M7 Naas to Newbridge By-Pass Upgrade Scheme

Phase 3 Design
Traffic Modelling Report

Final - Nov 2013

Designer
Roughan & O'Donovan – AECOM Alliance
Arena House
Arena Road
Sandyford
Dublin 18

Client
Kildare County Council
National Roads Design Office
Maudlins
Naas
County Kildare

M7 NAAS TO NEWBRIDGE BY-PASS UPGRADE SCHEME

TRAFFIC MODELLING REPORT

Project No:............ 60241946

Made: .... Katarzyna Miksiewicz/Declan Keenan

Checked: .... Philip Shiels

Approved:............ Shane Dunny

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TRAFFIC MODELLING REPORT

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TRAFFIC MODELLING REPORT

Glossary of Terms

AADT	Annual Average Daily Traffic
ATC	Automatic Traffic Count
CDP	County Development Plan
D	Destination
EB	Eastbound
GEH	Geoffrey E. Havers
HGV	Heavy Goods Vehicle
HV	Heavy Vehicle
KCC	Kildare County Council
LAM	Local Area Model
LAP	Local Area Plan
LGV	Light Good Vehicles
LV	Light Vehicles
MCC	Manual Classified Counts
ME	Matrix Estimation
NB	Northbound
NRA	National Roads Authority
NTM	National Traffic Model
O	Origin
O-D	Origin Destination
PAG	Project Appraisal Guidelines
PCU	Passenger Car Unit
PMG	Project Management Guidelines
RSI	Roadside Interview
SB	Southbound
TEG	Trip End Growth
TLD	Trip Length Distribution
TMR	Traffic Modelling Report
WB	Westbound

1.0 Introduction

The traffic model will be referred to as the M7 Local Area Model (LAM) throughout this report.

1.1 Overview

This report outlines the development of a traffic model built to assess the impact of the proposed M7 Naas to Newbridge By-Pass Upgrade Scheme. The traffic model study area is illustrated in Figure 1-1.

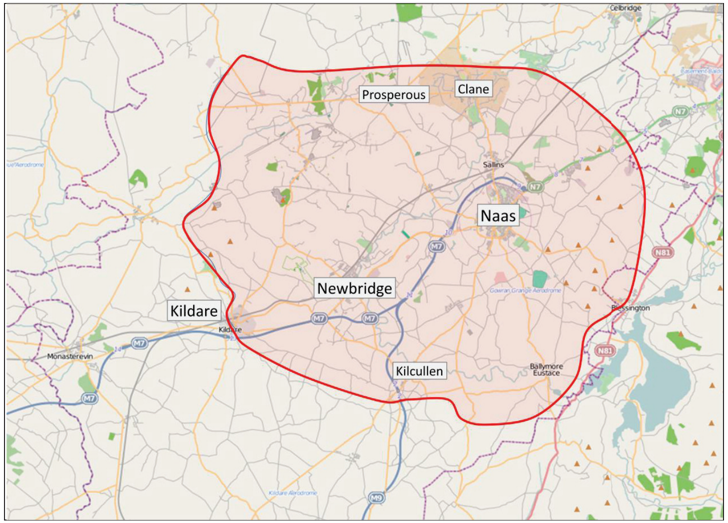

Figure 1-1: Traffic Model Study Area

The proposed scheme has been appraised in accordance with the NRA 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).

1.2 Project Appraisal Guidelines

The NRA Project Appraisal Guidelines (PAG) 2011 set out the following deliverables required as part of the appraisal process for major schemes:

- Project Brief;
- Traffic Modelling Report;
- Cost Benefit Analysis;

- Project Appraisal Balance Sheet;
- Business Case; and
- Post Project Review

The purpose of the Traffic Modelling Report (TMR) is to describe the development and application of the traffic model. The report outlines the development of the base year traffic model, the methodology for forecasting future year demands and presents the results of the modelling.

1.3 Existing Environment

The existing N7/M7 national primary route commences at the M50 Red Cow Interchange in Dublin and travels southwest to Limerick where it connects to the M20 at the Rossbrien junction. The N7 section runs between the M50 and the Maudlins Interchange (Naas North) and is designed as a 3 lane dual carriageway. The M7 section of the route commences at the Maudlins Interchange.

In 2011 the M7 section which runs between the Maudlins Interchange and M7/M9 Interchange carried an Annual Average Daily Traffic (AADT) flow of approximately 58,000, 9% of which was Heavy Commercial Traffic (HCV). This section of the M7 was designed as a wide 2 lane motorway (2 x 7.5m), the capacity of a wide 2 lane motorway operating at Level of Service D is approximately 55,500 AADT, which is currently being exceeded.

During the morning peak period (07:00 – 09:00) flows on the eastbound carriageway can exceed 3500 Passenger Car Units (PCU) per hour, these high levels of traffic flow lead to disruption (flow breakdown) in the traffic stream and reduce the level of service of the road, with average speeds reducing significantly (<80kph). In the morning peak hour (08:00 – 09:00) significant queuing occurs on the M7 eastbound off-ramp of the Newhall Interchange (Naas South) with vehicles queuing in the M7 mainline hard shoulder which raises significant safety concerns.

Due to the high traffic flow and the reduction in capacity (lane drop) on the westbound carriageway at the Maudlins Interchange congestion during the evening peak period (16:00 – 19:00) can be quite significant with queuing as far back as the Johnstown Interchange. Queuing on the westbound off-ramp of the Newhall Interchange also leads to flow breakdown in the southbound traffic steam in the evening peak hour (17:00 – 18:00).

Both of these issues lead to delays for southbound traffic and reduce average speeds along the full length of the M7 between the Johnstown Interchange and the M7/M9 Interchange significantly (<70kph).

1.4 Proposed Scheme

Kildare National Road Design Office (NRDO) proposes to widen 13km of the M7 from Greatconnell to Johnstown in County Kildare. The road will be widened from two to three lanes in each direction. It is not anticipated that the proposed widening will require the acquisition of any lands as the road will be widened within the existing landtake.

The scheme also includes the proposed upgrade of the existing M7 Newhall Interchange. The upgrade will see the closure of the existing Newhall Interchange slip roads and the construction of new slips roads which will connect to R445 Newbridge road forming a dumbbell junction.

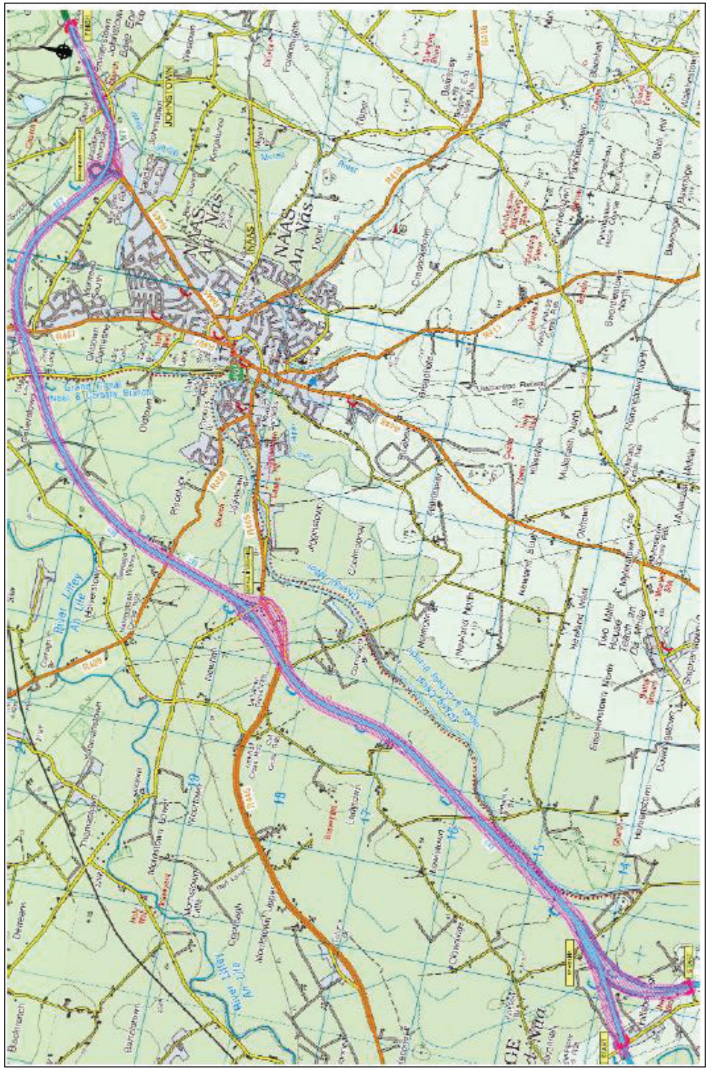

Figure 1-2: Proposed M7 Upgrades

2.0 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 collection of traffic data for the construction of the Base Year (2012) M7 Local Area Model (LAM).

2.2 National Traffic Model

The starting point for the Base Year M7 LAM is the 2010 Base Year National Traffic Model (NTM), which was developed by the National Road Authority (NRA). The NTM is a strategic (macroscopic) traffic model developed using the transportation modelling software VISUM. The model covers the entire national and regional road network and is used by the NRA as a tool in the appraisal of potential road schemes, land-use and policy changes. The NTM provides demand data for Light (Car & LGV) and Heavy (OGV1, OGV2 and PSV) vehicles 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).

2.3 Data Collection

A summary of the traffic survey that was collated, in addition to the NTM, as part of the development of the 2012 M7 LAM's is outlined below:

- Origin-Destination (O-D) Bluetooth surveys were carried out between 17th and 19th April 2012 at 6 sites;
- 11 Automatic Traffic Counts (ATC) carried out between 6th and 12th February 2012;
- 3 NRA Permanent ATC data carried out in 2010/2012;
- 10 Manual Classified Counts (MCC) undertaken over 12 hours (07:00 – 19:00) on Tuesday 7th of February 2012; and
- Journey time surveys (7 routes).

Figures 2-1 to 2-3 illustrate the location of the traffic surveys.

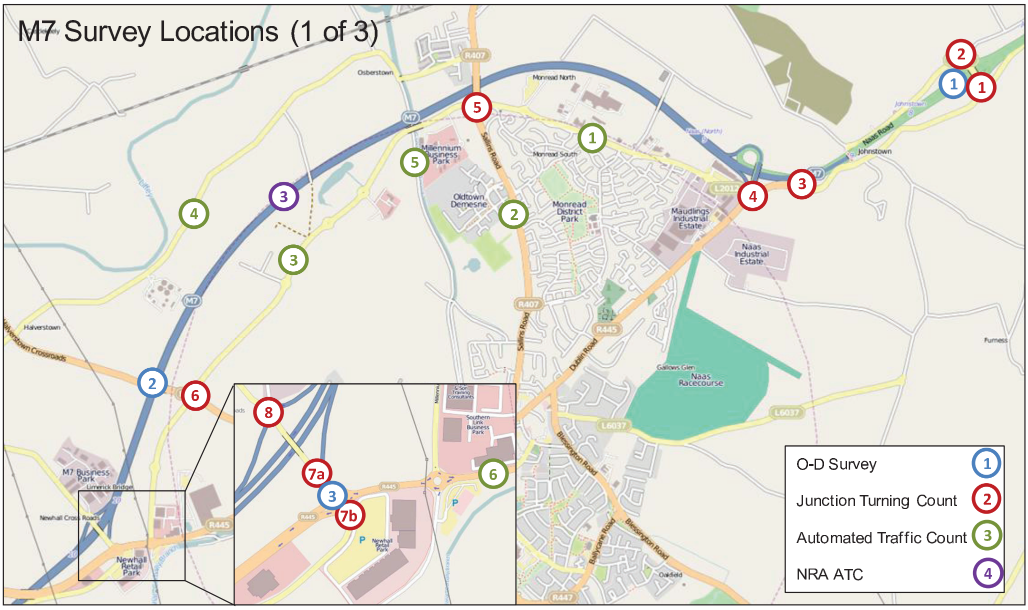

Figure 2-1: Location of O-D, ATC and MCC Surveys

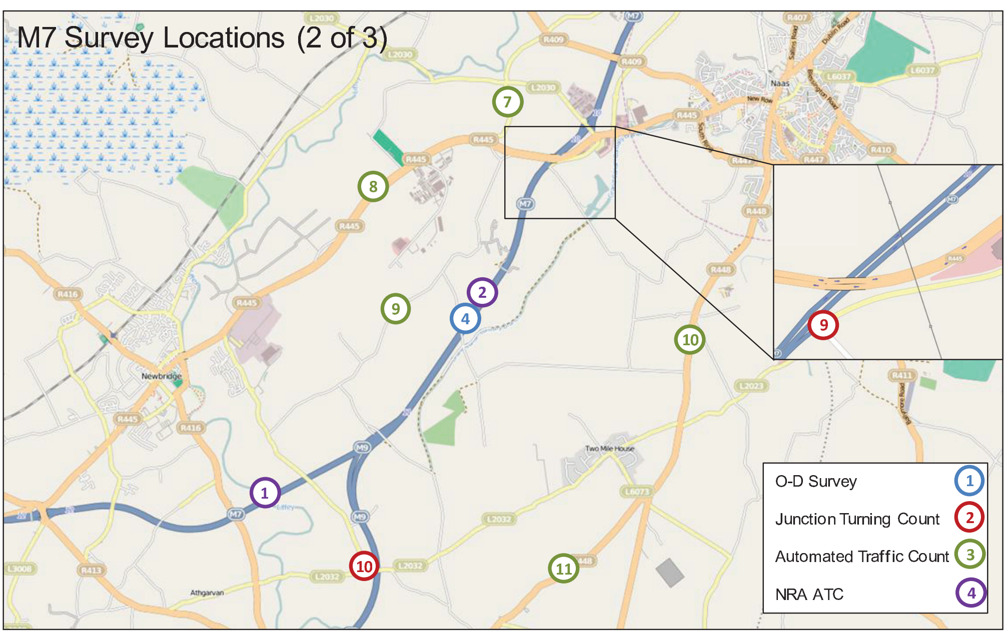

Figure 2-2: Location of O-D, ATC and MCC Surveys

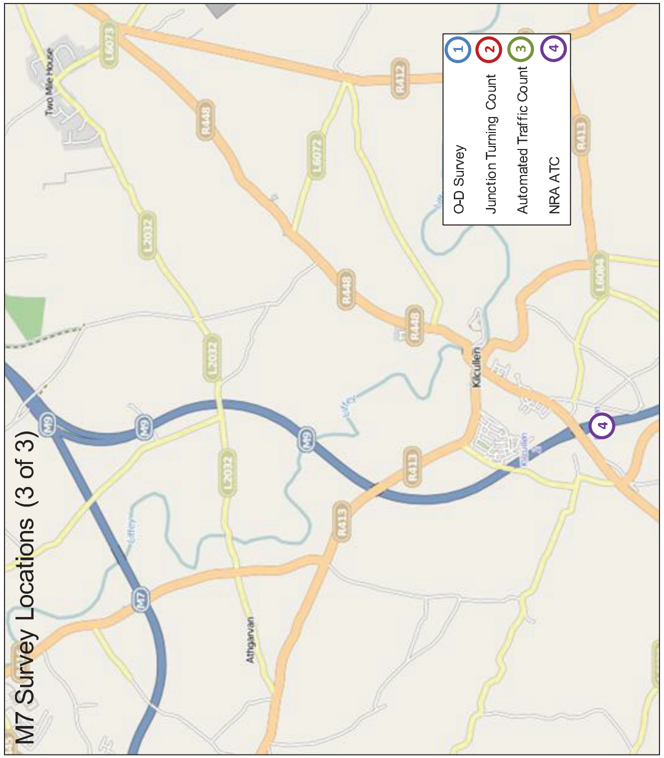

Figure 2-3: Location of O-D, ATC and MCC Surveys

2.3.1 Origin-Destination Data

In order to develop forecast traffic levels, it is first required to develop a robust representation of current traffic patterns. Origin-Destination (O-D) surveys were undertaken using a Bluetooth vehicle tracking system which recorded individual Bluetooth ID's at 6 cordon points.

The locations at which the Bluetooth devices were placed to collect data are illustrated in Figure 2-4. These locations were chosen to ensure a closed cordon was used to establish traffic pattern information in the area. The Bluetooth devices pick up unique identification numbers of individual electronic items that use Bluetooth (mobile phones, laptops, satellite navigation systems and hands free systems)

The O-D surveys were undertaken over a 3 day period between the 17th and the 19th April 2012. For the purpose of the developing the model, the "First seen – Last seen" dataset is utilised. This dataset outputs the Origin of a vehicle as the first time a vehicle is captured when it enters the cordon and Destination as the last time a vehicles is captured leaving the cordon.

In order to develop a robust O-D matrix sample rates were first calculated for each site by comparing the number of vehicles detected with the total AADT captured at the site. Table 2-1 below outlines the sample rate achieved at each individual site over the 3 day survey period.

Table 2-1: Average Bluetooth Sample Rates

Site Locations	% Sample Rate
1	38.4%
2	45.5%
3a	42.4%
3b	44.6%
3c	27.5%
4	31.6%

The sample rates outlined above allowed for the development of a full O-D matrix. A summary of the O-D data is provided in Table 2-2 below and shows average 24 hours flows for the 3 day survey

Table 2-2: Average Daily flows (24 hour period)

Site Location		No of Trips
From	To	
1	2	4450
1	3a	2120
1	3b	73
1	3c	784
1	4	17786
2	1	3975
2	3a	405
2	3b	17
2	3c	158
2	4	2838
3a	1	2454

Site Location		No of Trips
From	To	
3b	1	61
3b	2	20
3b	3a	71
3b	3c	244
3b	4	1874
3c	1	837
3c	2	153
3c	3a	1894
3c	3b	215
3c	4	2073
4	1	20914

3a	2	433
3a	3b	47
3a	3c	2281
3a	4	422

4	2	3067
4	3a	466
4	3b	36
4	3c	2095

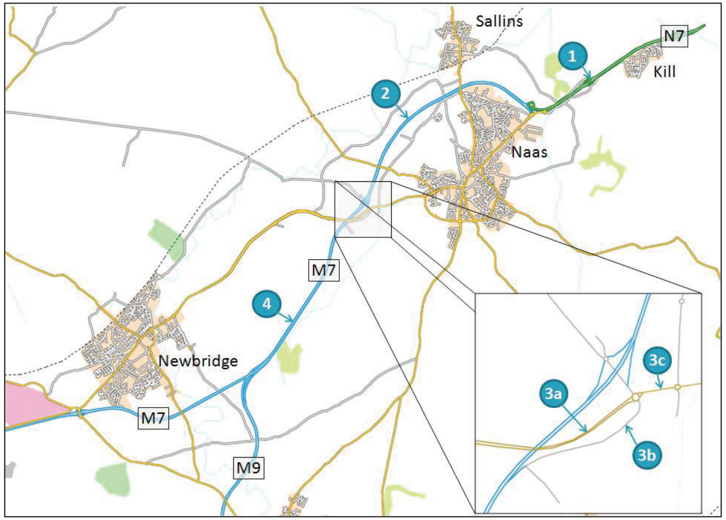

Figure 2-4: Location of O-D Surveys

2.3.2 Automatic Traffic Counters

Traffic flow data extracted from the 11 ATC surveys undertaken over a 7 day period between Sunday 6th – Saturday 12th February 2012 are presented in Table 2-3 below. From the ATCs a 7 day Weekly Average Daily Traffic (WADT) flows were extracted. This WADT was converted to Annual Average Daily Traffic (AADT) using data from the permanent NRA traffic counter at on the M7 at Lewistown in accordance with NRA *PAG Unit 16.1: Estimating AADT on National Roads.*

Table 2-3: Automatic Traffic Count (ATC) Data

ATC	ATC Location	Average Weekday 2-Way Flow			WADT	AADT	HGV
		AM Peak (8-9am)	Avg. Inter Peak (12-2pm)	PM Peak (5-6pm)			
1	Monread Rd.	1207	1182	1362	16390	16522	12%
2	R407 Sallins Rd.	1001	929	1020	13036	13141	9%
3	Naas North Ring Rd.	1102	758	1139	10775	10862	10%
4	Osberstown	159	95	169	1423	1435	11%

5	Canal Bank	186	36	83	588	592	3%
6	R445 Newbridge Rd	1235	1163	1011	14050	14164	9%
7	Newhall	493	222	316	2921	2945	21%
8	R445 Littleconnell	1104	986	1190	13713	13824	12%
9	Lewistown	27	21	31	259	261	11%
10	R448 Killashee	759	460	667	6922	6978	9%
11	R448 Brownstown	463	329	453	4725	4764	10%

2.3.3 NRA ATC Counters

A number of NRA permanent ATC sites are located in the study area along the M7 and M9. Data is available for a full year 2011 (M7) and 2010 (M9) at the sites presented in Table 2-4.

Table 2-4: NRA Permanent ATC Data (2010/2011)

NRA ATC	ATC Location	Year	Average Weekday 2-Way Flow			AADT	% HGV
			AM Peak (8-9am)	Avg. Inter Peak (12-2pm)	PM Peak (5-6pm)		
1	Great Connell M07-31	2010	2,995	2,289	3,450	37,946	8%
2	Lewistown M07-35	2010	4,789	3,436	5,398	58,172	9%
3	Naas Bypass M07-36	2010	4,466	3,368	5,019	54,805	8%
4	Kilcullen South M09-2	2011	1,477	1,072	1,775	18,350	9%

2.3.4 Manual Classified Counts (MCC)

Manual classified count (MCC) surveys were undertaken at 10 junctions on Tuesday 7th February 2012 over a 12 hour period (07:00 – 19:00). Traffic flow was disaggregated by vehicle type and recorded in 15min time intervals. The following junctions were surveyed:

- Junction 1: Johnstown – Roundabout on South Side of N7;
- Junction 2: Johnstown – Roundabout on North Side of N7;
- Junction 3: Johnstown Roundabout at Off Ramp from N7 to Naas North & Johnstown Village;
- Junction 4: Maudlins Roundabout;
- Junction 5: Sallins Road Roundabout;
- Junction 6: Carragh Road Millennium Park Roundabout;
- Junction 7: Newhall Interchange – Bundle of Sticks Roundabout;
- Junction 8: Newhall Interchange – Roundabout on North Side of M7;
- Junction 9: M7 On Ramp at Ladytown; and
- Junction 10: Rosetown – Great Connell & Two Mile House Road Junction.

The results of the MCC surveys are provided in Appendix A of this report.

2.3.5 Journey Time Surveys

Journey time information was collected as part of the O-D Bluetooth surveys.

Additional journey time surveys were also carried out in Naas between the Bundle of Sticks Roundabout and the Maudlins Roundabout to ascertain existing delays though Naas. The surveys were undertaken using a GPS data logger, which is carried in the vehicle undertaking the journey time surveys and tracks the position and speed of the vehicle every 2 seconds. Three runs in each direction were carried out during each time period. The results are outlined in Table 2-5 and journey times are illustrated in Figures 2-5 and 2-6.

Table 2-5: Journey Time Data (Naas)

Route	Time Period	Direction	Junction		Journey Time (sec)
			Start	End	
1	AM	EB	Bundle of Sticks	Maudlins	**726**
		WB	Maudlins	Bundle of Sticks	**685**
	Inter	EB	Bundle of Sticks	Maudlins	**660**
		WB	Maudlins	Bundle of Sticks	**716**
	PM	EB	Bundle of Sticks	Maudlins	**749**
		WB	Maudlins	Bundle of Sticks	**937**
2	AM	EB	Sallins Road	Maudlins	**161**
		WB	Maudlins	Sallins Road	**167**
	Inter	EB	Bundle of Sticks	Maudlins	**192**
		WB	Maudlins	Bundle of Sticks	**178**
	PM	EB	Bundle of Sticks	Maudlins	**195**
		WB	Maudlins	Bundle of Sticks	**319**
3	AM	NB	Sallins Road	Sallins	**97**
		SB	Sallins	Sallins Road	**146**
	Inter	NB*	Sallins Road	Sallins	**-**
		SB	Sallins	Sallins Road	**164**
	PM	NB	Sallins Road	Sallins	**163**
		SB	Sallins	Sallins Road	**155**
4	AM	WB	M7 (OD1)	M7 (OD4)	**401**
		EB	M7 (OD4)	M7 (OD1)	**531**
	Inter	WB	M7 (OD1)	M7 (OD4)	**407**
		EB	M7 (OD4)	M7 (OD1)	**385**
	PM	WB	M7 (OD1)	M7 (OD4)	**456**
		EB	M7 (OD4)	M7 (OD1)	**382**
5	AM	WB	M7 (OD1)	R445 (OD 3a)	**284**
		EB	R445 (OD 3a)	M7 (OD1)	**466**
	Inter	WB	M7 (OD1)	R445 (OD 3a)	**310**
		EB	R445 (OD 3a)	M7 (OD1)	**367**
	PM	WB	M7 (OD1)	R445 (OD 3a)	**400**
		EB	R445 (OD 3a)	M7 (OD1)	**329**
6	AM	WB	M7 (OD1)	Newbridge Rd (OD 3c)	**330**
		EB	Newbridge Rd (OD 3a)	M7 (OD1)	**410**
	Inter	WB	M7 (OD1)	Newbridge Rd (OD 3c)	**374**
		EB	Newbridge Rd (OD 3a)	M7 (OD1)	**341**
	PM	WB	M7 (OD1)	Newbridge Rd (OD 3c)	**404**
		EB	Newbridge Rd (OD 3a)	M7 (OD1)	**374**
7	AM	WB	M7 (OD4)	Newbridge Rd (OD 3c)	**315**
		EB	Newbridge Rd (OD 3a)	M7 (OD4)	**176**
	Inter	WB	M7 (OD4)	Newbridge Rd (OD 3c)	**214**
		EB	Newbridge Rd (OD 3a)	M7 (OD4)	**185**
	PM	WB	M7 (OD4)	Newbridge Rd (OD 3c)	**223**
		EB	Newbridge Rd (OD 3a)	M7 (OD4)	**210**

** No observed data available for this route in Northbound direction.*

The journey time surveys have been used to validate the base year LAM. The details of the validation process are summarised in Chapter 6.

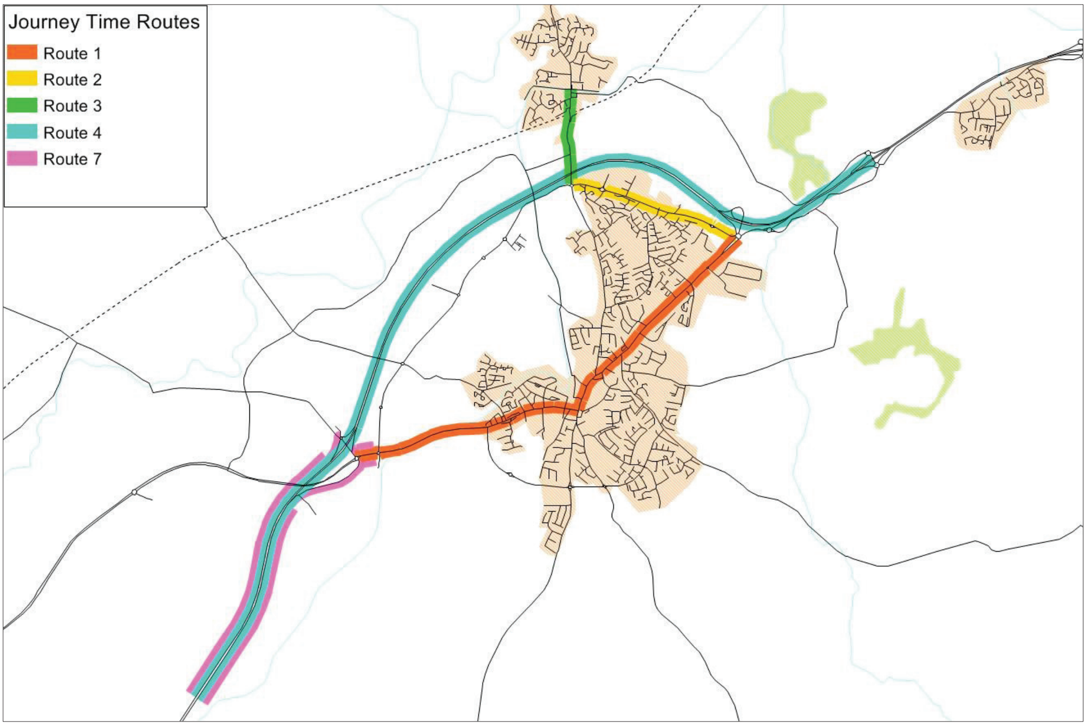

Figure 2-5: Journey Time Survey Routes (1-4 & 7)

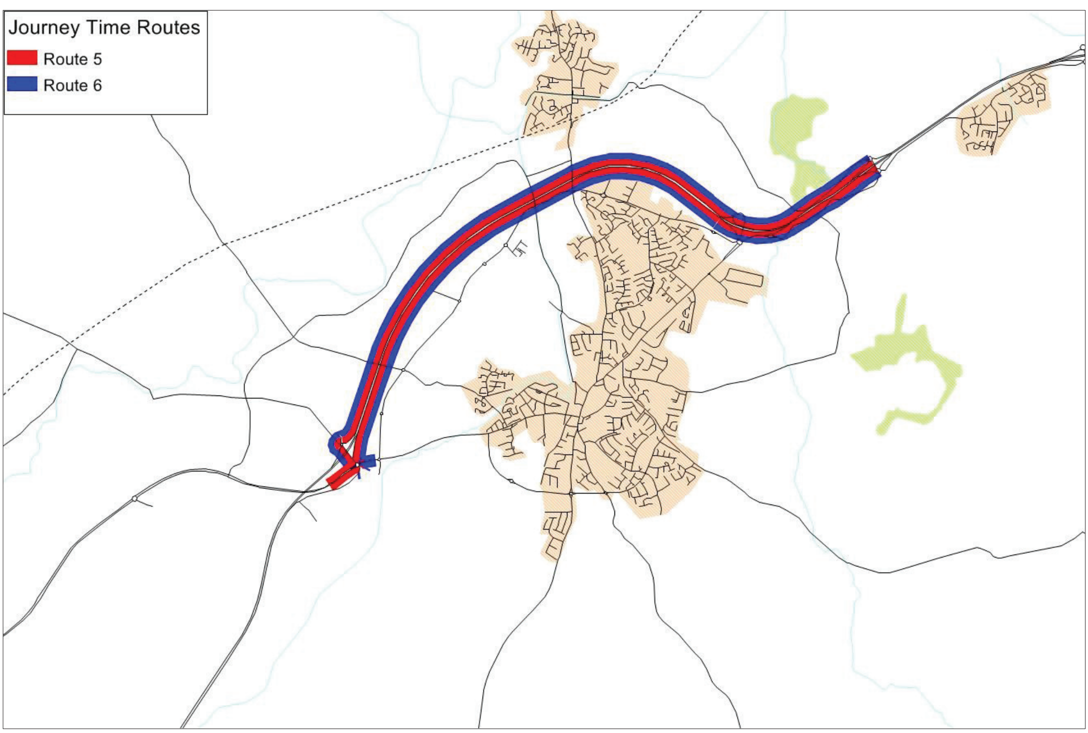

Figure 2-6: Journey Time Survey Routes (5 & 6)

3.0 Network and Matrix Development

3.1 Overview

This section of the report describes the development, calibration and validation of the 2012 M7 Base Year LAM's 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).

Assignment (fixed demand) models were developed using VISUM (V12.00-06).

3.2 Network Development

3.2.1 Cordoning the NTM

As outlined above, the NTM was used as a starting point for developing the 2012 M7 LAM's. The initial step was to identify the extent of the study area for the LAM. This area was identified by comparing the difference in flows between the 2040 Do-Nothing Scenario NTM (i.e. without the proposed scheme) and the 2040 Do-Something Scenario NTM (i.e. with the proposed scheme in place). Any links which showed a change in flow as a result of the scheme were included in the LAM network.

This test indicated that the main effects of the scheme were confined to the Naas and Newbridge areas as far North as the R403 (Kilcullen to Ballymote Road) and as far South as the R413 (Allenwood to Clane Road). This area of influence was 'cordoned' out of the 2010 NTM model and is shown in Figure 3-1 below.

Figure 3-1: 2010 NTM Cordon LAM Network

3.2.2 LAM Network Refinement

Following the cordoning process, the road network was further refined to ensure that all network characteristics (i.e. speed limits, banned turns, junction types etc.) were reflective of the 2012 road network. This information was collected through site observations and aerial mapping.

A number of additional local roads which were not included in the 2010 NTM model have been included in the 2012 LAM as they are impacted upon by the proposed scheme. The 2012 LAM network is illustrated in Figure 3-2 below.

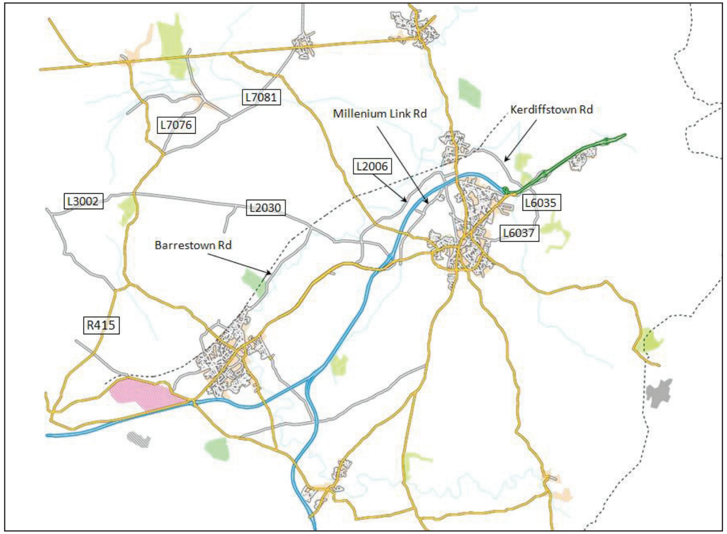

Figure 3-2: 2012 M7 LAM Network

3.2.3 LAM Zoning System

The zoning system for the LAM was initially based on the NTM model zoning system. The zoning system cordoned from the NTM model is illustrated in Appendix B.

In order to obtain greater detail within the LAM, the NTM model zones in the study area were further refined in order to improve traffic flows and trip patterns.

The NTM zones which represent Naas and Newbridge were disaggregated into several smaller zones. In total the model contains 49 zones (34 internal and 15 external). The distribution of demand in these disaggregated zones was based on an assessment of the An Post Geo-Coding data which provide data on the location of all residential and commercial postal address points within each zone. The refined zoning system is illustrated in Appendix B.

3.2.4 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 (BPR) function:

$$\mathbf{tCur = t0^* (1 + a * sat^b)}$$

where: *t0 = free flow travel time (based on link length (km) and free flow speed (v0))*
*sat = q/(qmax * c)*
a = 0.1, b = 2, c = 1

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 and c parameter values which reflect the quality of that road type.

3.2.5 Junction Delay

A number of key junctions in the model were modelled in detail to reflect existing junction delay. These junctions were modelled using the Intersection Capacity Analysis (ICA) tool in VISUM. The ICA calculation precisely considers the geometry and signal control of the junction and calculates the capacity of the junction and the turning time (tCur) of each turn according to the Highway Capacity Manual (HCM). The method takes into account the impact of conflicting turns upon junction capacity and therefore provides more realistic results of junction capacity and delay.

Delay at all minor junctions is calculated using the Turns Volume-Delay method, which considers the free-flow turning travel time (t0) of each turn.

3.3 Matrix Development

'Prior' AM Peak and Inter Peak hour Light and Heavy vehicle matrices were cordoned from the 2010 NTM. The matrices were disaggregated based on the LAM zoning system to establish 'Prior' matrices for the process.

These 'Prior' matrices were adjusted during the calibration process using the matrix estimation tool to reflect demand in 2012.

As there is no PM Peak Hour NTM an alternative approach to generate the PM Peak Hour 'Prior' matrix was required. The calibrated AM Peak Hour matrices were transposed to give a 'Prior' PM matrix.

Matrices were then modified during the calibration process using the 2012 traffic survey data ascertained for each peak, the select link analysis tool in VISUM and the matrix estimation tool.

3.4 Generalised Cost

The assignment model applies the demand for travel, represented by the trip matrices, to the supply, in the form of the road network. The route choice is based on the 'generalised cost' of each route option, represented by a combination of time and distance as follows:

- Generalised Cost = Value of Time * Time + Vehicle Operating Cost * Dist

The economic parameters used in the M7 Widening LAM are outlined in Table 3-1. These are fully compliant with parameters set out in PAG and in the DTTAS Common Appraisal Framework.

Table 3-1: Generalised Cost Economic Parameters

Peak hour	User Class	Value of Time (VoT)		Vehicle Operating Cost (VOC)	
		Cents/sec	*€/hr*	*Cents/metre*	*€/km*
AM and PM	Car	0.5169	18.61	0.0101	0.101
	HGV	0.8826	31.77	0.0382	0.382
Inter	Car	0.5053	18.19	0.0101	0.101
	HGV	0.9104	32.78	0.037	0.37

**Average VoT for Commuting, Working & Non-Working*

The 'generalised cost' equations used in M7 Widening LAM are set out below:

- AM and PM Peak LV Generalised Cost = 0.5169 * time (sec) + 0.0101 * distance (meters);
- AM and PM Peak HV Generalised Cost = 0.8826 * time + 0.0382 * distance;
- Inter Peak LV Generalised Cost = 0.5053 * time + 0.0101 * distance ; and
- Inter Peak HV Generalised Cost = 0.9104 * time + 0.0370 * distance.

For the purpose of the assignment in the VISUM software a scalar of 1000 is applied to the VoT and VOC.

3.5 Assignment Method

The Route Choice Algorithm selected is Equilibrium Lohse. This starts with an 'all or nothing' assignment, and assigns in an iterative fashion, with drivers utilising information gained during their last journey for the next route choice. The assignment terminates when a stable solution is calculated.

4.0 Model Calibration/Validation

4.1 Introduction

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

4.2 Model 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. Using transportation modelling software (VISUM in this case) it is possible to perform this operation at numerous locations in a single matrix estimation run, adjusting large sections of the trip matrix to match observed demand.

"TFlow Fuzzy" is the matrix estimation tool provided in VISUM, designed to automatically adjust trip matrices to match modelled volumes to observed volumes along multiple links or turns. Prior to the TFlow Fuzzy process, numerical parameters are set to form tolerance values, calculated as a percentage of the observed volumes, in order to ensure accuracy within the matrix estimation process.

Separate ME runs were carried out for light and heavy vehicles in the AM Peak, PM Peak and Inter Peak Hours. The calibration counts used for the ME process are illustrated in Appendix C.

4.2.2 Calibration Criteria and Link Flow Calibration Results

The model calibration process has been undertaken based on the requirements of The NRA Project Appraisal Guidelines *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 Figure 4-1 below.

Table 4-1: Model Calibration Criteria: Individual Flows

Criteria and Measure	Guideline
Assigned Hourly Flows (e.g. links or turning movements) vs. Observed Flows:	
Individual flows within 15% for flows 700 – 2700 vph Individual flows within 100 vph for flows <700 vph Individual flows within 400 vph for flows > 2700 Total screenline flows (normally >5 links to be within 5%)	> 85% of cases

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:

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

Where M = Modelled Flow and O = Observed Flow.

Guidance in the Project Appraisal Guidelines sets out the following criteria:

Table 4-2: Model Calibration Criteria: GEH Values

Criteria and Measures		Requirement
GEH statistic	Individual flows: GEH < 5	> 85% of cases
GEH statistic	Screenline totals: GEH < 4	All (or nearly all) screenlines

The links that were used in the model calibration process are illustrated in Appendix C. The results of the calibration exercise are outlined below in Table 4-3 and Table 4-4. The detailed summary tables are included in Appendix D.

Table 4-3: Calibration Results: Individual Links

Time Period	% of Calibration Sites Meeting the flow criteria that: Individual Flows within 15% for flows 700 – 2700 vph Individual flows within 100 vph for flows < 700 vph Individual flows within 400 vph for flows > 2700 vph			
	Link Flows			
	Total Traffic	Lights	Heavies	Required
AM Peak	90%	95%	100%	>85%
Inter Peak	97%	97%	100%	>85%
PM Peak	92%	92%	100%	>85%

Table 4-4: Calibration Results: GEH Values

Time Period	% of Calibration Sites with GEH < 5			
	GEH < 5			
	Total Traffic	Lights	Heavies	Required
AM Peak	94%	100%	87%	>85%
Inter Peak	95%	95%	100%	>85%
PM Peak	92%	92%	92%	>85%

The comparison of modelled and observed flows has identified that the AM, Inter and PM Peak period models match the flow criteria for all user classes. Likewise, the GEH results show that the AM Peak, Inter Peak and PM Peak periods models also match 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.

4.3 Trip Distance Check

The output trip matrix from the matrix estimation process must be checked to ensure that the process has not significantly altered the trip length 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 excess short distance trips while longer distance trips are unaffected, which in turn would push the trip length 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 trip length distributions for each peak hour for Light Vehicles are represented as histograms in Figure 4-1 to 4-3. The figures shows that the TLD has not been significantly altered as a result of the ME process.

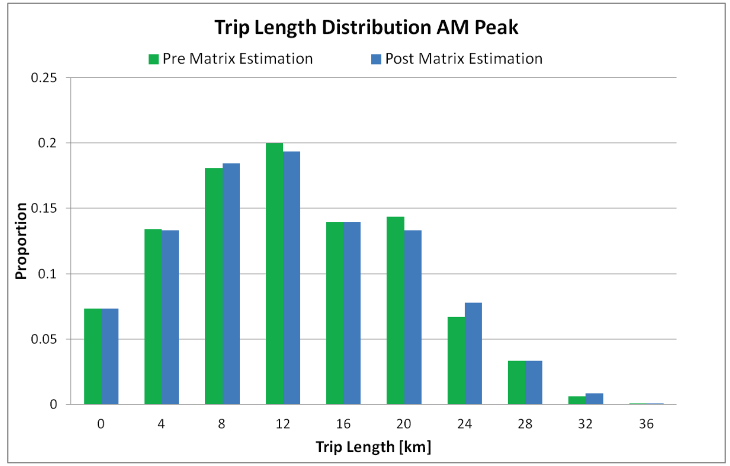

Figure 4-1: TLD AM Peak Hour (LV)

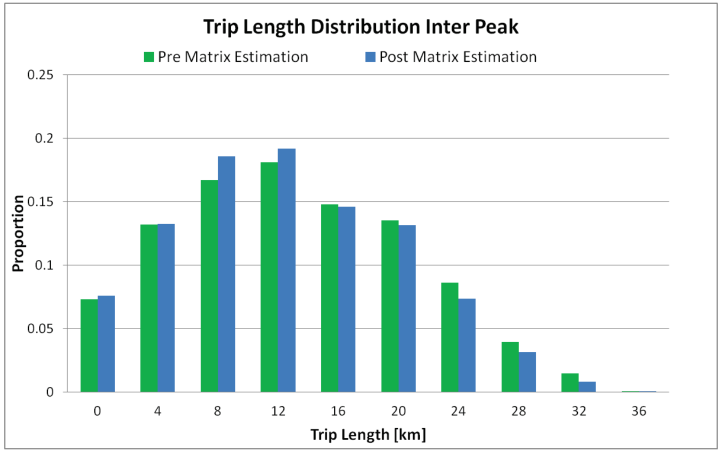

Figure 4-2: TLD Inter Peak Hour (LV)

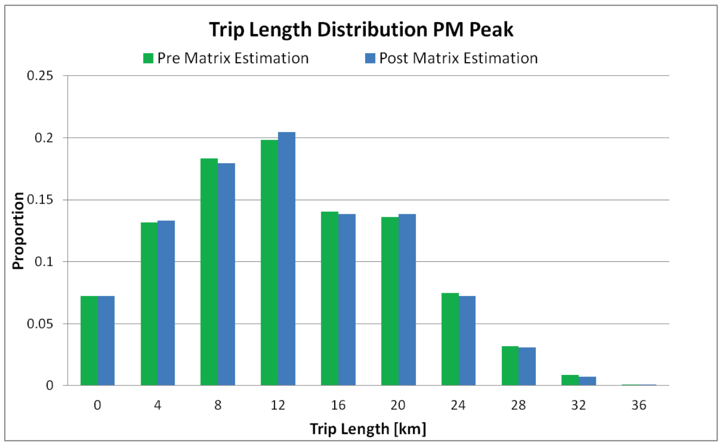

Figure 4-3: TLD PM Peak Hour (LV)

4.4 Model Validation

4.4.1 Overview

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

- Link flow validation and statistical criteria;
- Overall model validation (e.g. journey times); and
- Validation of routing through the network.

The count locations that were used in the model validation process are illustrated in Appendix C.

4.4.2 Validation of Traffic Flows

The observed and modelled flows were compared at each of the validation sites in accordance with the criteria outlined in *PAG Unit 5.2: Construction of Traffic Models* and with reference to the validation criteria outlined in Table 5.2.3 of that unit. 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 E and are summarised in Tables 4-5 and 4-6 below.

Table 4-5: Validation Results: Individual Links

Time Period	**% of Validation Sites Meeting the flow criteria that: Individual Flows within 15% for flows 700 – 2700 vph Individual flows within 100 vph for flows < 700 vph Individual flows within 400 vph for flows > 2700 vph**			
	Link Flows			
	Total Traffic	Lights	Heavies	Required
AM Peak	85%	90%	100%	>85%
Inter Peak	100%	100%	100%	>85%
PM Peak	85%	85%	100%	>85%

Table 4-6: Validation Results: GEH Values

Time Period	**% of Validation Sites with GEH < 5**			
	GEH < 5			
	Total Traffic	Lights	Heavies	Required
AM Peak	90%	95%	95%	>85%
Inter Peak	100%	100%	100%	>85%
PM Peak	95%	90%	95%	>85%

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

4.4.3 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 4-7 to 4-9 for the AM, Inter and PM peak hours, respectively.

Table 4-7: AM Peak Journey Times Validation (sec)

Route	Direction	Time Period	Modelled	Observed	Difference	% Diff	Validated
1	Eastbound	08:00 – 09:00	735	726	9	1%	Yes
1	Westbound	08:00 – 09:00	652	685	-33	-5%	Yes
2	Eastbound	08:00 – 09:00	185	161	24	15%	Yes
2	Westbound	08:00 – 09:00	165	167	-2	-1%	Yes
3	Northbound	08:00 – 09:00	99	97	2	3%	Yes
3	Southbound	08:00 – 09:00	118	146	-28	-19%	Yes
4	Westbound	08:00 – 09:00	386	431	-45	-10%	Yes
4	Eastbound	08:00 – 09:00	540	531	9	2%	Yes
5	Westbound	08:00 – 09:00	345	286	59	21%	Yes
5	Eastbound	08:00 – 09:00	440	466	-26	-6%	Yes
6	Westbound	08:00 – 09:00	340	330	10	3%	Yes
6	Eastbound	08:00 – 09:00	478	414	64	15%	Yes
7	Westbound	08:00 – 09:00	305	315	-10	-3%	Yes
7	Eastbound	08:00 – 09:00	207	176	31	18%	Yes

Table 4-8: Inter Peak Journey Times Validation (sec)

Route	Direction	Time Period	Modelled	Observed	Difference	% Diff	Validated
1	Eastbound	12:00 – 14:00	617	660	-43	-6%	Yes
1	Westbound	12:00 – 14:00	685	716	-31	-4%	Yes
2	Eastbound	12:00 – 14:00	190	192	-2	-1%	Yes
2	Westbound	12:00 – 14:00	178	178	0	0%	Yes
3*	Northbound	12:00 – 14:00	107	-	-	-	-
3	Southbound	12:00 – 14:00	106	164	-58	-35%	Yes
4	Westbound	12:00 – 14:00	361	407	-46	-11%	Yes
4	Eastbound	12:00 – 14:00	364	385	-21	-5%	Yes
5	Westbound	12:00 – 14:00	355	310	45	15%	Yes
5	Eastbound	12:00 – 14:00	342	367	-25	-7%	Yes
6	Westbound	12:00 – 14:00	348	374	-26	-7%	Yes
6	Eastbound	12:00 – 14:00	367	341	26	8%	Yes
7	Westbound	12:00 – 14:00	215	214	1	0%	Yes
7	Eastbound	12:00 – 14:00	173	185	-12	-6%	Yes

** No observed data available for this route in Northbound direction.*

Table 4-9: PM Peak Journey Times Validation (sec)

Route	Direction	Time Period	Modelled	Observed	Difference	% Diff	Validated
1	Eastbound	17:00 – 18:00	725	749	-24	-3%	Yes
1	Westbound	17:00 – 18:00	1015	937	78	8%	Yes
2	Eastbound	17:00 – 18:00	192	195	-3	-2%	Yes
2	Westbound	17:00 – 18:00	308	319	-11	-3%	Yes
3	Northbound	17:00 – 18:00	106	163	-57	-35%	Yes
3	Southbound	17:00 – 18:00	99	155	-56	-36%	Yes
4	Westbound	17:00 – 18:00	610	562	48	9%	Yes
4	Eastbound	17:00 – 18:00	385	442	57	13%	Yes
5	Westbound	17:00 – 18:00	449	400	49	12%	Yes
5	Eastbound	17:00 – 18:00	387	329	58	18%	Yes
6	Westbound	17:00 – 18:00	462	404	58	14%	Yes
6	Eastbound	17:00 – 18:00	429	374	55	15%	Yes
7	Westbound	17:00 – 18:00	239	223	13	6%	Yes
7	Eastbound	17:00 – 18:00	298	210	49	23%	Yes

All models satisfy the PAG requirement that 85% of all modelled journey times are within 15% of observed data or less than 60 seconds. As such the base year model is validated to the requirements of *PAG Unit 5.2: Construction of Transport Models.*

4.4.4 Assessment 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 2.3.1. The patterns were compared based on the percentage split of destinations from each survey location based on the locations shown in Figure 2.4. Whilst no guidelines exist on validation targets, a target of +/- 20% was used as a target deviation limit. Tables 4-10 to 4-12 below show that the AM Peak, Inter Peak and PM Peak model met this target with no O-D pair having a difference in excess of +/- 20%.

Table 4-10: Comparison of AM Period Traffic Patterns

		Last Seen					
		1	**2**	**3a**	**3b**	**3c**	**4**
First Seen	**1**		-18%	3%	0%	0%	15%
	2	-19%		10%	0%	-1%	10%
	3a	-6%	5%		0%	0%	1%
	3b	-	-	-	-	-	-
	3c	-13%	-2%	20%	-2%		-4%
	4	5%	-8%	2%	0%	0%	

Table 4-11: Comparison of Inter Peak Period Traffic Patterns

		Last Seen					
		1	2	3a	3b	3c	4
First Seen	1	-	-16%	7%	0%	-1%	10%
	2	-18%	-	9%	0%	-2%	11%
	3a	-9%	-3%	-	0%	15%	-3%
	3b	7%	-1%	-3%	-	10%	-12%
	3c	-11%	-6%	8%	-1%	-	10%
	4	-1%	-2%	-1%	1%	3%	-

Table 4-12: Comparison of PM Peak Period Traffic Patterns

		Last Seen					
		1	2	3a	3b	3c	4
First Seen	1		-15%	3%	0%	3%	10%
	2	-14%		16%	0%	0%	-1%
	3a	-6%	-6%		1%	4%	7%
	3b	-	-	-	-	-	-
	3c	4%	-1%	-9%	-3%		10%
	4	5%	-10%	1%	0%	5%	

4.5 Review of Travel Patterns

As a final check of the Base Year Models, it was considered prudent to review the travel patterns trough the model to understand dominant movements. A good understanding of the existing travel demand is derived through an analysis of key desire lines from the traffic models. This analysis of desire lines is achieved through the definition of 'sectors' which represent key areas of the traffic models as follows:

- Sector 1 – M9/Kilcullen;
- Sector 2 – Naas;
- Sector 3 – N7 East/Dublin;
- Sector 4 – Newbridge;
- Sector 5 – M7 West; and
- Sector 6 – Clane/Prosperous.

These 6 sectors are illustrated in Figure 4-4

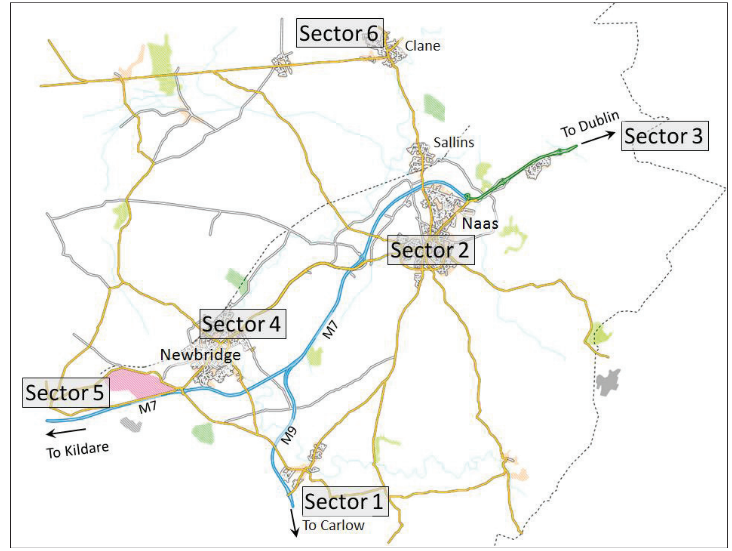

Figure 4-4: Traffic Model Sectors

Figures 4-5 to 4-7 illustrate the key desire lines in the study area during the AM Peak, Inter Peak and PM Peak hours. The desire lines highlight the dominance of the demand between Naas and N7 East with a strong by-pass movement of Naas being most evident during the peak periods.

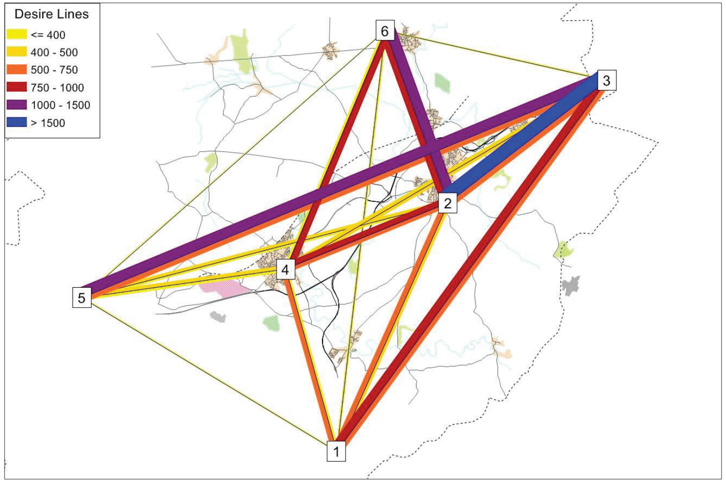

Figure 4-5: AM Peak Desire Lines (vehs)

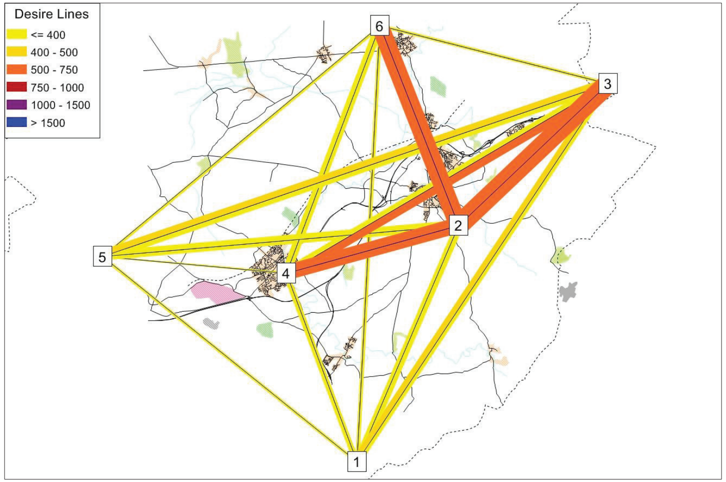

Figure 4-6: Inter Peak Desire Lines (vehs)

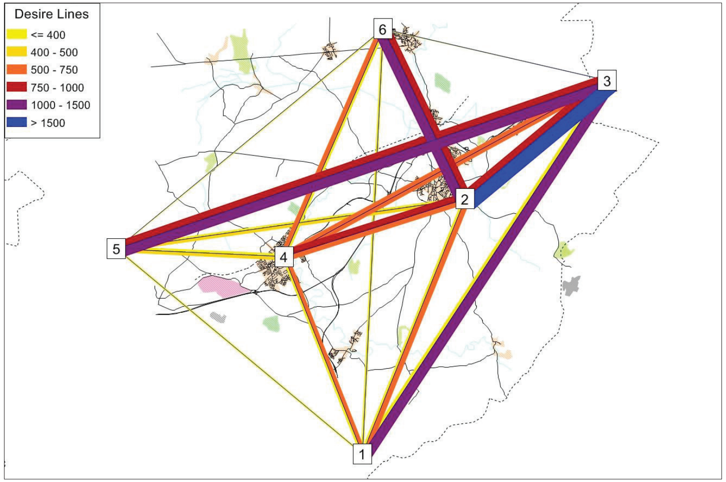

Figure 4-7: PM Peak Desire Lines (vehs)

5.0 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 Opening Year (2015) and Design Year (2030) of the scheme.

5.2 Future Year Matrix Development

The development of traffic growth forecasts for the future year LAM's has been based on the requirements set out in PAG unit 5.4: *Zone-Based Traffic Growth Forecasting*. That guidance sets out separate methodologies for establishing trip end growth for internal and external zones within the LAM.

5.2.1 Demographic Growth (NTM)

The NTM is made up of 874 zones, each of which contains demographic data (population, employment and car ownership) for a base year of 2010 and forecast years of 2025 & 2040. Demographic data is available for three future year growth scenarios namely NRA Low, Medium and High.

The future year traffic forecasts for the NTM are based on demographic and economic projections which have been prepared at a zonal level. The medium growth projections are consistent with aggregate forecasts prepared by the Central Statistics Office scenario M0F1 which assumes zero net-migration. High and Low projections represent upper and lower bounds on anticipated growth over the same period. The NTM uses a Trip Attraction Generation Model (TAGM) to convert these demographic and economic indicators into trip ends for each NTM zone.

The future year growth in traffic in the LAM is based on the forecast growth in population and employment in the LAM. The LAM for the M7 is made up of the following NTM zones located in County Kildare:

- Clane, Staffan and Balraheen: Zone 494;
- Bodenstown: Zone 496;
- Kilmeage and Robertstown: Zone 500;
- Carragh, Donore and Downings: Zone 502;
- Naas Town and Naas Rural, Kill, Kilteen and Rathmore: Zones 504;
- Dunmurry, Feighcullen, Pollardstown and Ratheman: Zone 508;
- Droichead Nua, Ladytown, Morristownbiller and Oldconnel: Zone 510;
- Ballymote Eustace, Carnalway, Killashee and Newtown: Zone 512; and
- Gilltown, Kilcullen and Usk: Zone 514.

A total of 15 external zones (2000-2014) feed traffic into and out of the study area. The zones included in the M7 LAM are illustrated below in Figure 5-1.

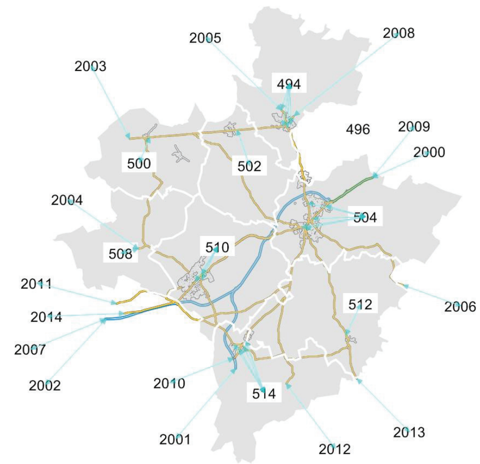

Figure 5-1: NTM Zones in LAM

5.2.2 Internal Zone Trip End Growth Factors

The first step was to establish the relationship between the LAM zones and the NTM zones. Following this the origin (O) and destination (D) Trip End Growth (TEG) factors for the zones in the LAM were identified for the AM Peak, Inter Peak and PM Peak hours from PAG Unit 5.4. The TEG factors established for the AM, Inter and PM Peak hours for the NRA low, medium and high growth scenarios are presented in the Appendix F.

5.2.3 External Zone Trip End Growth Factors

The LAM boundary was then cordoned from the both the 2010 Base Year NTM and 2025 and 2040 Do-Nothing NTM, these models where then compared against each other to establish growth factors for each external zone. These growth factors were then annualised to provide annual external TEG factors for the periods 2010–2025 and 2026-2040.

5.2.4 Total Growth in LAM

The total growth in the LAM was established by furnessing the 2012 base year matrices to the forecast 2015 and 2030 target trip ends outlined above. As part of this exercise the matrix totals were doubly constrained to the mean of the origin and destination forecast trip ends totals. Table 5-1 below presents the matrix totals for the NRA medium growth scenario.

Table 5-1: Total Growth in LAM (vehicles) – NRA Medium Growth

Matrix	2012	2015	2030	Growth			
				2012 - 2015	%	2012 - 2030	%
AM LV	20,196	21,041	25,384	845	4.2%	5188	25.7%
AM HV	975	1,001	1,089	26	2.6%	114	11.6%
Inter LV	11,110	11,523	13,593	413	3.7%	2483	22.4%
Inter HV	1,062	1,089	1,195	27	2.5%	133	12.5%
PM LV	20,557	21,419	25,855	862	4.2%	5298	25.8%
PM HV	748	768	833	20	2.7%	85	11.4%

Traffic growth in the LAM that does not have an origin or destination within the study area (i.e. through traffic) was then isolated from the total growth outlined in Table 5-1 above to highlight level of local growth. The results of this exercise are presented in Table 5-2.

Table 5-2: Total Growth in LAM excluding through traffic (vehicles) – NRA Medium Growth

Matrix	2015 Total Growth	2015 Through Traffic	Local Growth (2015)	2030 Total Growth	2030 Through Traffic	Local Growth (2030)
AM LV	844	87	757	5187	513	4674
AM HV	22	7	15	108	31	77
Inter LV	413	53	360	2483	333	2150
Inter HV	24	9	15	115	43	72
PM LV	861	82	779	5296	503	4793
PM HV	18	6	12	83	27	56

5.2.5 Reallocation of Future Year Growth

NRA PAG Unit 5.3 states that *"Within the LAM, there is some flexibility to reallocate growth between different LAM zones within a single NTM zone, although the trip end growth for the collective LAM zones that form the NTM zone should remain consistent with the zone-based trip end growth rates".*

In order to allocate the forecast growth to the disaggregated zones in Naas and its environs which is represented by NTM Zone 504 (as illustrated in Figure 5.2), a study of land use zonings was undertaken using the following documentation:

- Naas Local Area Plan (LAP) 2011 – 2017 (Naas Town Council);

- Kildare County Development Plan (CDP) 2011 – 2017;
- Kildare County Development Plan 2011 – 2017 Variation No.1 (to incorporate small towns) June 2012; and
- Sallins Local Area Plan (LAP)

The review identified a total of 16 zones within Naas Town and its environs where development could potentially occur. The locations of these zones within NTM zone 504 are illustrated in Figure 5.3.

Table 5-3 below outlines the proposed distribution of growth for the 16 zones which represent Naas Town and its environs (50401 to 50416). The actual total growth in trips within the 16 growth areas for Opening Year (2015) and Design Year (2030) during the AM Peak, Inter Peak and PM Peak hours is presented in Table 5-4 to Table 5-6 for Light Vehicles.

Table 5-3: Allocation of Additional Traffic to Zone 504 Sub-Zones

Zone 504 Sub-Zones	Trips								
	AM Peak			Inter Peak			PM Peak		
	IN	Out	Total	IN	Out	Total	IN	Out	Total
50401	1%	2%	1%	1%	1%	1%	2%	1%	1%
50402	0%	0%	0%	0%	0%	0%	0%	0%	0%
50403	1%	3%	2%	2%	2%	2%	3%	1%	2%
50404	3%	1%	2%	2%	2%	2%	1%	3%	2%
50405	2%	7%	4%	5%	5%	5%	8%	4%	5%
50406	5%	12%	8%	8%	7%	7%	13%	6%	9%
50407	8%	11%	9%	6%	5%	5%	7%	5%	6%
50408	2%	6%	4%	4%	4%	4%	7%	3%	5%
50409	2%	1%	2%	2%	2%	2%	1%	2%	1%
50410	0%	0%	0%	0%	0%	0%	0%	0%	0%
50411	69%	40%	57%	51%	51%	51%	34%	62%	51%
50412	0%	1%	1%	1%	1%	1%	2%	1%	1%
50413	1%	4%	3%	3%	3%	3%	5%	2%	3%
50414	1%	0%	1%	1%	1%	1%	0%	1%	1%
50415	3%	3%	3%	10%	11%	11%	8%	6%	7%
50416	3%	9%	5%	6%	6%	6%	10%	4%	7%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

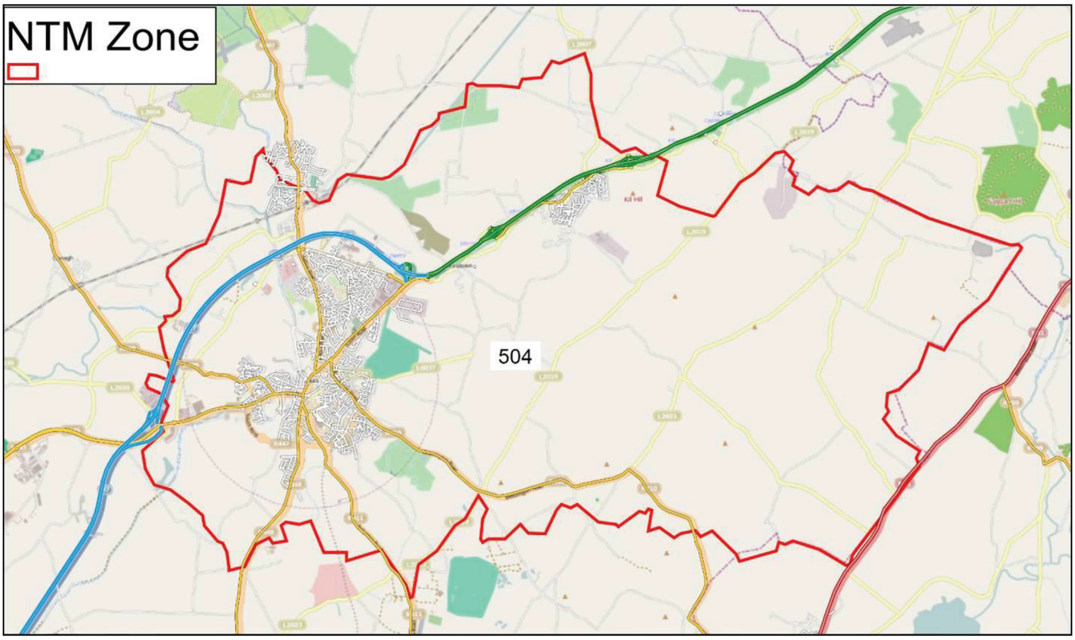

Figure 5-2: NTM Zone 504

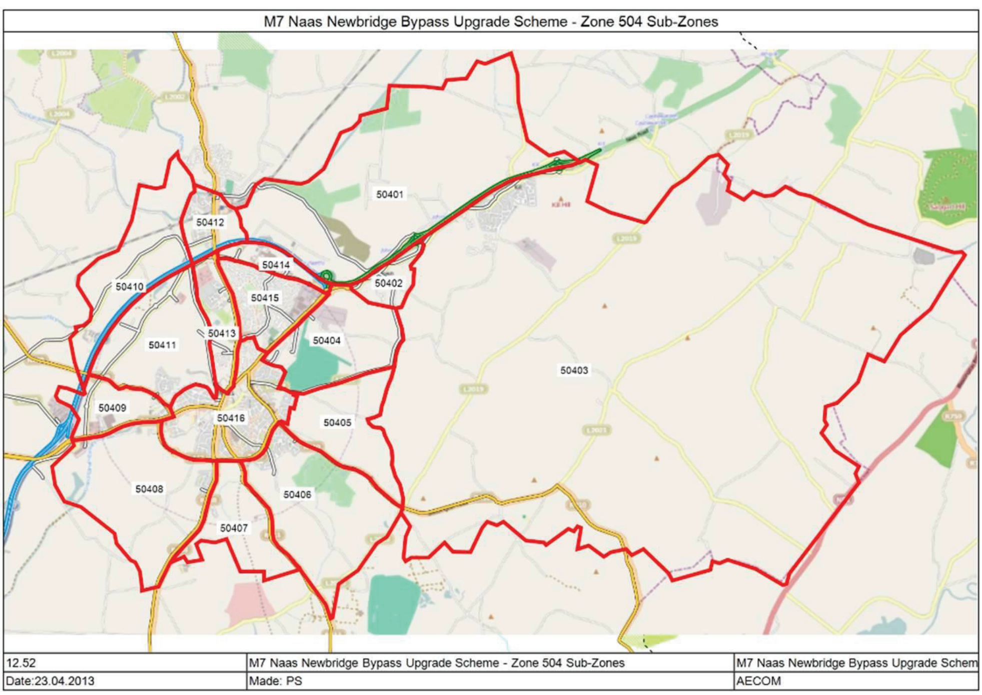

Figure 5-3: Zone 504 (Sub-Zones)

The future year target trip ends for the Opening Year, Design Year and Forecast Year scenarios were adjusted to take into account of the reallocation of the additional growth as outlined in Table 5-3 above. The forecast growth within disaggregated zones in Newbridge was allocated evenly across zones.

A detailed Technical Paper on the process for allocating the additional future demand in the Naas and environs area is presented in Appendix G.

5.2.6 Seeding

It was necessary to 'seed' the cells with no trips in the base year matrices with very small numbers to allow for future year trips between those specific origins and destinations. Otherwise any cell with a zero value will remain zero irrespective of the factor applied.

Following this the base matrices were 'furnessed' to the forecast origin and destination trip ends. The furnessing process was undertaken again whereby the matrix totals were doubly constrained to the mean of the forecast origin and destination trip end totals.

5.2.7 Matrix Totals

The subsequent trip matrix totals for the NRA low, medium and high growth scenarios following the reallocation of growth and trip distribution process outlined above is shown in Tables 5-4 to 5-6.

Table 5-4: Matrix Totals NRA Low Growth (vehicles)

Matrix	2012	2015	2030	% Growth	
	Base	Opening	Design	2012 - 2015	2012 - 2030
AM LV	20196	20896	24597	3.5	21.7
AM HV	975	995	1046	2.1	7.3
Inter LV	11110	11447	13140	3.3	18.3
Inter HV	1062	1090	1150	2.6	8.3
PM LV	20557	21275	25056	3.5	21.9
PM HV	748	761	805	1.7	7.6

Table 5-5: Matrix Totals NRA Medium Growth (vehicles)

Matrix	2012	2015	2030	% Growth	
	Base	Opening	Design	2012 - 2015	2012 - 2030
AM LV	20196	21040	25384	4.2	25.7
AM HV	975	1001	1089	2.7	11.7
Inter LV	11110	11523	13593	3.7	22.3
Inter HV	1062	1098	1195	3.5	12.5
PM LV	20557	21419	25855	4.2	25.8
PM HV	748	768	833	2.7	11.6

Table 5-6: Matrix Totals NRA High Growth (vehicles)

Matrix	2012	2015	2030	% Growth	
	Base	Opening	Design	2012 - 2015	2012 - 2030
AM LV	20196	21599	28878	6.9	43.0
AM HV	975	1028	1255	5.4	28.7
Inter LV	11110	11832	15635	6.5	40.7
Inter HV	1062	1132	1373	6.6	29.2
PM LV	20557	21985	29416	6.8	43.0
PM HV	748	790	960	5.6	28.3

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 Peak, Inter Peak and PM Peak (Light Vehicles) are illustrated below for the NRA medium growth scenario. The figures compare the TLD in the 2012 Base Year models and the 2030 Design Year Medium 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 Peak, Inter Peak and PM Peak are shown respectively in Figure 5-4 to 5-6 below.