM Peak LV Traffic Patterns

		Destination Sector						
AM LV		1	2	3	4	5	6	7
Origin Sector	1	3%	-10%	0%	4%	2%	0%	1%
	2	-6%	7%	-4%	-1%	3%	0%	0%
	3	1%	-2%	-9%	7%	-3%	6%	1%
	4	0%	1%	-4%	-3%	4%	2%	0%
	5	3%	2%	12%	-4%	-1%	-12%	0%
	6	0%	1%	-2%	2%	3%	-4%	0%
	7	0%	-2%	5%	5%	2%	5%	-15%

Table 4.15 - Comparison of AM Peak HV Traffic Patterns

		Destination Sector						
AM HV		1	2	3	4	5	6	7
Origin Sector	1	0%	-6%	5%	-3%	0%	0%	3%
	2	-2%	8%	10%	-12%	0%	-3%	0%
	3	17%	-10%	-7%	3%	-4%	-1%	1%
	4	7%	-3%	-9%	-1%	4%	-1%	3%
	5	0%	-1%	-4%	-2%	7%	-1%	0%
	6	0%	0%	14%	-5%	0%	-9%	0%
	7	0%	10%	0%	8%	0%	0%	-18%

Table 4.16 - Comparison of Inter Peak LV Traffic Patterns

		Destination Sector						
IP LV		1	2	3	4	5	6	7
Origin Sector	1	-2%	-7%	8%	1%	0%	0%	0%
	2	-3%	-10%	9%	1%	2%	-1%	1%
	3	2%	2%	-8%	4%	-4%	4%	1%
	4	1%	0%	9%	-10%	4%	-3%	0%
	5	1%	3%	6%	3%	-4%	-9%	1%
	6	0%	0%	-5%	1%	3%	0%	0%
	7	0%	0%	0%	7%	-4%	-4%	7%

Table 4.17 - Comparison of Inter Peak HV Traffic Patterns

		Destination Sector						
IP HV		1	2	3	4	5	6	7
Origin Sector	1	0%	-2%	6%	2%	0%	-3%	-3%
	2	1%	0%	8%	-9%	0%	1%	0%
	3	13%	1%	-12%	0%	-2%	1%	0%
	4	2%	2%	-9%	4%	1%	-2%	2%
	5	1%	0%	-7%	9%	-1%	-7%	5%
	6	0%	-6%	10%	-6%	-7%	8%	0%
	7	0%	5%	0%	17%	0%	-4%	-19%

Table 4.18 - Comparison of PM Peak LV Traffic Patterns

		Destination Sector						
PM LV		1	2	3	4	5	6	7
Origin Sector	1	-1%	-3%	0%	4%	0%	0%	0%
	2	-5%	-2%	4%	3%	1%	0%	-1%
	3	2%	4%	-9%	2%	-2%	3%	1%
	4	0%	1%	9%	-8%	1%	-2%	-1%
	5	1%	1%	8%	-10%	2%	-2%	2%
	6	0%	1%	-14%	4%	2%	7%	0%
	7	0%	2%	0%	7%	2%	4%	-15%

Table 4.19 - Comparison of PM Peak HV Traffic Patterns

		Destination Sector						
PM HV		1	2	3	4	5	6	7
Origin Sector	1	0%	5%	-8%	-2%	0%	0%	5%
	2	-4%	-4%	12%	-1%	0%	0%	-3%
	3	0%	2%	-13%	8%	0%	1%	2%
	4	6%	-2%	5%	7%	-9%	-9%	3%
	5	0%	3%	13%	-11%	-9%	4%	0%
	6	0%	0%	10%	-12%	-6%	8%	0%
	7	-5%	1%	0%	17%	0%	0%	-12%

4.5 Model Convergence

The model assignment procedure involves the model reaching a point of equilibrium through an iterative process. The model must therefore achieve a satisfactory point of convergence in order to produce results that are reflective of the network over a number of iterations of assigning demand to the network.

The convergence indicators vary by different transport modelling packages; therefore multiple criteria are outlined in the UK Department for Transport (DFT) Transport Appraisal Guidance (TAG) Unit M3.1 – Highway Assignment Modelling (Jan 2014). The criterion that is used to show that the VISUM software reaches a level of convergence is as follows:

- the difference between the costs along the chosen routes and those along the minimum cost routes, summed across the whole network, and expressed as a percentage of the minimum costs, usually known as 'Delta' or the '%GAP' (<0.1%); and
- the percentage (P) of links on which flows or costs change by less than a fixed percentage (<5%)[6] for four consecutive iterations greater than 98%.

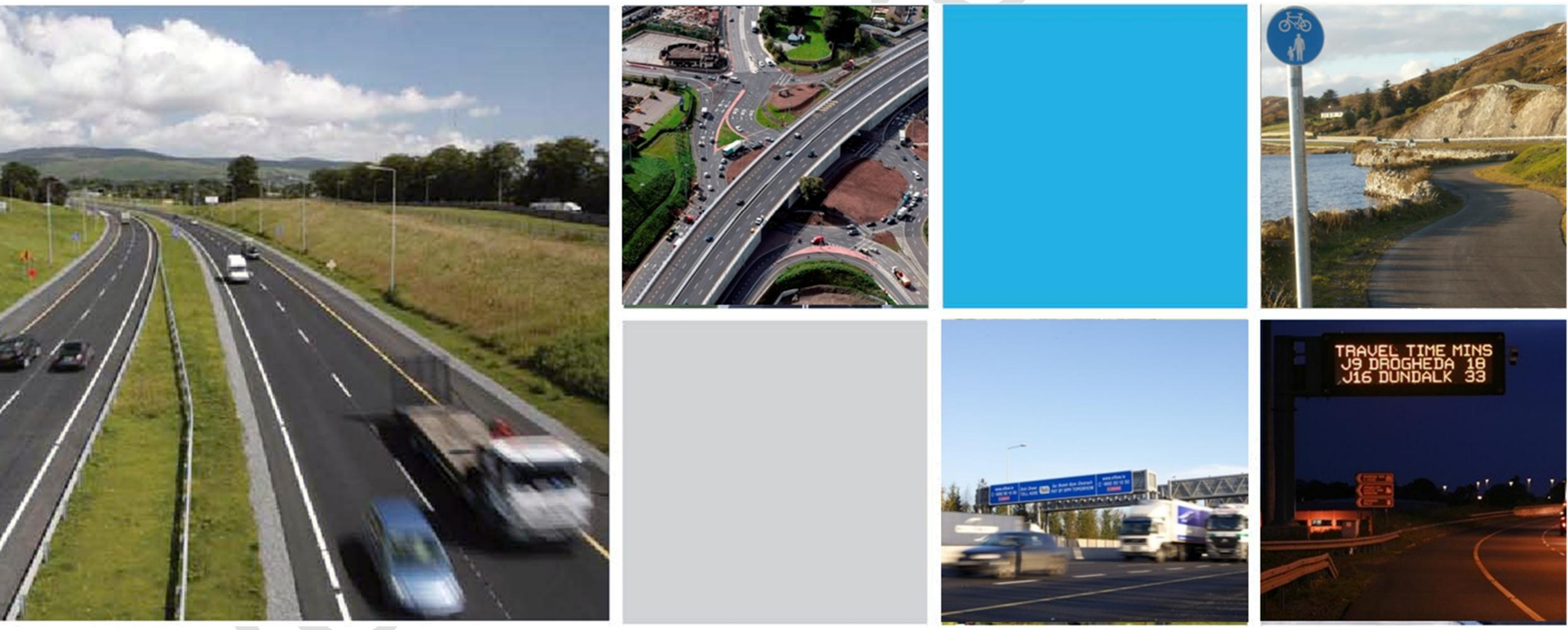
The model software produces the convergence information by user class, defining the percentage difference in link volume per vehicle class. Table 4.20 below indicates that the AM Peak, Inter and PM Peak models all reached a satisfactory level of convergence.

Table 4.20 - Model Convergence

Time Period	%GAP	Light		Heavies	
		Iterations	P	Iterations	P
AM	0.002	11	99.7%	11	99.8%
Inter	0.001	11	99.6%	11	100%
PM	0.002	11	99.7%	11	100%

[6] TAG Unit M3.1 recommends a value of <1% but the VISUM software only provides data at <5% as per the previous UK DMRB guidance on convergence. However due to the nature of the scheme it is estimated that a value of <1% would readily be achieved.

Chapter 5
Future Year Model Development



5 Future Year Model Development

5.1 Introduction

This section of the report sets out the development of the future year traffic models for the proposed scheme Opening Year (2024) and Design Year (2039).

5.2 Future Year Matrix Development

5.2.1 Overview

The development of traffic growth forecasts for the proposed scheme Opening Year and Design Year LAMs is based on the methodology set out in NRA PAG Unit 5.4 – Zone Based Traffic Growth Forecasting. The PAG sets out the criteria for using the Zonal Growth Rates forecasting methodology which is used for forecasting traffic growth when using traffic assignment models.

5.2.2 NTM Growth

The future year forecasted growth in the LAM is based on growth rates developed from the NTpM. The growth for light and heavy vehicles in the NTM is based on different economic and demographic projections. The growth in light vehicles is forecast based on demographic data such as employment, population, jobs and car ownership.

The forecast increase in heavy vehicles is based on the projected increase in the size of the national goods vehicle fleet which in turn is related to Gross Domestic Product (GDP). Full details on the process for both light and heavy vehicle forecasting can be found in the NTpM Demographic and Economic Forecasting Report (NTpM Volume 3).

5.2.3 Internal Zone Trip End Growth

The relationship between the LAM zones and the NTM zones was established, then annualised origin and destination Trip End Growth factors for the zones in the LAM were obtained from Unit 5.4 of the PAG for the AM, IP and PM Peak Periods.

Trip End Growth (TEG) factors were then identified for each zone in the LAM for both the scheme Opening Year (2024) and Design Year (2039). The TEG factors were then applied to the base year origin and destination trip ends for all internal zones in the LAM.

5.2.4 External Zone Trip End Growth

The LAM boundary was cordoned from the NTM Future Years (2030 & 2050) and compared against the Base Year (2013) NTM. The resultant growth factor for each external zone trip end was identified and then converted to annualised growth rates.

The resulting TEG factors were then applied to the base external origin and destination trip ends in the LAM for the scheme Opening (2024) and Design (2039) Years.

5.2.5 Future Year Trip Distribution

Future year trip distribution was undertaken utilising the furnessing distribution method. In order to carry out the trip distribution process it was first necessary to 'seed' the cells with no trips in the base year matrices with very small numbers (0.01 vehicles) to allow for future year trips between those specific cells. Otherwise any cell with a zero will remain zero irrespective of the factor applied. As part of the trip distribution process the matrix totals were doubly constrained to the mean of the forecast trip end totals.

5.2.6 Future Demand Forecast Totals

The total growth forecasts between the 2014 base and future year scenarios (2024 & 2039) for each modelled time period is outlined in Table 5.1 below, while Table 5.2 presents the trip matrix totals.

Table 5.1 – Total Growth in LAM

Matrix	2024			2039		
	Low Growth	Central Growth	High Growth	Low Growth	Central Growth	High Growth
AM Peak Car	8%	12%	14%	10%	20%	25%
AM Peak HGV	25%	27%	27%	59%	69%	72%
Inter Peak Car	4%	7%	8%	4%	12%	14%
Inter Peak HGV	25%	26%	27%	59%	68%	72%
PM Peak Car	8%	12%	14%	10%	20%	25%
PM Peak HGV	25%	27%	27%	59%	69%	72%

Table 5.2 - Trip Matrix Total Comparison

Matrix	2014	2024			2039		
		Low Growth	Central Growth	High Growth	Low Growth	Central Growth	High Growth
AM Peak Car	27,258	29,521	30,621	31,048	30,036	32,632	34,019
AM Peak HGV	666	829	843	846	1,058	1,122	1,147
Inter Peak Car	24,948	26,053	26,780	26,996	25,952	27,873	28,533
Inter Peak HGV	743	925	940	944	1,180	1,251	1,279
PM Peak Car	32,755	35,520	36,836	37,358	36,128	39,404	40,944
PM Peak HGV	609	758	771	774	966	1,024	1,047

5.3 Future Year Matrix Analysis

The PAG requires a quantitative assessment of the impact of the traffic forecasting process to be undertaken upon the following criteria:

- Trip Length Distribution;
- Trip End Growth; and
- Zone to Zone Growth.

5.3.1 Trip Length Distribution

Trip Length Distribution (TLD) graphs for the AM, Inter and PM Peak (Light Vehicles) are illustrated below for the NRA central growth scenario. The figures compare the TLD in the 2014 Base Year models and the 2039 Design Year Central Growth Do-Minimum models.

The purpose of comparing the TLD in the base and future year models is to assess the impact of the trip distribution (furnessing) process. The proportions of trips in the various distance bands should be similar between the base and future (e.g. no significant change in short trips).

Overall the TLD is similar between the Base and Design Year models in the AM, PM and Inter Peak with slight changes as a result of the trip distribution process. These changes are not deemed significant. TLD for AM, Inter and PM Peak are shown respectively in Figures 5.1 to 5.3 below.

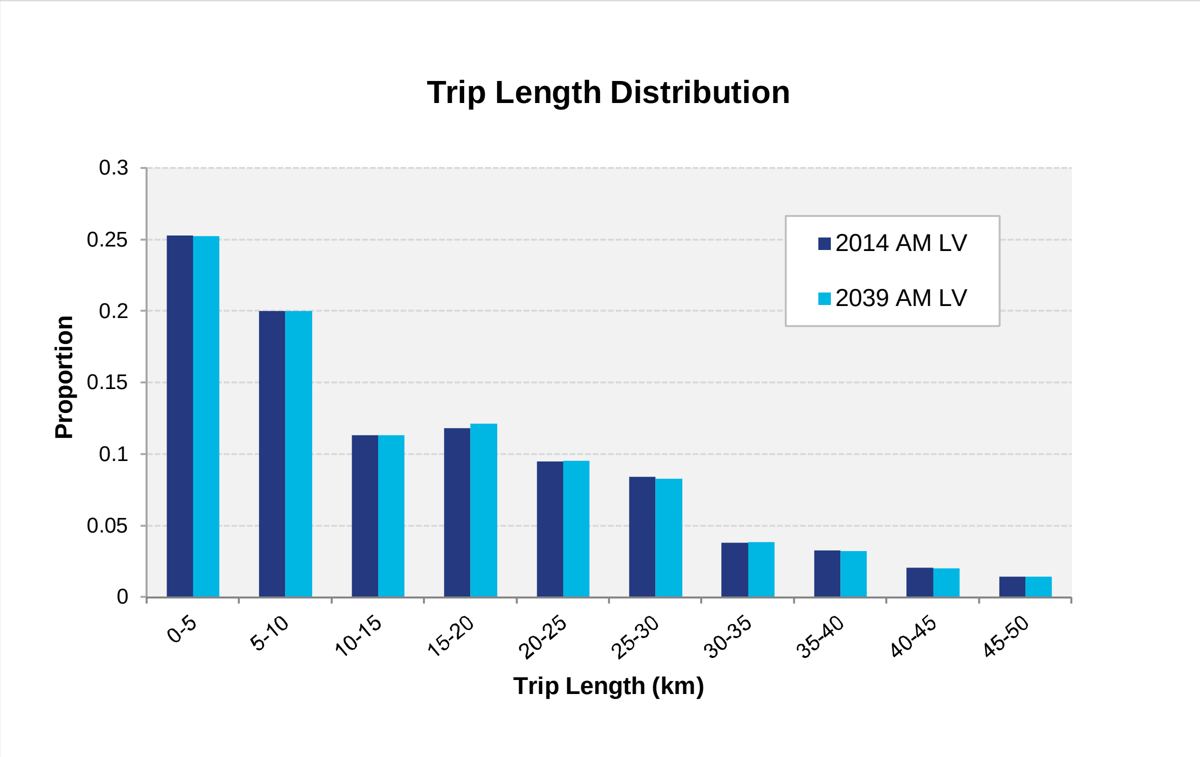


Figure 5.1 - AM Peak TLD (LV)

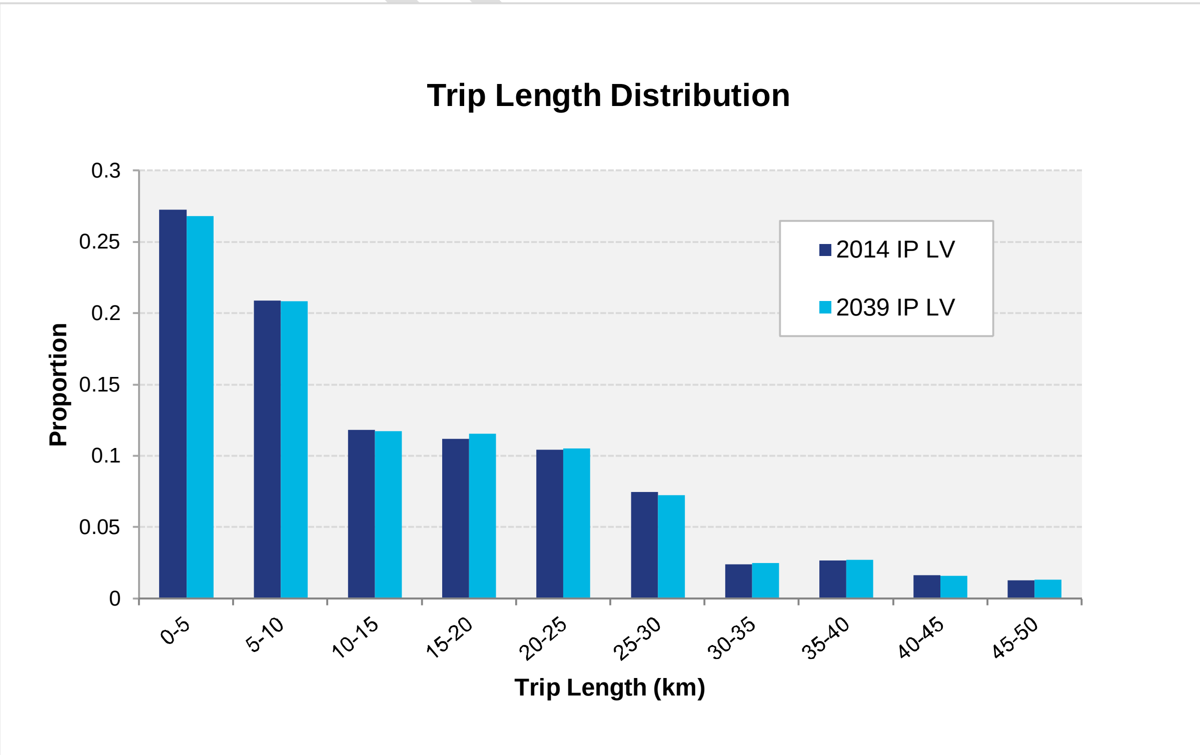


Figure 5.2 - Inter Peak TLD (LV)

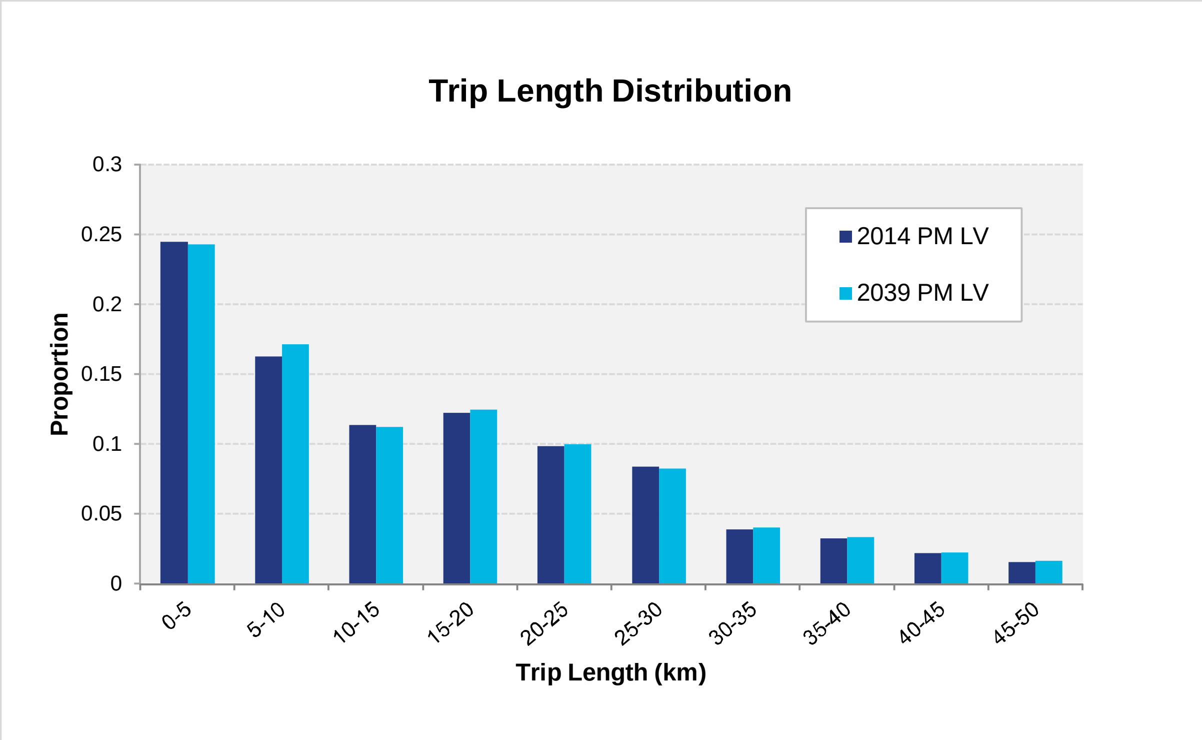


Figure 5.3 - PM Peak TLD (LV)

5.3.2 Trip End Growth

An assessment of the Trip End Growth (TEG) between the Base and Design Year demand in the AM, Inter and PM Peak was undertaken to assess if there were any significant changes in demand at trip end level when compared to the overall growth between the Base and Design Year demand.

The assessment indicated that the percentage increase between several trip ends in the Base and Design Year demand was significant but that the actual increase in the number of trips was only minor. In order to assess the true magnitude of TEG, the GEH statistic was applied to the Base and Design Year trip ends in order to take account of not only the difference between the Base and Design Year demand, but also the magnitude of the difference.

The PAG guidance on the GEH statistic indicates that any GEH statistic above 10 warrants further investigation. However, no zones were identified with a GEH statistic above 10 in any time period, therefore no further investigation was required.

5.3.3 Zone to Zone Growth

The same procedure for TEG was also undertaken for zone to zone growth. The GEH statistic for each origin-destination pair was assessed to show any significant outliers or issues in the AM, Inter and PM Peak demand. No zone to zone growth had a GEH statistic above 10. As such no further investigation was required.

5.4 Future Year Network Development

5.4.1 Do-Minimum & Do-Something Road Network

A future year 'Do-Minimum' network should include the existing road network plus any committed infrastructure improvements in the study area. As there is no significant road improvements committed currently within the study area, the 'Do-Minimum' future network for the Foynes to Limerick Road Improvement Scheme consists of the existing road network, which is assumed to be maintained over time.

For the purpose of the Stage 2 Route Selection process four route corridor options were identified and assessed, these are referred to as Options 1, 2, 3 & 4 and are illustrated in Figure 5.4. These options were modelled and assessed through the LAMs.

An overview of the four Do-Something Route Options assessed as part of the Stage 2 Route Selection process is outlined below. Full details of how the four route corridor options were identified and detailed description of the options is provided in Chapter 6 of the scheme Route Selection Report.

In assessing the relative benefits of each option, network statistics were extracted from the traffic models for each scenario and a comparison was made between the Do-Minimum and the Do-Something Route Options under consideration. The key network statistics comprise the following:

- Total Network Travel Time (hrs) for all vehicles;
- Total Network Vehicle Kilometres (vkms) for all vehicles; and
- Average Vehicle Speed (km/hr).

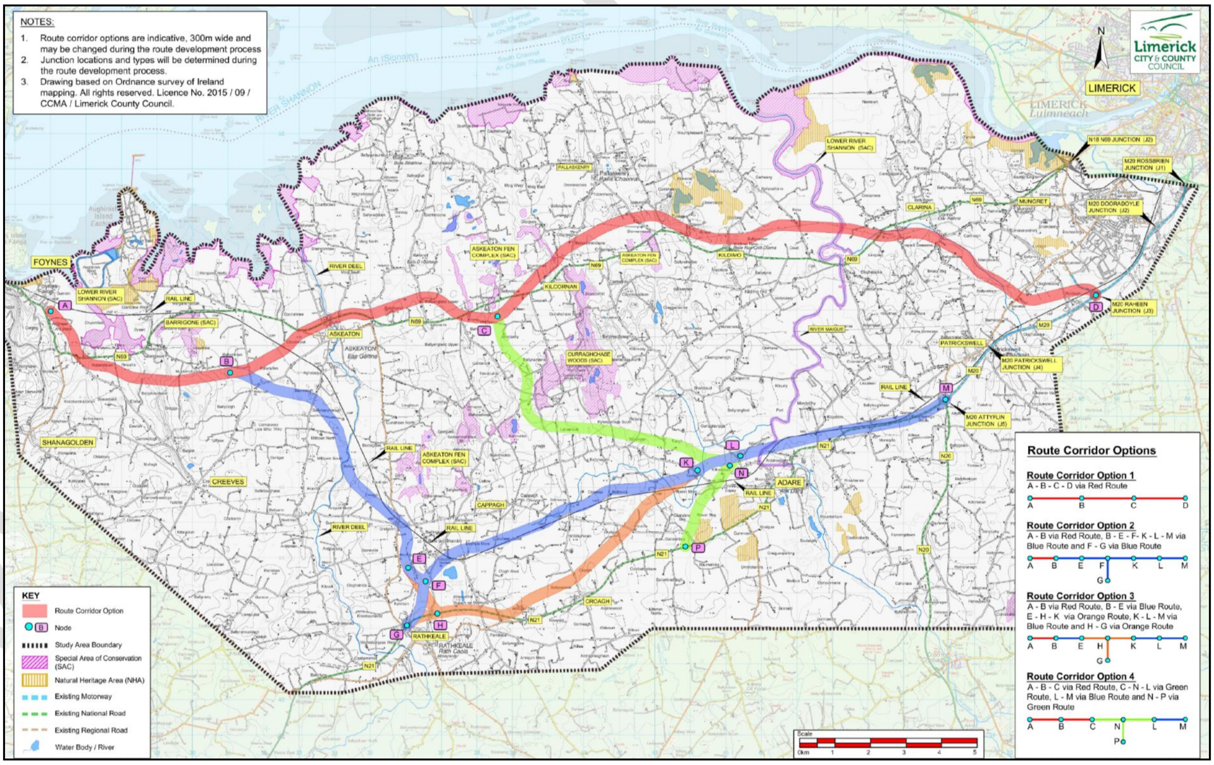


Figure 5.4 – Stage 2 Route Selection Options

5.4.2 Route Option 1

Commencing at Foynes, Route Corridor Option 1 runs parallel to the existing N69 diverting south at Clarina to tie in with the M20 Raheen Junction (J3). The route is approximately 33km in length and illustrated in Figure 5.5.

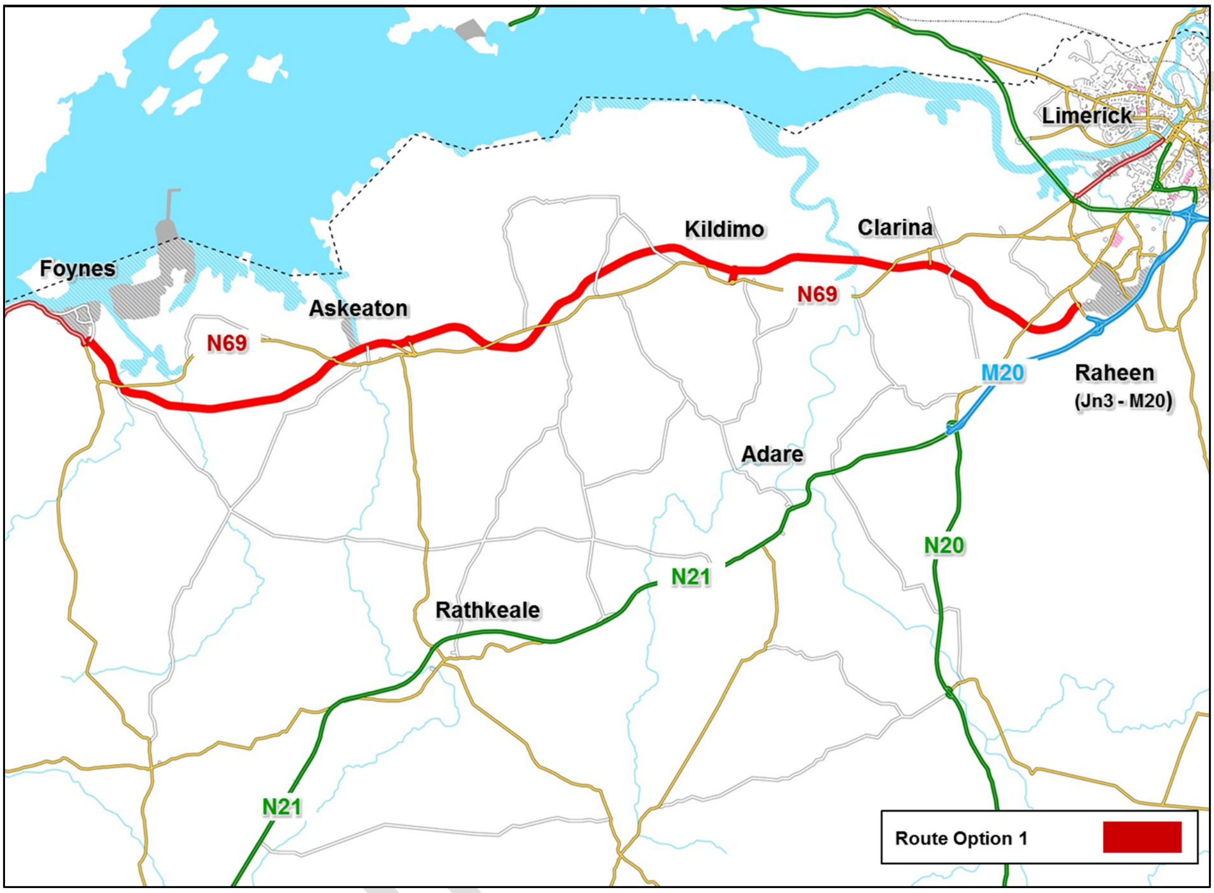


Figure 5.5 - Route Option 1

5.4.3 Option 2

Route Option 2 connects Foynes Port to Limerick and will bypass the towns of Rathkeale and Adare. The route option connects back onto the existing M20 at Attyflin (Junction 5). The route is shown in Figure 5.6 and is approximately 32 km in length.

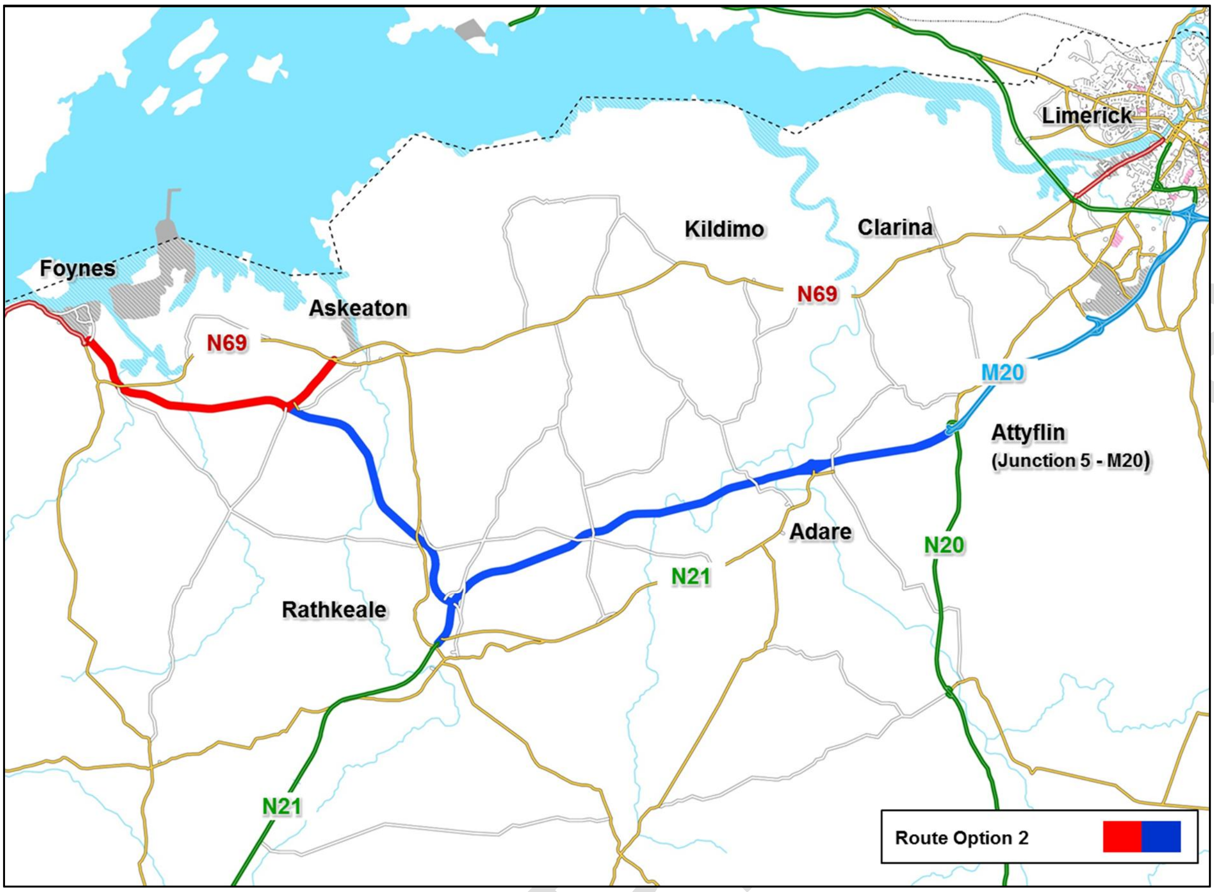


Figure 5.6 - Route Option 2

5.4.4 Option 3

Commencing at Foynes, Route Corridor Option 3 runs parallel to the N69 before heading south of Barrigone and travelling parallel to the Foynes / Limerick Rail line to Rathkeale. From Rathkeale the route runs along the existing N21 before heading in a north easterly direction, bypassing Adare to the north and tying into the N21 before the M20 Attyflin Junction (J5). The route is approximately 33km in length and is shown in Figure 5.7.

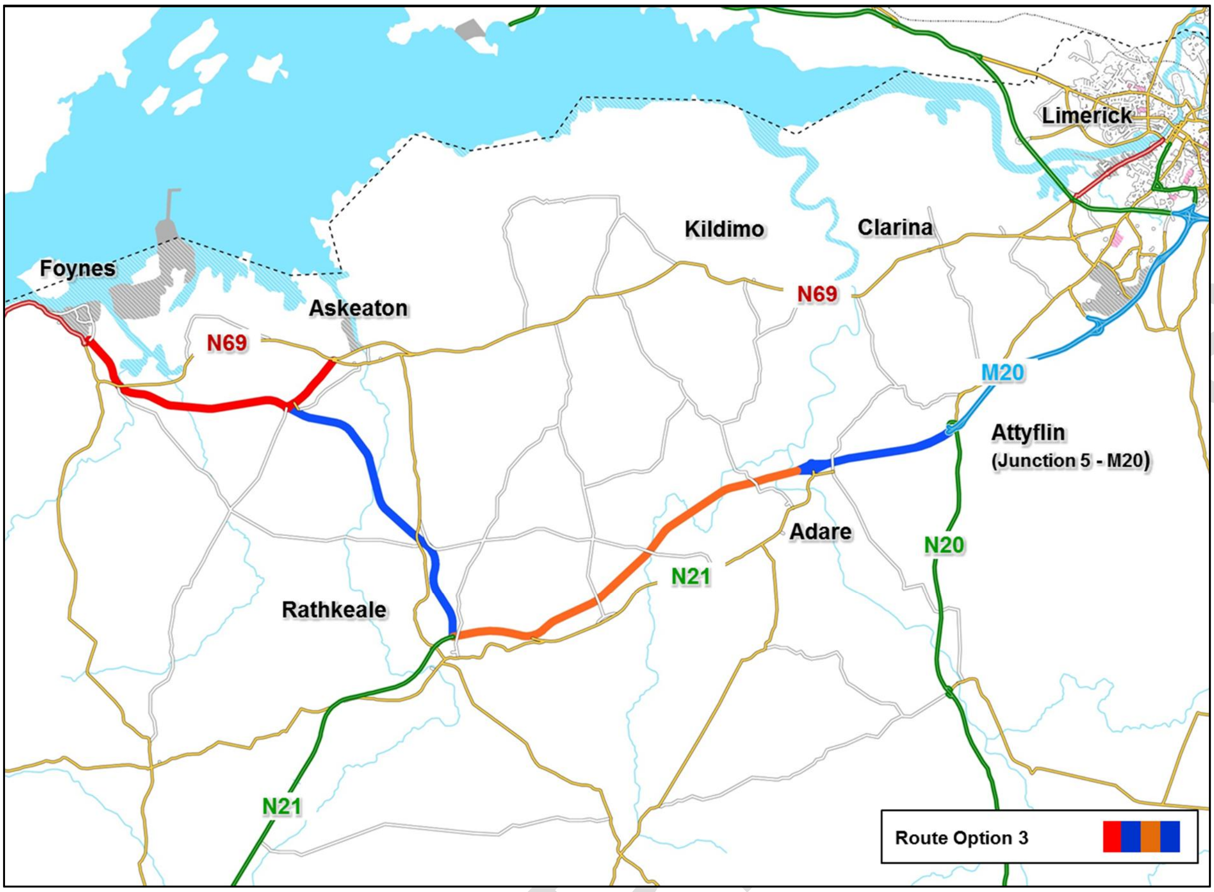


Figure 5.7 - Route Option 3

5.4.5 Option 4

Route Corridor Option 4 is approximately 32km long. Route Corridor Option 3 follows the same route as Route Corridor Option 1 through to Curraghchase before heading in a south easterly direction towards Adare. The Route Corridor Option is shown in Figure 5.8.

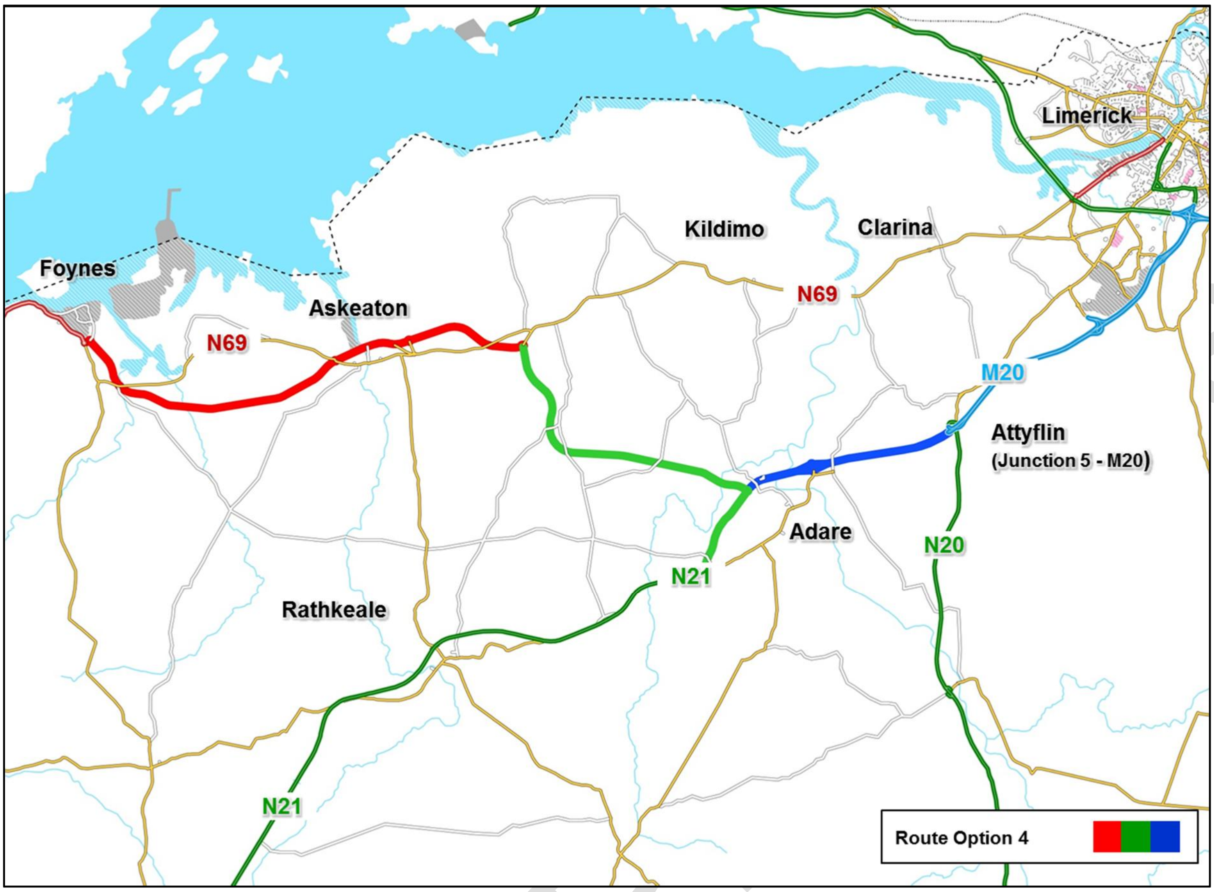


Figure 5.8- Route Option 4

5.5 Initial Selection of Road Type

For the purposes of the Route Selection process initial road types have been identified for the various route options and modelled accordingly.

5.5.1 N69 Foynes to Limerick

Traffic flow on the N69 is expected to grow to a maximum of 14,850 AADT in the Do-Minimum scenario by the scheme Design Year (2039), with the majority of the road experiencing traffic volumes much lower than this, 12,200 AADT at Kildimo, 8,150 AADT east of Askeaton and 6,250 AADT west of Askeaton.

For Route Corridor Option 1, which runs parallel to the existing N69 corridor, the anticipated traffic flow is 5,480 AADT east of Foynes, increasing to a maximum of 9,530 AADT to the west of Limerick City. The average flows along the N69 corridor of the options will therefore be within the range indicated for a Type 1 Single Carriageway (Capacity 11,600 AADT) in accordance with Table 6/1 of NRA TD9.

5.5.2 N21 Rathkeale to Limerick

Route Corridor Options 2, 3 and 4 utilise sections of the N21 corridor before tying into the existing M20 at the Attyflin junction. The anticipated traffic flows on Route Corridor Options 2, 3 and 4 in the Scheme Design Year (2039) range from a minimum of 14,250 AADT east of Rathkeale on Route Corridor Option 4 to a maximum of 22,860 AADT east of Adare on Route Corridor Option 4.

These flow volumes are within the ranges indicated for either a Type 1 (Capacity 42,000 AADT) or Type 2 (Capacity 22,000) Dual Carriageway as indicated in Table 6/1 of NRA TD9. Given that each of Route Corridor Options 2, 3 and 4 constitute a continuation of the existing M20 (an existing Type 1 Dual Carriageway motorway) it may be considered appropriate that the options along the N21 corridor should be developed as Type 1 Dual Carriageways at this stage of the project.

5.5.3 N69 to N21 Corridor Link Road

Whilst Route Corridor Options 2, 3 and 4 utilise sections of the N21 corridor to the greatest extent possible, each of these options have a link road which connects the existing N69 corridor to the N21 corridor. The anticipated traffic flows on these link roads range from a minimum of 2,040 AADT for Route Corridor Option 3 to a maximum of 3,160 ADDT on Route Corridor Option 4.

These flows are below the levels indicated for both a Type 1 and Type 2 Single Carriageway in Table 6/1 of NRA TD9. As the key scheme objective is to provide a high quality road link from Foynes to the existing motorway network in the vicinity of Limerick City it is considered appropriate that these link roads should be considered as a Type 1 Single Carriageway for the route selection stage of the project.

5.6 Consideration of Preliminary Junction Strategy

A preliminary junction strategy has been identified as part of the Route Selection process and modelled accordingly.

5.6.1 N69 Foynes to Limerick

For Route Corridor Option 1, terminal roundabouts will be provided at either end to the corridor, near Foynes and again on the R510 near the M20. Roundabouts will connect the corridor to the existing N69 where required while local and regional roads will be bridged over or under the mainline of the road. For modelling purposes, the section of the corridor online of the N69 at Askeaton will retain its current at-grade junctions.

Route Corridor Options 2 and 3 will have a roundabout junction near Foynes, with a further roundabout proposed at the Junction with the N69 to N21 Corridor Link Road and another roundabout to the west of Askeaton connecting to the existing N69. Local and regional roads will be bridged over or under the mainline of the road.

For Route Corridor Option 4, the junction strategy is the same as for Route Corridor Option 1 up to where the N69 to N21 Corridor Link Road is proposed for this option near Kilcornan. Here, a roundabout is proposed, with the existing N69 to the east of this junction realigned to tie into the roundabout.

5.6.2 N21 Rathkeale to Limerick

For Route Corridor Options 2, 3 and 4, a junction to the east of Adare is proposed with the current N21 extended through to this junction, which is a grade separated junction to NRA TD 22 design standards with merges and diverges in both east and westbound directions.

For Route Corridor Options 2 and 3, a roundabout is proposed with the N69 to N21 Corridor Link Road near Rathkeale, with the corridor then tying in with the existing N21 in advance of the existing N21/R518 grade separated junction north of Rathkeale. All of the local and regional roads between these two junctions are proposed to be bridged over or under the mainline of the road.

For Route Corridor Option 4, a roundabout is proposed with the N69 to N21 Corridor Link Road west of Adare, with a further link formed between the end of the corridor and a roundabout on the existing N21 west of Adare. The junction formed with the N69 to N21 Corridor Link Road could also be a grade separated but has been assumed as a roundabout for modelling purposes.

5.6.3 N69 to N21 Corridor Link Road

For Route Corridor Options 2, 3 and 4, between the roundabouts at either end of the scheme, it is proposed that all of the local and regional roads will be bridged over under the mainline for modelling purposes. Due to the low traffic volumes on these sections, further consideration may need to be given to potential junctions with other roads where necessary due to localised constraints or demands, if any of these route corridors are considered at a later stage of the project.

5.7 Estimation of Annual Average Daily Traffic

To estimate the Annual Average Daily Traffic (AADT), conversion rates were developed which allowed the extrapolation of AM, Inter and PM peak hour traffic flows to AADT. The AM, Inter and PM Peak Hour flows were converted to AADT flows using the following formula:

$$(3.1275 * u) + (7.9746 * v) + (3.1275 * w) = LV\ AADT$$

$$(5.6175 * x) + (4.1197 * y) + (5.6175 * z) = HV\ AADT$$

$$LV\ AADT + HV\ AADT = Total\ AADT$$

Where,

u = AM Peak Period LV Demand, x = AM Peak Period HV Demand

v= Inter Peak Period LV Demand, y= Inter Peak Period HV Demand

w = PM Peak Period LV Demand, z = PM Peak Period HV Demand

Regression analysis based on data from the TII Traffic Monitoring Units located within the study area was used to generate the equation outlined above. As such seasonality has been taken into account within the formula above. In order to assess the accuracy of the AM, Inter and PM Peak hour expansion factors to AADT, a comparison of observed and modelled 2014 base year AADT has been undertaken in Table 5.3.

Table 5.3 - Accuracy of AM, Inter & PM Expansion Factors to AADT

Location	TII TMU	2014 AADT		Accuracy
		Observed	Modelled	
N69 West of Askeaton	1692	5,581	5,285	-5%
N18 East of Shannon	20183	26,592	26,293	-1%
N18 East of Cratloe	20184	33,921	32,560	-4%
M20 Jn 2 – Jn 3	20205	26,999	26,034	-4%
M20 Jn 3 – Jn 4	20203	26,457	24,967	-6%
N20 North of Croom	20202	13,102	13,924	6%
N21 East of Adare	20212	15,612	16,571	6%

Location	TII TMU	2014 AADT		Accuracy
		Observed	Modelled	
N21 East of Abbeyfeale	20211	9,684	9,280	-4%
N24 East of Ballysimon	20243	15,338	15,569	2%
R445 West of Annacotty	200714	16,553	15,619	-6%
M7 Jn 27 – Jn 28	200721	17,174	17,076	-1%
M7 Jn 28 – Jn 29	200722	23,346	24,279	4%
M7 Jn 29 – Jn 30	200713	34,428	33,796	-2%

The table above shows that the expansion factors used to estimate AADT from AM, Inter and PM peak hour models lead to accurately modelled AADT forecasts.

5.8 Forecast AADT

The AADT for the following scenarios is presented in Figures 5.9 – 5.13:

- 2039 Do- Minimum;
- 2039 Do-Something Option 1;
- 2039 Do-Something Option 2;
- 2039 Do-Something Option 3; and
- 2039 Do-Something Option 4.

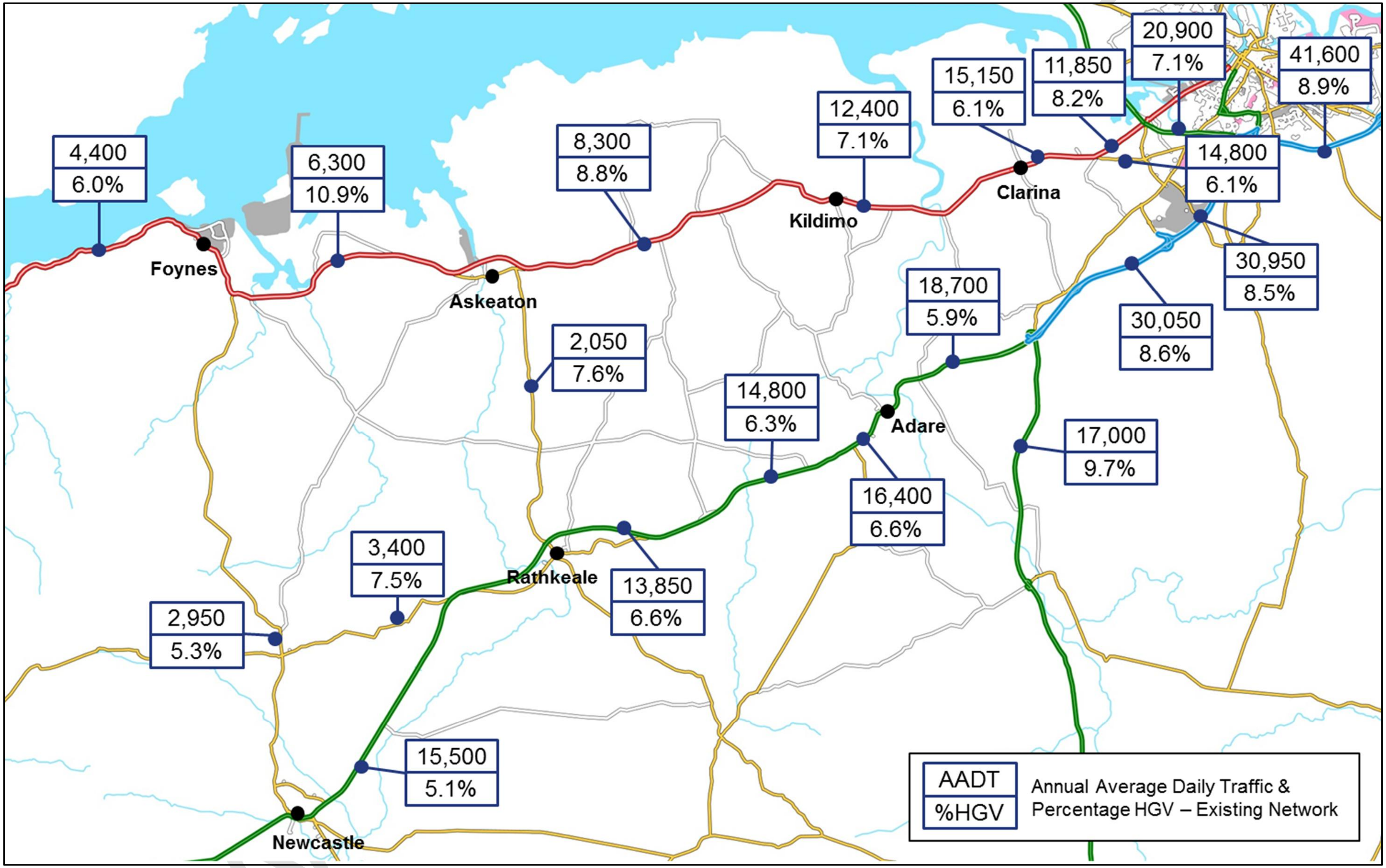


Figure 5.9 - 2039 Modelled Future AADT & Percentage HGV– Do Minimum Network

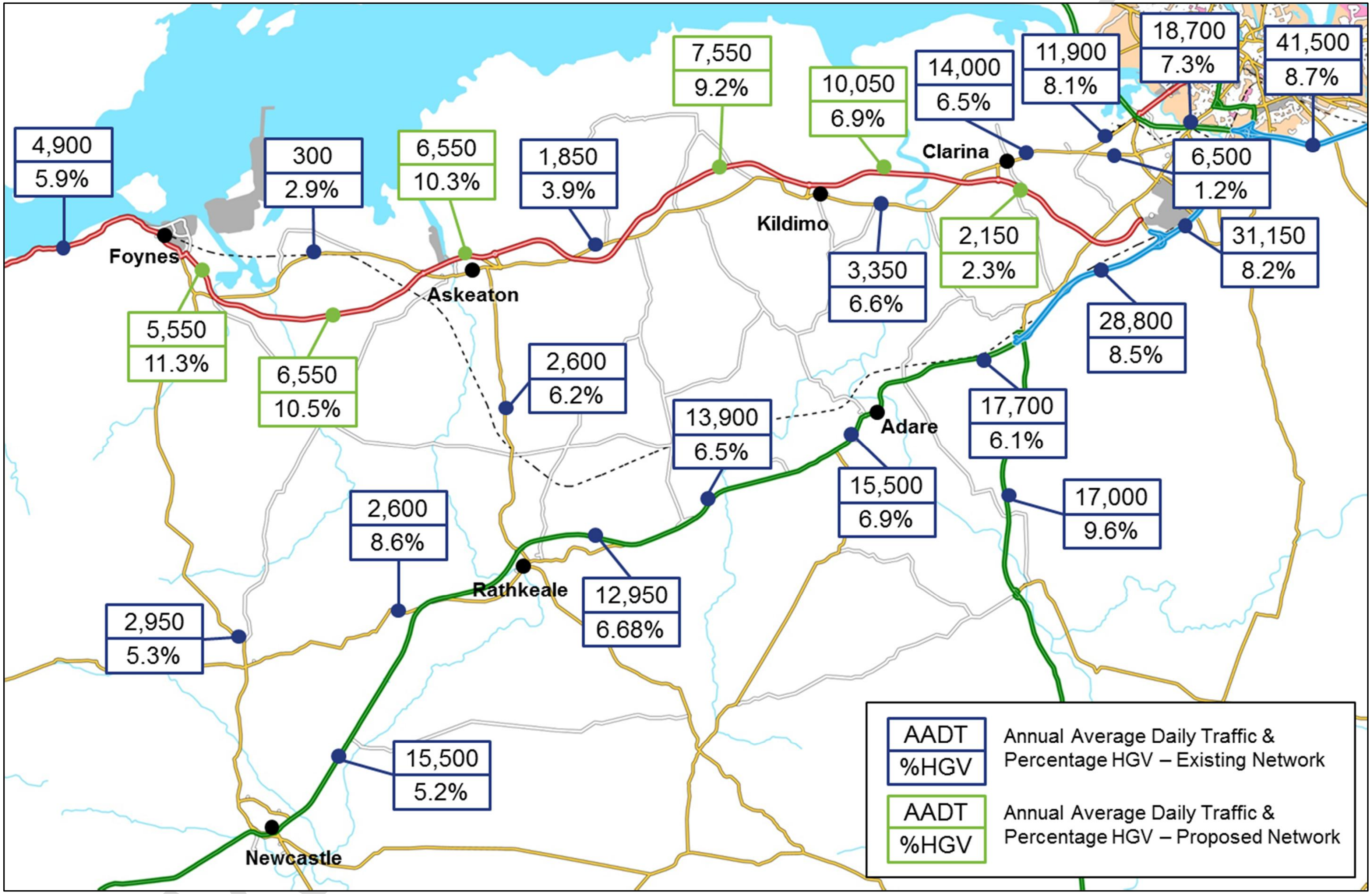


Figure 5.10 - 2039 Modelled Future AADT & Percentage HGV – Do Something Option 1

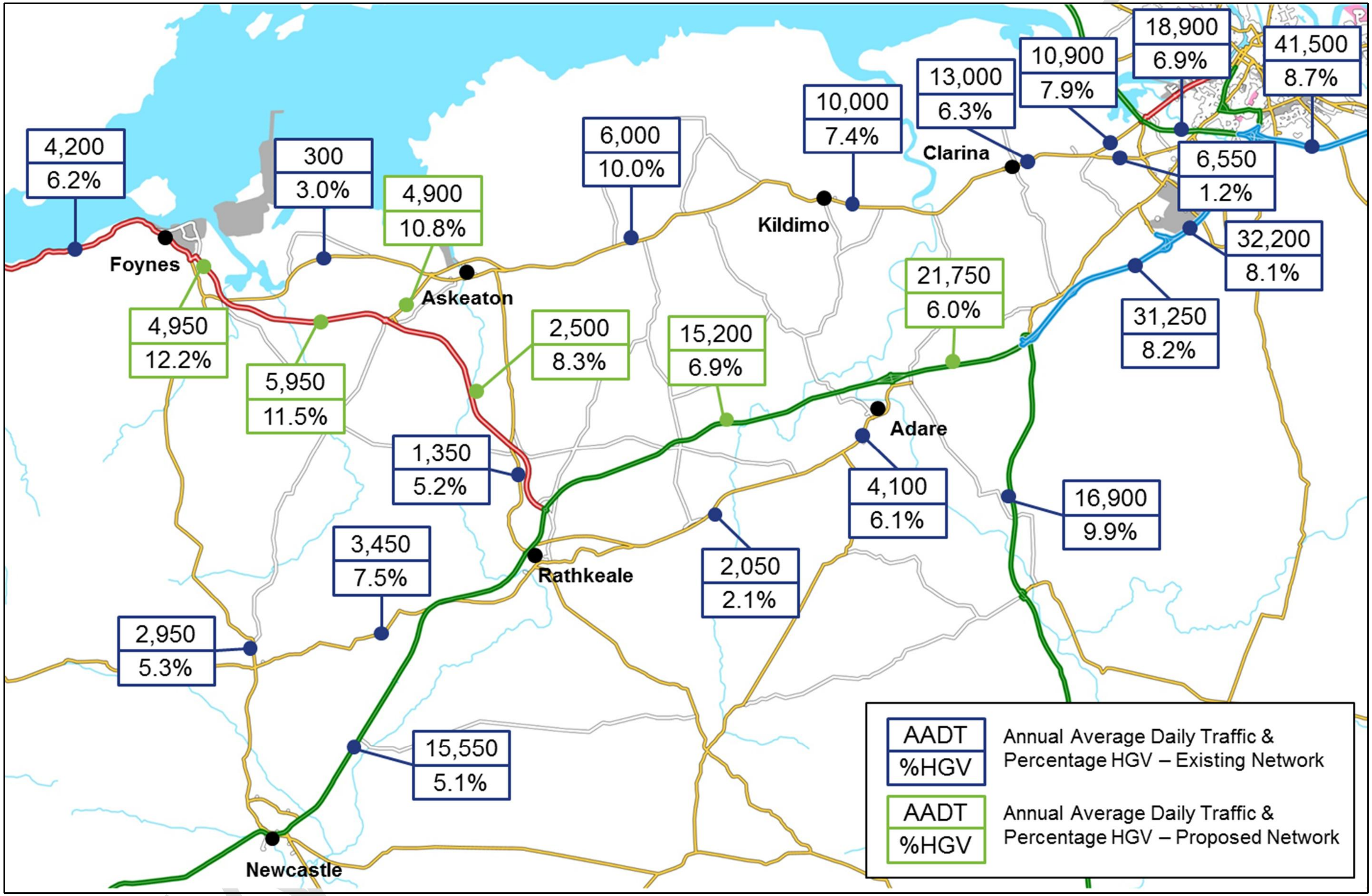


Figure 5.11 - 2039 Modelled Future AADT & Percentage HGV – Do Something Option 2

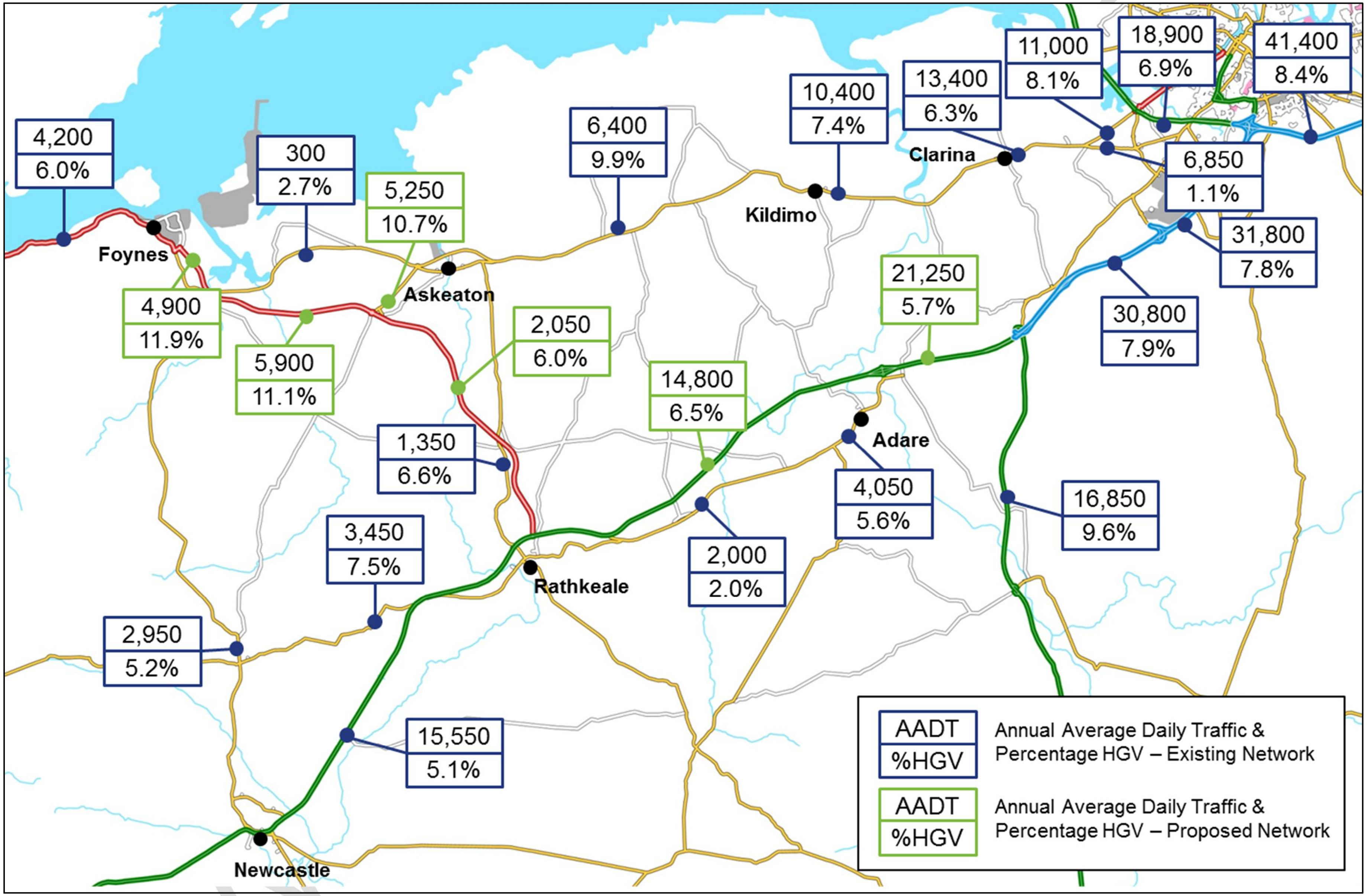


Figure 5.12 - 2039 Modelled Future AADT & Percentage HGV – Do Something Option 3

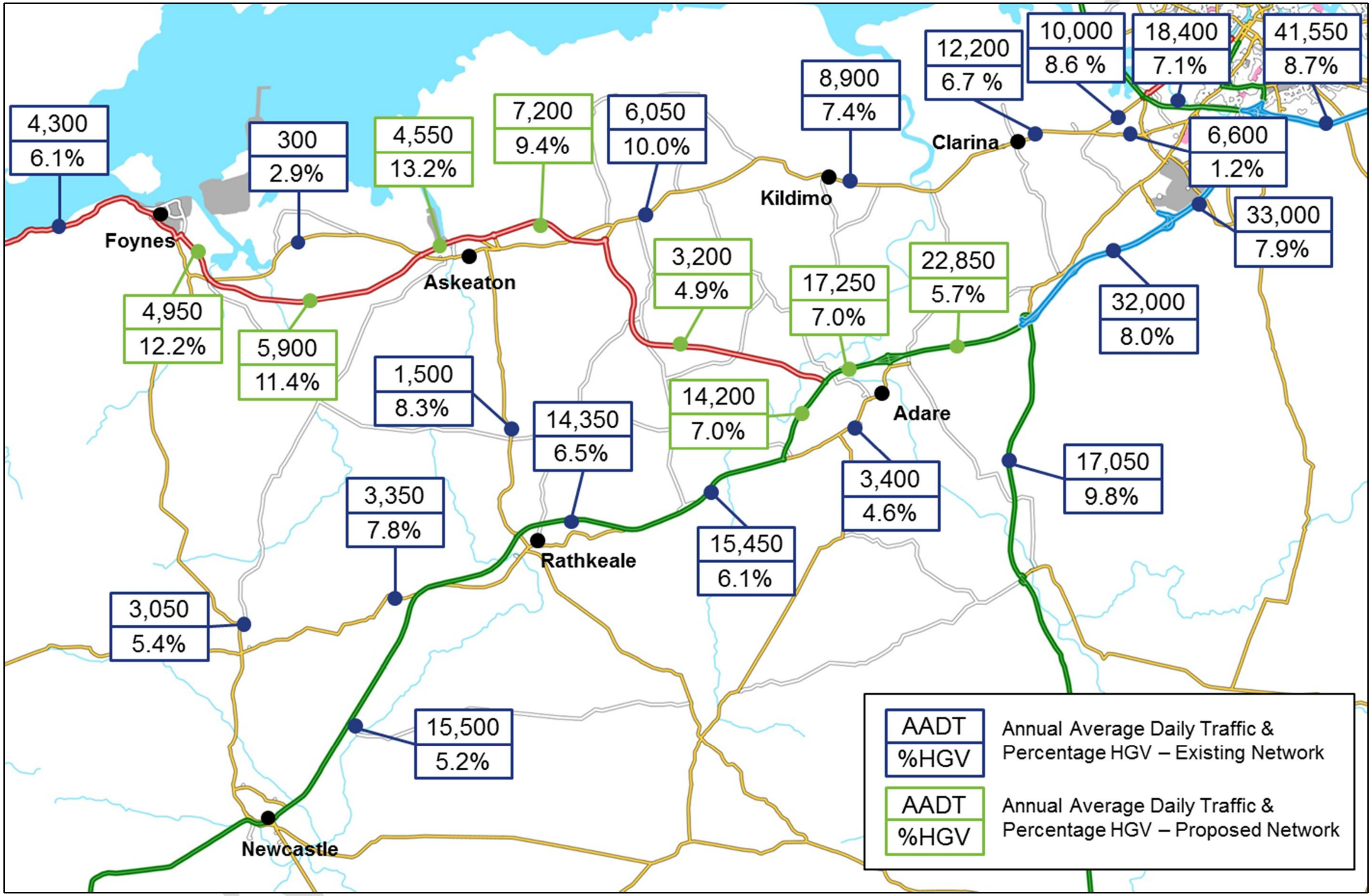


Figure 5.13 - 2039 Modelled Future AADT & Percentage HGV – Do Something Option 4

5.9 Network Statistics

Network statistics were extracted from the traffic models for each of the growth scenarios and a comparison was made against the Do-Minimum Option. The key network statistics comprise the following:

- Total Network Travel Time (hrs) for all vehicles;
- Total Network Vehicle Kilometres (vkms) for all vehicles; and
- Average Vehicle Speed (km/hr).

The key network statistics are presented for the Do-Minimum and each of the three route options for AM, IP and PM peak periods for the 2039 design year central growth scenario.

Table 5.4 - Network Statistics – AM – Central Growth

Scenario	Total Network Trips	Total Vehicle km	Total Network Travel Time (hrs)	Average Vehicle Speed (km/hr)
2039 Do-Minimum	33,755			
2039 DS Option 1	33,755			
2039 DS Option 2	33,755			
2039 DS Option 3	33,755			
2039 DS Option 4	33,755			

Table 5.5 - Network Statistics – IP – Central Growth

Scenario	Total Network Trips	Total Vehicle km	Total Network Travel Time (hrs)	Average Vehicle Speed (km/hr)
2039 Do-Minimum	29,124			
2039 DS Option 1	29,124			
2039 DS Option 2	29,124			
2039 DS Option 3	29,124			
2039 DS Option 4	29,124			

Table 5.6 - Network Statistics – PM – Central Growth

Scenario	Total Network Trips	Total Vehicle km	Total Network Travel Time (hrs)	Average Vehicle Speed (km/hr)
2039 Do-Minimum	40,429			
2039 DS Option 1	40,429			
2039 DS Option 2	40,429			
2039 DS Option 3	40,429			
2039 DS Option 4	40,429			

The statistics show that there is a decrease in total network travel time and total network delay and a subsequent increase in average speeds between the Do-Minimum and all of the Do-Something scenarios. As such, the tables above demonstrate that the Do-Something scenario will provide benefits for the entire network.

Appendices