Blyth Traffic Model Local Model Validation Report

Northumberland County Council

Project Number: 60514724

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Quality information

Prepared by	Checked by	Approved by
Philip Miller Consultant	Gemma Paget Principal Consultant	Gary Macdonald Regional Director

Revision History

Revision	Revision date	Details	Authorised	Name	Position
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Distribution List

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Prepared for:

Northumberland County Council

Prepared by:

AECOM Limited
One Trinity Gardens
First Floor
Quayside
Newcastle-upon-Tyne
NE1 2HF
UK

T: +44 (191) 224 6500
aecom.com

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1. Introduction

1.1 Introduction

Northumberland County Council understands that the efficient operation of local and strategic highway routes is an important factor in helping deliver and sustain a thriving and competitive economy. They also recognise that traffic congestion in the town of Blyth is resulting in key routes into and out of the town not operating as efficiently as they could.

A transport study undertaken in 2015 identified a number of quick wins to help alleviate congestion. However, the study also recognised that if proposals outlined in the emerging Local Plan are to be delivered, additional highway capacity will need to be considered; a relief road into Blyth was identified as a potential solution.

A relief road into Blyth has been considered for a number of years to alleviate the growing traffic congestion issues facing the area. In 2013, Northumberland County Council submitted a bid to the Department for Transport (DfT) for pinch point funding to develop the initial stages of a relief road. However, the bid was unsuccessful, as it was recognised by DfT that the scheme being proposed would constitute a major scheme and would need to be subject to a more detailed appraisal approach to ensure the optimum solution is identified, which demonstrates clear value for money.

In May 2016, Northumberland County Council (NCC) commissioned AECOM to develop a strategic traffic model for Blyth to appraise a number of alignment options for a relief road into Blyth. The outputs from the traffic modelling and appraisal will be used to produce an Outline Business Case for investment. The methodology which has been adopted to build this model is summarised in the remaining sections of this report.

1.2 Purpose of the LMVR Report

The purpose of this Local Model Validation Report (LMVR) is to:

- Describe how the traffic model has been developed;
- Assess how well the traffic model compares with surveys; and
- Summarise the accuracy of the Base Year model from which forecasts are prepared.

This report will demonstrate that the Base Year model is able to accurately reflect current traffic conditions and will provide a reliable basis for the development of the forecast models needed to promote the scheme.

1.3 Report Structure

The structure of this LMVR reflects the recommended structure set out in WebTAG Unit M3.1 and contains the following chapters:

- Chapter 2 – Proposed Uses of the Model and Key Design Considerations: this section outlines the known and expected uses of the model, and how the model has been defined in response to these objectives;
- Chapter 3 – Model Standards: this chapter details the measures used to assess the model in terms of modelled flows and journey times, and also discusses the convergence criteria and standards adopted within the model;
- Chapter 4 – Key Features of the Model: this chapter considers the main characteristics of the highway model: including the network structure, zone system, time periods modelled, and the user classes within the assignment;
- Chapter 5 – Calibration and Validation Data: this chapter details the data collection and processing, and identifies data suitable for the calibration and validation of the highway model;

- Chapter 6 – Network Development: this chapter details the methods and processes adopted in the development and checking of the highway network including junction modelling and the speed-flow relationships;
- Chapter 7 – Trip Matrix Development: this chapter details the development of the prior matrices using observed roadside interview data and the synthesis of unobserved movements using a gravity model approach;
- Chapter 8 – Trip Matrix Calibration and Validation: this chapter details the prior matrix validation across screenlines and the matrix estimation process;
- Chapter 9 – Network Calibration and Validation: this chapter details the checks on the network coding;
- Chapter 10 – Route Choice Calibration and Validation: this chapter uses a series of logic checks to review the routing within the highway assignment;
- Chapter 11 – Assignment Calibration and Validation: this chapter details the performance of the model assignment against the standards defined in Chapter 3; and
- Chapter 12 – Summary of Model Development, Standards Achieved and Fitness for Purpose: this chapter summaries the results of the model calibration and validation, and assesses the outcome of this process against the applications of the model.

2. Proposed Uses of the Model and Key Model Design Considerations

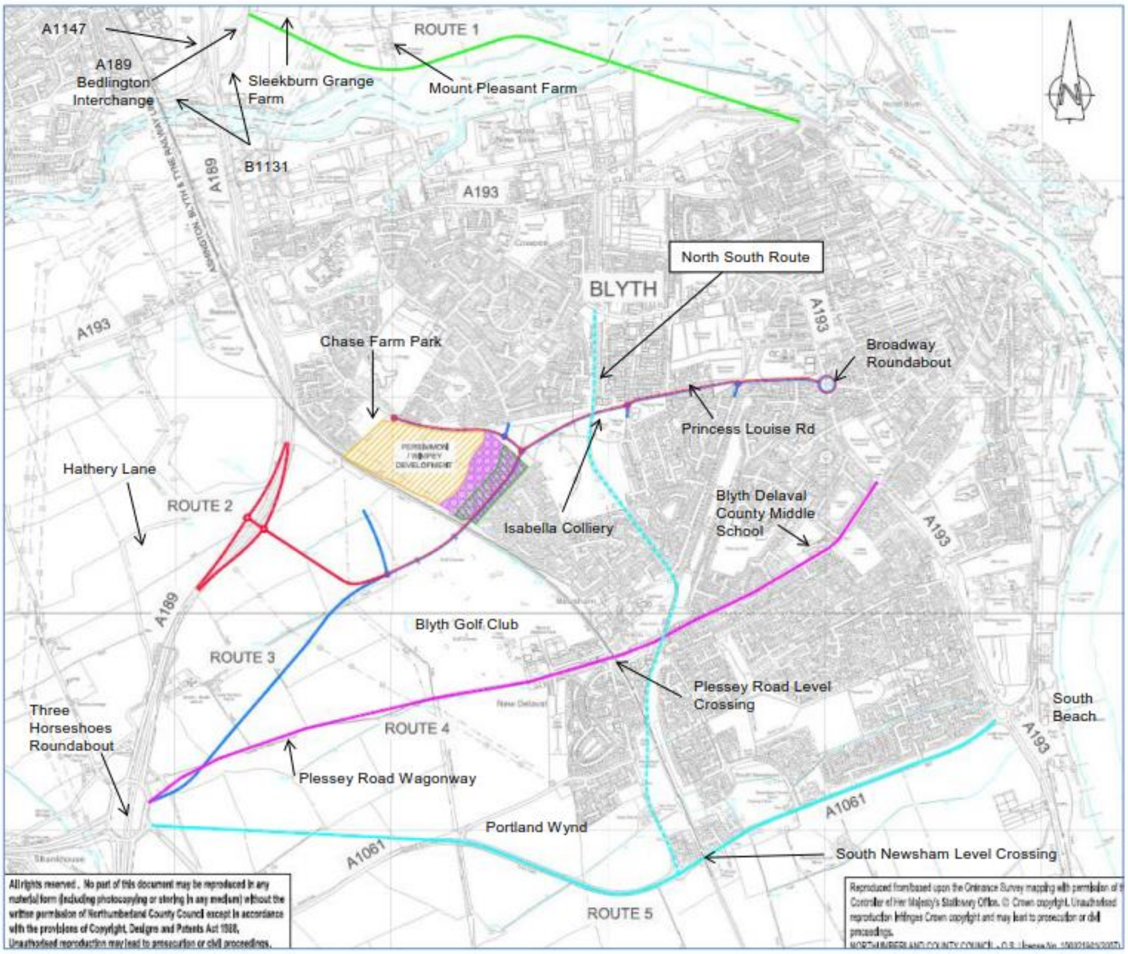
2.1 Overview

Northumberland County Council has identified five potential relief road options for Blyth, which the Blyth traffic model should be capable of assessing. The outputs from the traffic modelling will be used to develop an Outline Business Case for the scheme and will be used in statutory consultation. The model must therefore be developed to adhere to WebTAG guidance for the development of traffic models, and the NECA Assurance Framework, used to appraise the credibility of business cases. The following sections of this chapter of the report outline the factors which need to be taken into consideration in developing the traffic model for Blyth, to ensure the key purposes of the model are met.

2.2 Proposed Uses of the Model

The traffic model for Blyth needs to be developed so that it is capable of assessing five potential relief roads into Blyth. The assessment would need to be WebTAG compliant and adhere to the NECA Assurance Framework. The five options are shown in the figure below.

Figure 2-1: Blyth Relief Road Options



2.3 Key Model Design Considerations

There are four main responses to a transport scheme that the model would likely need to cover. These responses are set out below.

Table 2-1: Transport Scheme Responses

Traveller Response	Likely Importance to Blyth
Route Choice	This is likely to be the most important response to the proposed scheme and therefore this functionality must be included in the Blyth model
Time of Day Choice	Given the existing level of congestion and the time periods over which it occurs, it is possible that some existing trips have already shifted their time of travel in order to avoid the most congested periods. A new scheme is likely to offer improved journey times during the peak periods and therefore some of these trips may choose to return to their preferred time. This impact may be large enough to justify including a basic time of day choice in the mode.
Mode Choice	The relief road is aimed at improving private transport capacity and journey times. Given the low levels of public transport provision, it is unlikely that any material levels of model shift will result from these schemes and therefore it is not expected to be necessary to include a mode shift function in the model. The Ashington, Blyth and Tyne rail scheme may influence mode of travel in the area, particularly in relation to car access to the rail stations, but this scheme does not currently have sufficient status to justify including it in the relief road modelling assessments. Clearly, this could change over the course of the development of the relief road scheme and it is possible that a mode split or park and ride model may be required in the future
Destination Choice	These schemes will make Blyth more accessible to the areas around it. This will increase its attractiveness for some types of destination trips and could result in some trips choosing destinations in Blyth rather than surrounding towns and villages. A destination choice model may therefore be required within the Blyth model.

From the information in the table above, it is important that the model functionality includes route choice and perhaps time of day choice and destination choice. The route choice requirement can be satisfied by an appropriately specified highway assignment model. There are a number of different packages which could be used but the preference would be SATURN as it has a number of advantages over other packages given its representation of junctions is more detailed and accurate than in other packages. As the area under consideration is and urban area, this is important as the majority of delay comes from junctions.

The time of day choice and destination choice would need to be provided through the development of a bespoke model or through the use of DIADEM. DIADEM has a number of demand responses coded within it and will provide the functionality for Blyth. DIADEM also contains an automated link with SATURN. The need for variable demand modelling cannot be established until the highway assignment modelling is complete and therefore the DIADEM modelling has not been progressed at this stage.

3. Model Standards

3.1 Overview

Typical model standards for this type of model are well documented in WebTAG to help guide methodologies to adopt a standard practice. This section of the report looks at this guidance in order to make clear the standards to which the Blyth model will be developed to. This chapter looks at convergence criteria as well as calibration/validation criteria

3.2 Validation Criteria and Acceptability Guidelines

Validation of base year trip matrices and model traffic flows should be carried out prior to forecasting any future year situation. This confirms the performance of the network against the real life situation and highlights any areas where adjustments may be required. Where adjustments are required, it is known as calibration.

Validation is a comparison of modelled and observed data, independent of that data used in calibration.

Validation criteria is set out in section 3.2 of WebTAG Unit M3.1 Highway Assignment Modelling (January 2014), given in the tables below. This specifies that the validation of a highway assignment model should include comparisons of the following:

- assigned flows and counts totalled for each screenline or cordon, as a check on the quality of the trip matrices;
- assigned flows and counts on individual links and turning movements at junctions as a check on the quality of the assignment; and
- modelled and observed journey times along routes, as a check on the quality of the network and the assignment.

The above criteria has been used in the assessment of the suitability of the Blyth traffic model, to ensure the model accords with DfT best practice and will be a suitable tool to inform any subsequent business case.

Table 3-1. Validation Criterion and Acceptability Guidelines for Screenline Flows in Trip Matrix Validation

Criteria	Acceptability Guideline
Differences between modelled flows and counts should be less than 5% of the counts	All or nearly all screenlines

Source: WebTAG Unit M3.1, 3.2, Table 1

Table 3-2. Validation Criteria and Acceptability Guidelines for Link Flow and Turning Movement Validation

Criteria	Description of Criteria	Acceptability Guideline
1	Individual flows within 100 veh/h of counts for flows less than 700 veh/h	>85% of cases
	Individual flows within 15% of counts for flows from 700 to 2700 veh/h	
	Individual flows within 400 veh/h of counts for flows more than 2700 veh/h	
2	GEH <5 for individual flows	

Source: WebTAG Unit M3.1, 3.2, Table 2

In the above, GEH is a form of Chi-squared statistic that incorporates both relative and absolute errors and is defined as below:

$$GEH = \sqrt{\frac{(M-C)^2}{\left(\frac{(M+C)}{2}\right)}}$$

Where:

M = Modelled flow

C = Observed flow

With regard to flow validation, the following should be noted:

- the comparisons should be presented for cars and all vehicles but not for light and other goods vehicles unless sufficiently accurate link counts have been obtained;
- the comparisons should be presented separately for each modelled period; and
- it is recommended that comparisons using both measures are reported in the model validation report.

These conventions are followed in this report.

In addition to traffic flows, WebTAG also stipulates that journey times should be validated, with overall performance requirements detailed below in Table 3-3:

Table 3-3. Journey Time Validation Criterion and Acceptability Guideline

Criteria	Acceptability Guideline
Modelled times along route should be within 15% of surveyed times (or 1 minute, if higher than 15%)	>85% of routes

Source: WebTAG M3.1, 3.2, Table 3

3.3 Convergence Criteria Standards

Convergence is associated with the level of stability within the model whereby trip distributions do not alter substantially between runs and the model is in equilibrium.

Before any results of a traffic assignment can be used to influence a decision, it must be confirmed that the model has reached an acceptable level of stability.

Convergence criteria are set out in WebTAG Unit M3.1 Highway Assignment Modelling (January 2014). It is suggested to meet a high level of convergence for any highway assignment. This is particularly important as a lower level of convergence may result in unstable and unreliable assessments of benefits associated with any forecasted scheme. Table 3-4 presents guidance on convergence criteria best-practice.

Table 3-4. Summary of Convergence Measures and Base Model Acceptable Values

Measure of Convergence	Base Model Acceptable Values
Delta and %GAP	Less than 0.1% or at least stable with convergence fully documented and all other criteria met
Percentage of links with flow change (P)<1%	Four consecutive iterations greater than 98%
Percentage of links with cost change (P2)<1%	Four consecutive iterations greater than 98%
Percentage change in total user costs (V)	Four consecutive iterations less than 0.1% (SUE only)

Source: WebTAG M3.1, 3.3, Table 4

The Blyth traffic model has been developed to ensure the %GAP and the Percentage of link flows with flow change 1% meet the criteria identified in the above table.

4. Key Features of the Model

4.1 Introduction

This section of the report outlines the key features of the Blyth traffic model. It briefly looks at strategic components of the model, including study area, zoning, user classes and assignment methodologies.

4.2 Highway Model Description

The Blyth traffic model has been developed using the SATURN highway assignment software package (version 11.3.12U). One of the main benefits of using SATURN for the assignment process is that it is applicable to both urban and rural networks and can model peak hour congestion in sufficient detail. As a combined simulation and assignment model, SATURN also has the advantage that it enables detailed junction modelling.

The traffic model comprises two elements:

- Network: Represented by a series of nodes and links. The nodes represent junctions, whilst the links represent the sections of road connecting the junctions. This is discussed further in Chapter 6; and
- Traffic Demand: the demand for travel represented by the starting point (known as an origin) and finishing point (known as a destination) of a journey; the information for which is stored within a "trip matrix" containing the number of trips from each origin to each destination. Origins and destinations are defined by geographic zones. This is discussed further in Chapter 7.

SATURN is built upon two key modelling functions: simulation and assignment. The simulation function attempts to represent link and junctions properties as they exist in real life, based on what has been coded into the model and what flows are detected on them. These properties help determine factors such as the capacity of links and junctions, speeds, and delays.

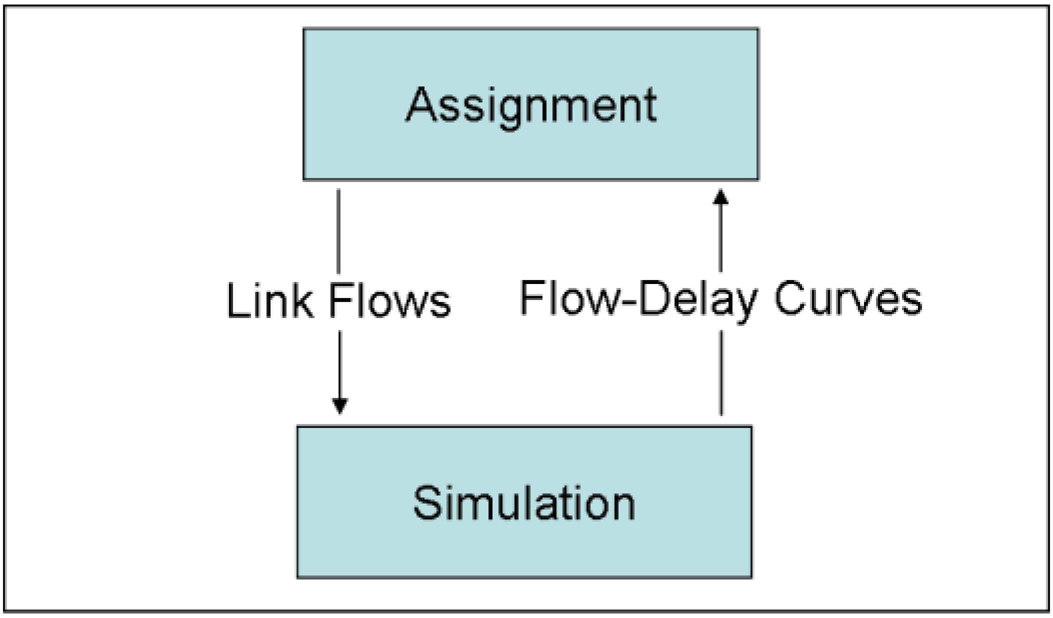
The assignment function takes the journeys within the matrices and loads them onto the transport network, providing a prediction of the routes that vehicles will select for their journeys and the way that traffic (demand) interacts with the network (supply).

Whilst the assignment function is running, it takes into account factors such as link and junction delay from the simulation function and develops a series of optimum routes that take into account those delays. The simulation function then produces revised delay statistics and journey time information based on network conditions and the flows assigned to the network.

The assignment function is then run again, taking those most recent delay calculations into account, which produces a new set of routes and flows which can be assessed by the simulation network.

This iterative process between these two functions is known as an "assignment-simulation loop", whereby the simulation and assignment functions interact until the routes predicted in the traffic model stabilise and the changes in flow compared to the previous loop become very small and/or the route choices in the model are within a given range of the minimum cost routes that could be utilised. The model is then said to have "converged". The process is shown in Figure 4-1.

Figure 4-1. Assignment-Simulation Loop Flow Diagram



Source: SATURN Manual (V11.2)

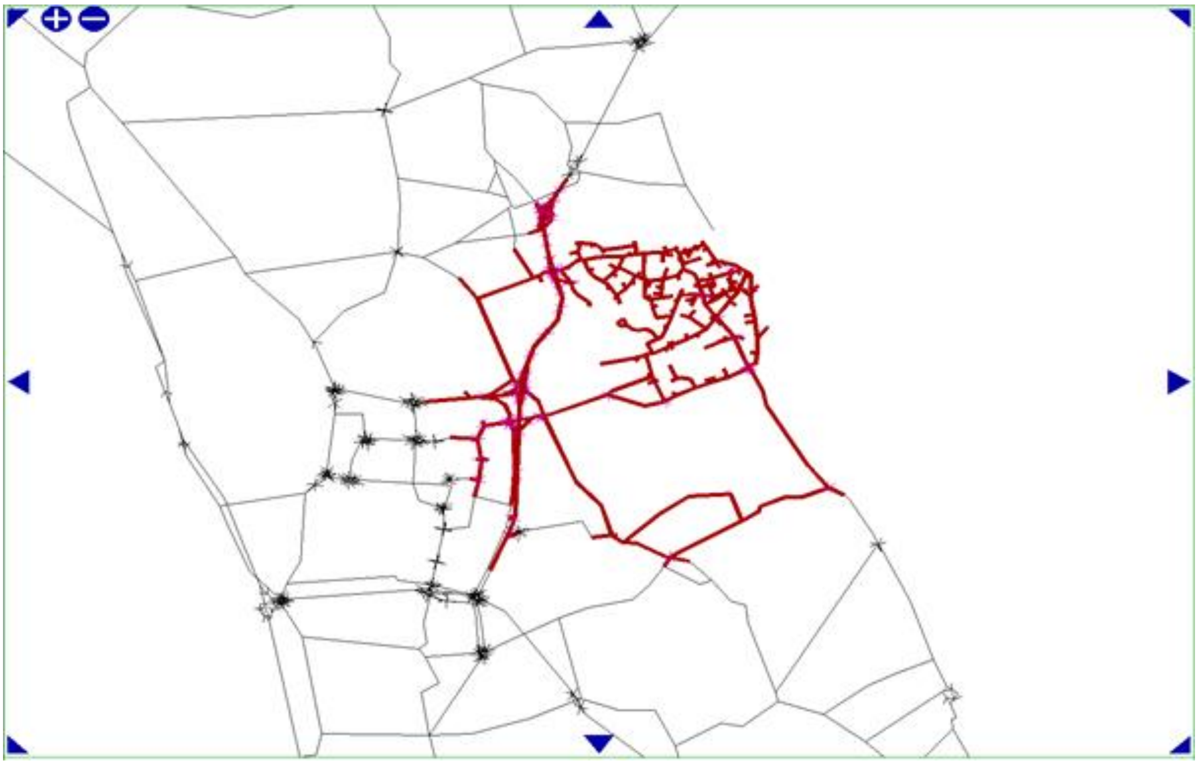
The resultant flows and journey times can then be compared to observed values to see how well the model represents real life traffic conditions and determine whether the model is fit-for-purpose for assessing the effects of the new scheme. This process is known as “validation”.

In order to achieve an acceptable level of validation, the traffic model may be first subject to local adjustments. These adjustments can be applied to both the network and the matrix in a process known as “calibration”, further discussed in Chapter 5.

4.3 Study Area

The aim of the Blyth traffic model is to model travel demand and network conditions within the Blyth local area; the model also needs to be sufficient to enable all route choices resulting from the proposed schemes to be modelled appropriately. Based on these requirements, the detailed coverage of the model includes the whole of the Blyth urban road network, a section of the A189, East Cramlington, Seaton Delaval and Seaton Sluice; this is shown in red in Figure 4-2 below.

Figure 4-2. Blyth SATURN Model: Extent of Simulation Links



The area covered by simulation network in the Blyth traffic model accords with WebTAG guidance M3.1 which states the following:

> '***Area of Detailed Modelling****: This is the area over which significant impacts of interventions are certain…*"all roads that carry significant volumes of traffic" should be included and more generally that networks "should be of sufficient extent to include all realistic choices of route available to drivers". For a model created for a specific scheme, the network should include all main roads, as well as those secondary routes, and roads in residential areas (especially 'rat-runs'), that are likely to carry traffic movements which could use the scheme being assessed'

The model extends outside of this area but the level of spatial detail reduces the further from the study area of Blyth. The remainder of Cramlington, Whitley Bay, Ashington and other immediate surrounding areas to the simulation areas have been coded as buffer network, with speed-flow curves providing anticipated speeds and capacity on surrounding links. This is in line with WebTAG M3.1 guidance as identified below:

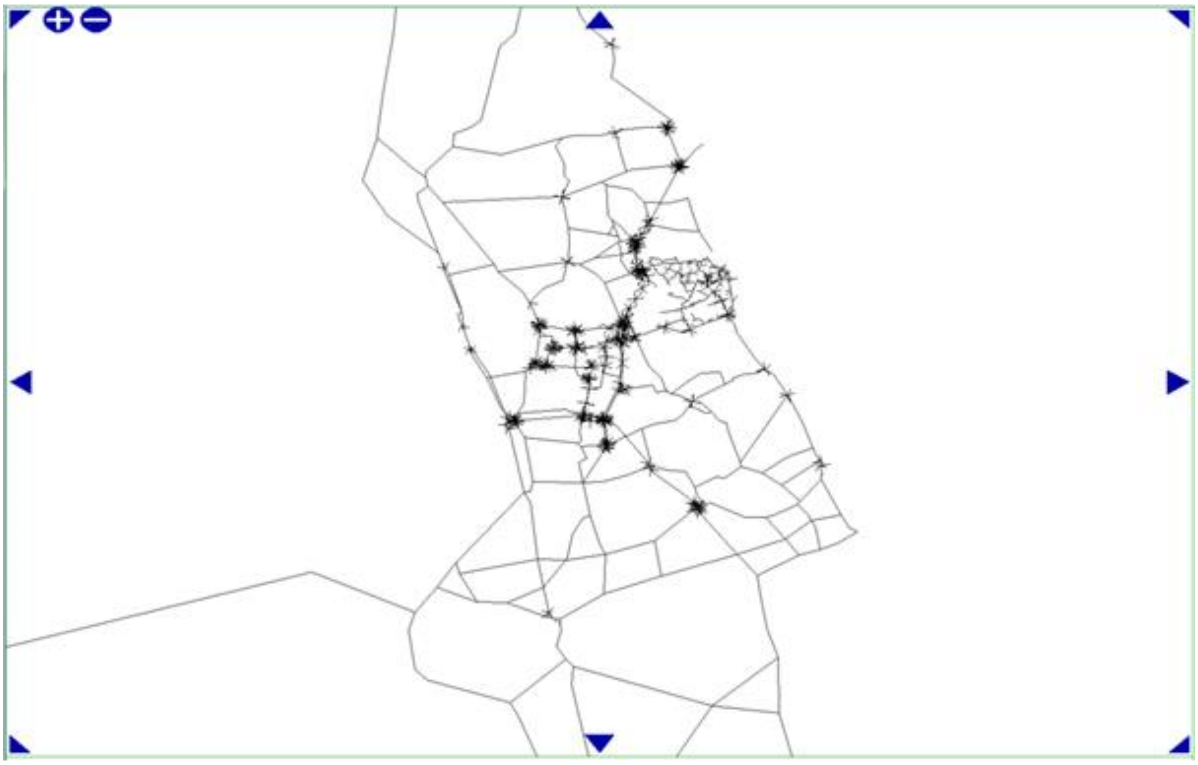
> '***Rest of the Fully Modelled Area****: This is the area over which the impacts of interventions are considered to be quite likely but relatively weak in magnitude. It would be characterised by: representation of all trip movements; somewhat larger zones and less network detail than for the Area of Detailed Modelling; and speed/flow modelling (primarily link-based but possibly also including a representation of strategically important junctions).*

Further out, and covering routes across the country, an external network has been coded using SATURN buffer network with fixed speeds. The purpose of this external network is to provide a realistic estimate of end to end journey costs for long-distance trips coming in and out of Blyth to ensure that these trips approach the simulation area on the correct road. The roads serve larger zones and are therefore coded with infinite capacity to avoid unrealistic delay. This again accords with WebTAG guidance as set out in the paragraph below.

> '***External Area****: In this area impacts of interventions would be so small as to be reasonably assumed to be negligible. It would be characterised by: a network representing a large*

proportion of the rest of Great Britain, a partial representation of demand (trips to, from and across the Fully Modelled Area); large zones; skeletal networks and simple speed/flow relationships or fixed speed modelling.'

Figure 4-3. Blyth SATURN Model: Wider Extent



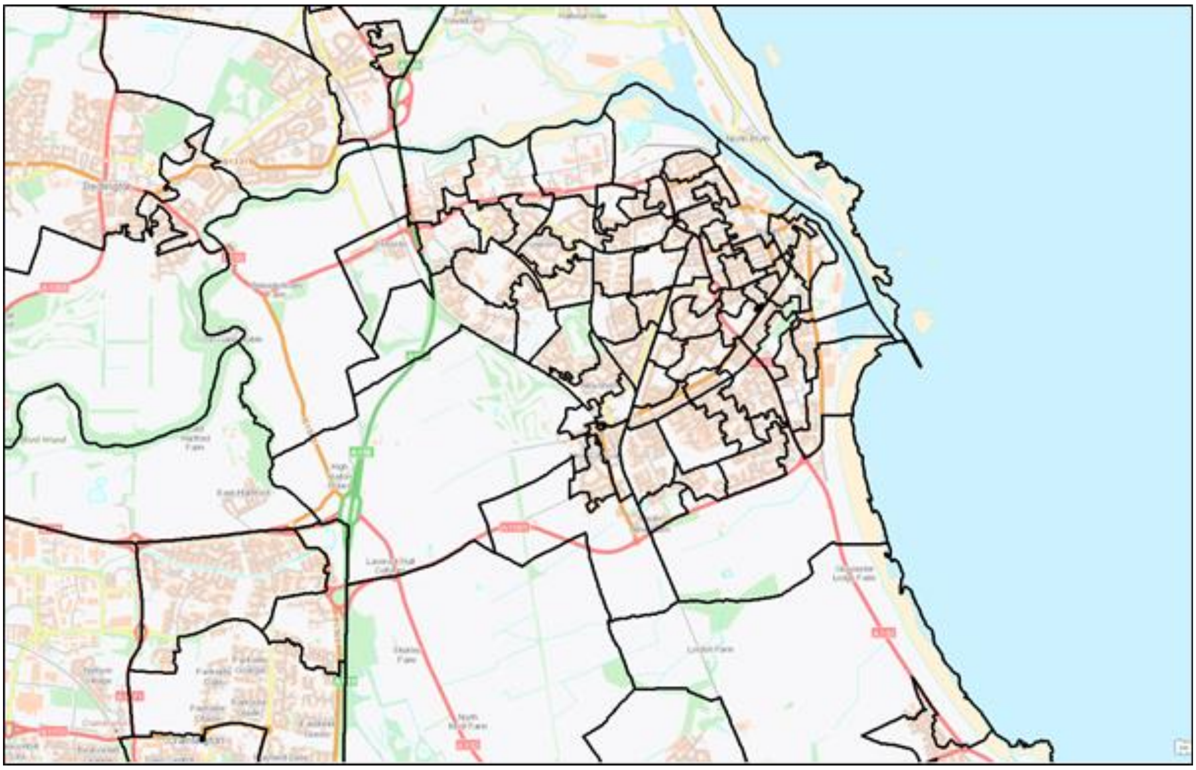
4.4 Zoning System

The zoning system follows a similar methodology to the road network described above, giving consideration to the guidance for a model zoning system provided in WebTAG M3.1.

Zones should be smallest in the Area of Detailed Modelling, becoming larger for the Rest of the Fully Modelled Area and progressively much larger for the External Area. At the boundary between the classifications of area type, it is important to avoid sudden changes in average zone size and a graduated approach is desirable. The primary building block for the zone system should be Census and administrative boundaries, and boundaries relating to national forecasts.'

The zoning system which covers the Blyth network has been disaggregated to the lowest spatial scale of Output Area (OA). The zoning system primarily follows these administrative boundaries due to the availability of planning data and inherent similar size of each area. This is shown below in Figure 4-4.

Figure 4-4. Blyth SATURN Model: Local Zoning System



Centroid connectors are links used to load traffic onto a network from a zone. The positioning of these centroid connectors on the road network are considered somewhat critical to achieving validation from the assignment model. Centroid connectors have been considered when designing the zoning system by deciding where traffic would realistically load onto the modelled road network within each zone. A series of spigot links have been used to connect centroid connectors to the road network in the detailed modelled area. These practices are reinforced in WebTAG M3.1 which stresses the importance in their appropriate use. This guidance also states:

> *'It is generally preferable to minimise the number of centroid connectors from a single zone to a network. Multiple connections can lead to instability during assignment and model convergence problems. There are also associated difficulties introduced where multiple centroid connectors can straddle traffic count locations and this should be avoided.'*

The surrounding zoning system varies at spatial scale depending on its proximity to the study area. The further from the Blyth road network, the larger the spatial aggregation of the zoning system becomes. These therefore extend from Lower Spatial Output Area (LSOA), Medium Spatial Output Area (MSOA), Local Authority (LA) up to Regional. Similar to the road network, the zoning system extends to cover the whole of GB in order to reflect longer distance trips.

Figure 4-5. Blyth SATURN Model: Wider Local Zoning System

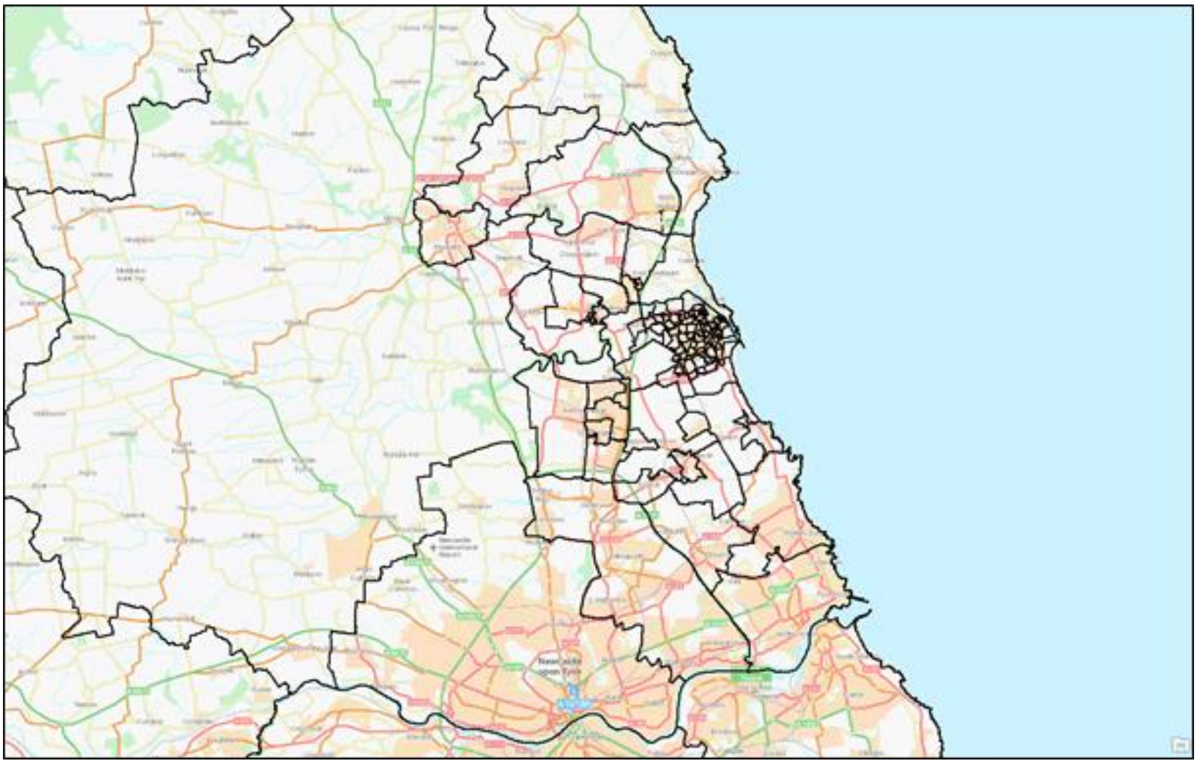
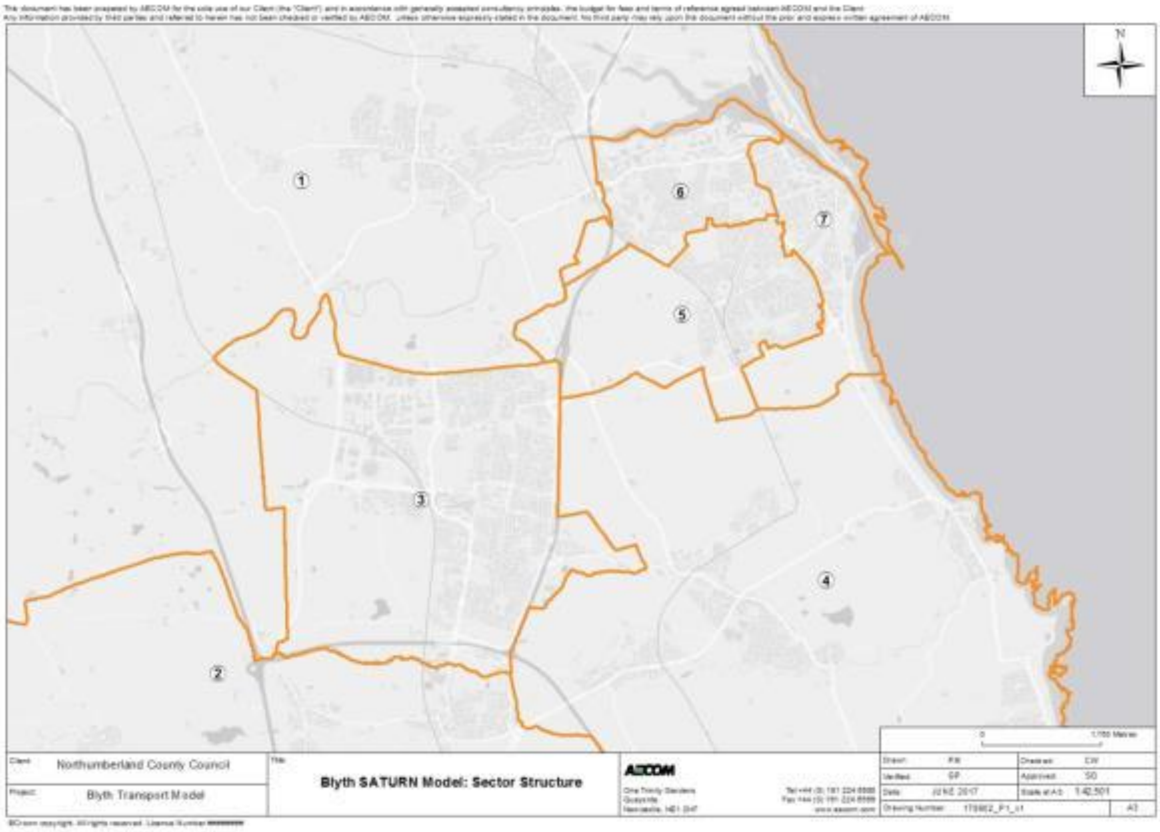


Figure 4-6. Blyth SATURN Model: Wider National Zoning System

4.5 Sectors

In order to report on overall trends in overall movements in and around Blyth, sectors were drawn up in order to observe general traffic movements throughout the peaks. A 7 zone system was created; with sectors 5 to 7 representing internal origins and destinations for Blyth. These sectors are also shown below in Figure 4-7.

Figure 4-7. Blyth Sector Location Map



4.6 Time Periods

The Blyth SATURN model has been calibrated in 3 time periods as set out in Table 4-1 below. It is considered that these peak hours represent the 3 key distinct peaks which represent different traffic behaviour and movements.

Table 4-1. Blyth SATURN Model Time Periods

Model Name	Modelled Time
AM Peak Hour	08:00 – 09:00
Inter-peak Hour	Average hour 10:00 – 16:00
PM Peak Hour	17:00 – 18:00

It is noted that a Saturday model has not been created due to the availability of data. Given the location of the study area, and the presence of retail developments along the A193 Cowpen Road corridor, the absence of a Saturday model will underestimate the benefits of a proposed scheme as congestion is also prevalent during the weekend.

4.7 User Classes

Blyth SATURN model has been coded in order to assign 5 distinct user classes, these are as follows:

- Car – Commute,
- Car – Employers Business,
- Car – Other,
- LGV – Business; and
- HGV – Business

Different user classes are used in order to define different generalised costs of operation, cost of time and distance. This means different combinations of vehicle type and user type have different costs, defining routing decisions based upon the journey purpose and total journey cost. These journey purpose splits are defined by observations as noted further in this document in Chapter 4.2. Each of these user classes also has different PCU factors based upon the vehicle common size and length, as displayed in Table 4-2 below:

Table 4-2. Blyth SATURN Model User Class PCUs

Vehicle Type	PCU Values
Car	1.0
LGV	1.0
HGV	2.3
Bus	2.0

Buses have been coded into the SATURN model separately from the traffic demand matrices in order to specifically define routing and frequencies. This data was derived from the respective bus route timetables sourced from the Nexus website at the time of coding.

4.8 Assignment Methodology

The assignment in the highway model is based Wardrop's First Principle ("Traffic arranges itself on congested networks such that the cost of travel on all routes used between each O-D pair is equal to the minimum cost of travel and all unused routes have equal or greater cost").

4.9 Generalised Cost Formulations and Parameter Values

The assignment generalised cost formulations (generally expressed as PPM and PPK – pence per minute and pence per kilometre) were derived from the WebTAG databook. The base parameters PPM and PPK vary with each user class, with the PPM varying by modelled time period, and are shown in below in Table 4-3.

Table 4-3. Blyth SATURN Base Year 2016 Model User Class Generalised Cost Values

Matrix Name	AM Value of Time (PPM)	IP Value of Time (PPM)	PM Value of Time (PPM)	Value of Distance (PPK) (All Peaks)
Car – Commute	14.00	13.89	13.67	9.29
Car – Employers Business	56.48	55.11	54.43	12.35
Car – Other	17.79	18.47	18.86	9.29
LGV – Business	25.01	25.01	25.01	14.84
HGV - Business	25.79	25.79	25.79	40.52

During the assignment process, a generalised cost for each journey is calculated in order to inform route choice in the network. The generalised cost uses the values of time and distance for the different user classes as set out in Table 4-3 to calculate an overall generalised cost. The generalised cost formulation used within the highway model is as follows:

$$C_{ij} = 60 \times \left(\frac{(T \times VOT) + (D \times VOD) + M}{VOT}\right)$$

Where:

C_{ij} = Cost of trip in generalised seconds;

T = Travel time between O and D in minutes;

VOT = Value of time in pence per minute (PPM);

D = Distance between O and D in kilometres;

VOD = Value of distance in pence per kilometre (PPK); and

M = Any monetary tolls in pence.

4.10 Capacity Restraint Mechanisms

4.10.1 Junction Modelling

“Simulation” level of detail is used within the fully modelled area of the model (corresponding to the Blyth area and peripheral area). In this area, all junctions are modelled in detail such that the junction delays are modelled. Within urban areas it is important to model junction delay as this can account for a large proportion of overall journey time. WebTAG M3.1 highlights that:

> *‘Junction modelling will be required where junction capacities have a significant impact on drivers' route choice, and where delays are not adequately represented by speed/flow relationships applied to network links.’*

4.10.2 Speed/Flow Relationships

For urban links within the simulation area, fixed cruise speeds (based on observed data) are used on links. This is in line with best practice where it is felt that, in urban areas, general activity on a link (for example parked cars, bus stops, side entrances, pedestrians crossing etc.) has the primary influence on the standard “cruise” speed as opposed to a speed/flow relationship typically used on rural links.

For rural links and key strategic roads within the simulation area, speed/flow relationships are used on links which are rural in character yet lie within the simulation area of the model.

Links in the external area (i.e. outside the Fully Modelled Area) but in close proximity to the simulation area (e.g. Cramlington) have also been coded using the same urban/rural methodology as above.

In the wider buffer network, fixed speed flow curves have been used with unlimited capacity. This is to allow more stable routing of high volume trips between large external zones. It has been found that, if a relatively sparse buffer network does not have sufficient capacity, then there is an inaccurate volume of delay, especially in the areas surrounding centroid connectors where a large volume of traffic loads onto the sparse network at a single point. Unlimited capacity has been used in these areas to counteract this.

4.11 Relationship with Demand Models

Demand modelling is not always necessary in many modelling scenarios, however it is deemed necessary when testing large scale schemes where a possible shift has the potential to have an impact on proposed interventions. At the current time, demand modelling for the Blyth traffic model has not been undertaken.

5. Calibration and Validation Data

5.1 Overview

In order to develop a realistic model and demonstrate its accuracy compared with real-world conditions, it is necessary to use a number of pieces of survey data.

The purpose of this chapter is to summarise the data sources used to calibrate and validate the highway element of the Blyth SATURN model with information provided on the background to the work and the methods by which the surveys were carried out. A more detailed overview of the surveys carried out is contained in the '*Blyth Traffic Model Report of Surveys'*.

Calibration and validation data are of two kinds: traffic counts, and journey times.

Traffic counts are required for:

- expanding new roadside interviews – these are discussed more fully in Chapter 7;
- calibrating trip matrices by means of matrix estimation; and
- validating the model.

Journey times are required for:

- calibrating cruise speeds (speeds between junction queues); and
- validating the model.

Traffic counts may be obtained by automatic means (Automatic Traffic Counts, ATCs) or manually (Manual Classified Counts, MCCs). Journey times may be obtained by moving car observer (MCO) surveys or from commercial sources such as Trafficmaster. In selecting the appropriate type of count and source of journey times, two factors need to be considered:

- the accuracy of the data; and
- the need for information by vehicle type.

5.2 Data Sources

5.2.1 Road Side Interviews (RSI)

Four Road Side Interviews (RSI) were carried out on the 27th and 28th of September 2016. These surveys were carried out between the hours of 0700 - 1900. These were carried out in locations strategically placed in order to capture a snapshot of all traffic entering and exiting the Blyth urban area.

Table 5-1. List of RSIs Carried Out

Site	Location	Date
1	A193 Cowpen Road	27/09/2016
2	Chase Farm Road	28/09/2016
3	A193 Links Road	28/09/2016
4	A1061 Laverock Hall Road	27/09/2016

These surveys consisted of pulling or stopping vehicles in order for a quick series of questions to be asked regarding origin and destination of vehicles. These surveys, which are outlined further in the 'Blyth Report of Surveys', were used to inform the matrix creation process

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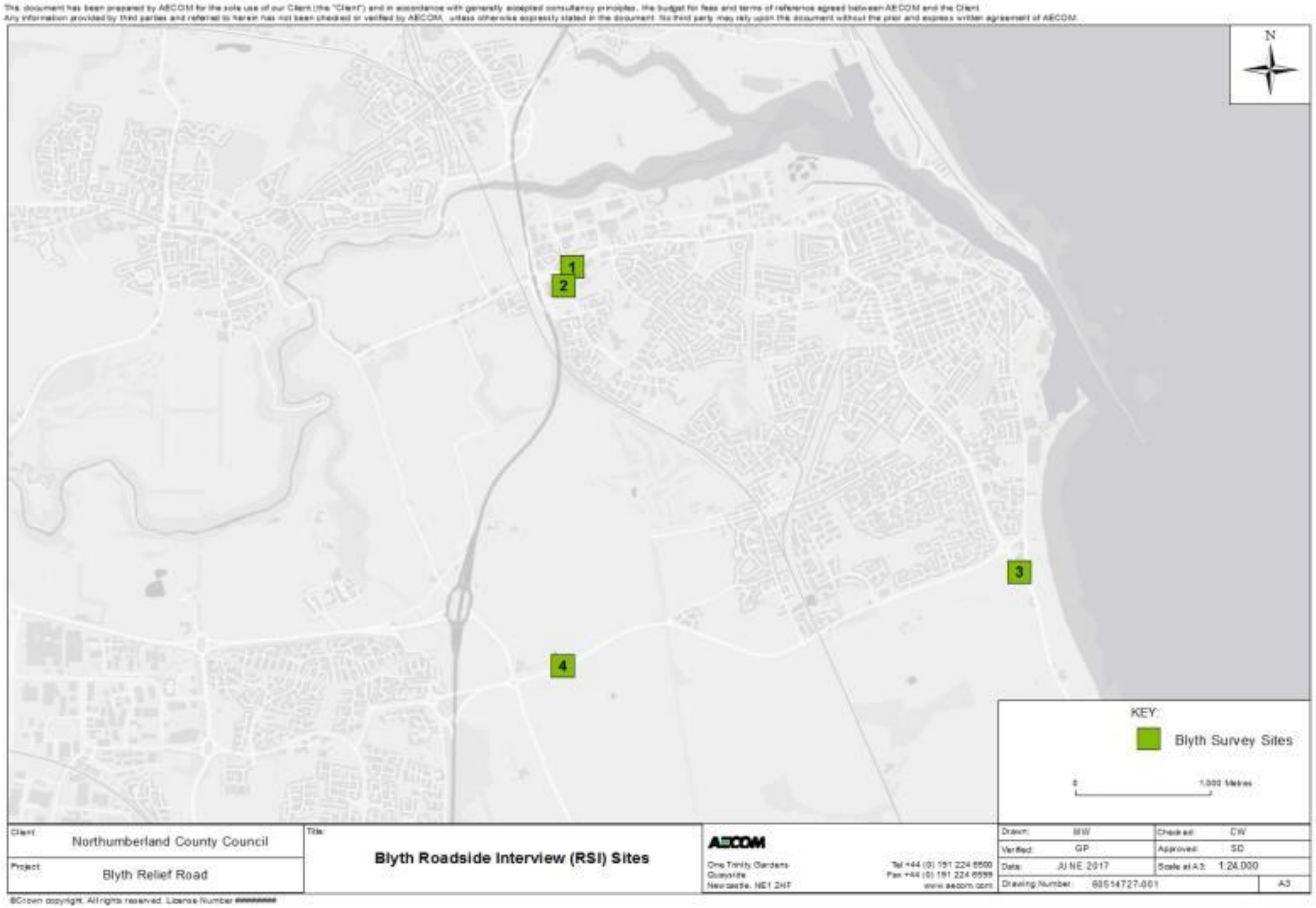
Figure 5-1: Location of RSI Sites



5.2.2 Automatic Traffic Count (ATC) Surveys

ATC Data can provide detailed link count information throughout the year and tries to iron out any day to day variations that may not be picked up by a single day count. Recent ATC data for the Blyth area was obtained at the following 22 locations.

Table 5-2. ATC Survey Sites

ATC Sites		
Bebside Road	Horton Road	A192 Eastbound
A192 Westbound	A192	Laverock Hall Road
South Newsham Road	A193 Links Road Northbound	A193 Links Road Southbound
B1329 Links Road	A1147	B1331 Furnace Bank
Chase Farm Drive	Cowpen Road (West)	Cowpen Road (Middle)
Cowpen Road (East)	A193 Cowpen Road South	B1329
A193	Deneview Drive	Newsham Road
Plessey Road		

5.2.3 Manual Classified Count (MCC) Surveys

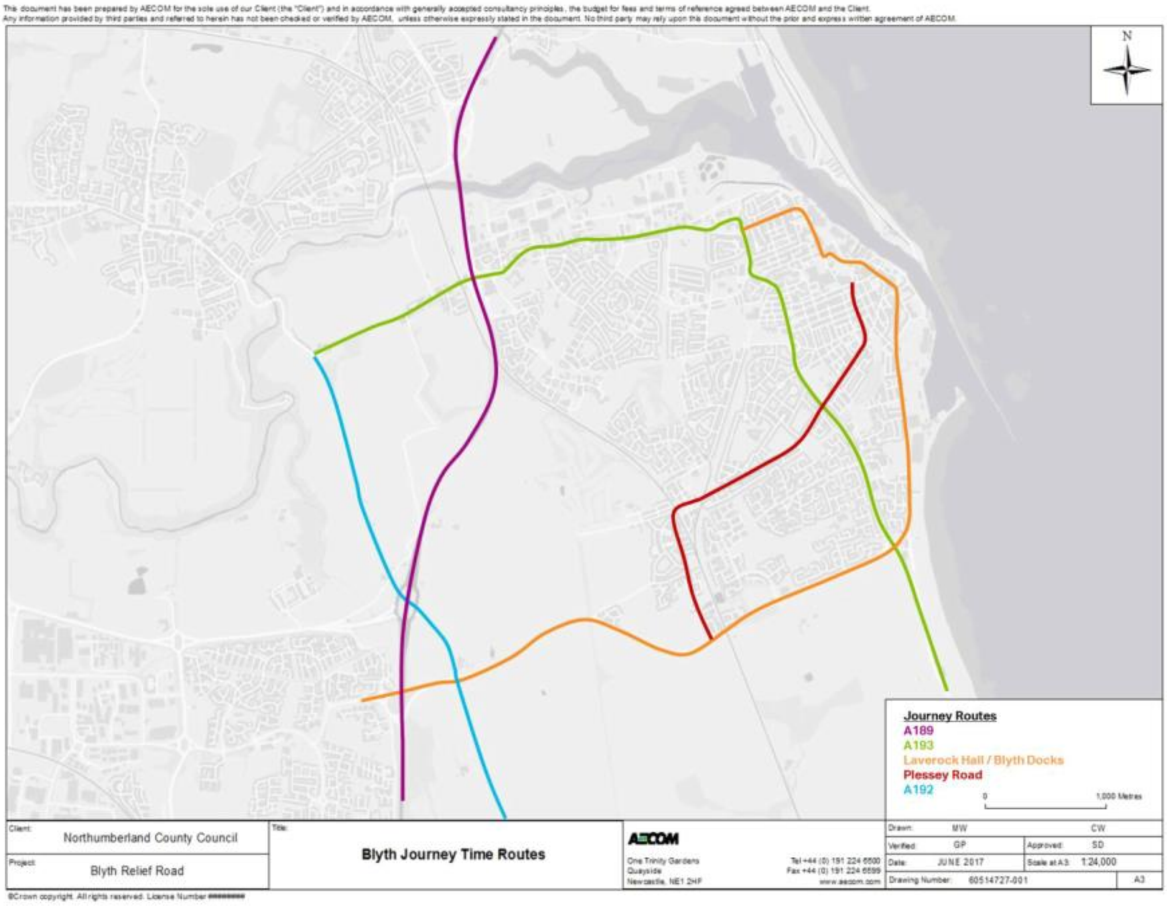
Manual Classified Counts (MCC) give an indication of the turning movements observed at key junctions in the network. An audit of existing data revealed that a number of counts had been collected on the A193 Cowpen Road that would be useful. However, a number of turning counts were needed across the rest of the highway network and were commissioned at the locations shown in the table below on September 22nd 2016.

Site	Site
A189 at A1147	Plessey Road West
A193 Cowpen Road at Hodgsons Road	Newcastle Road at Laverock Hall Road
B1329 Regent Street at Quay Road	A192 at Laverock Hall Road
A193 Renwick Road at Waterloo Road	B1505 at A1061 Durham Road
A193 at Princess Road, Blyth	A189/a192/B1505
The Broadway at Plessey Road	A1061 at B1505
Rotary Way at Links Road	A1061 at the south on slip

5.2.4 Journey Time Data

Journey time information was extracted from TrafficMaster for the key routes into and out of Blyth. TrafficMaster data is provided by DfT to local authorities and contains global positioning system (GPS) derived journey times of vehicles. Travel times for particular routes can be derived from the data based on specification of links in the Integrated Transport Network (ITN). Journey times along a defined route are produced based on a collation and aggregation of data for individual ITN links along the route. The data set is recorded continuously, and is available for all primary and secondary road links across the UK. This data provides a large vehicle sample, which can help to provide a statistically accurate representation of existing journey time conditions. The data available for the purpose of this study covers the 2016 information at the time of the validation of the model for an average weekday of neutral months. The locations of the journey time routes used in the validation of the Blyth traffic model are shown below.

Figure 5-2: Journey Time Routes



6. Network Development

6.1 Introduction

This chapter of the report documents the work that has been undertaken in terms of coding and checking the SATURN highway network for the Blyth traffic model.

6.2 Network Coverage

The network and zoning system of the Blyth traffic model is made up of the following:

- 126 zones;
- 507 simulation nodes;
- 126 external nodes;
- 344 priority junctions;
- 13 roundabouts;
- 18 traffic signals;
- 1228 buffer nodes;
- 3 time periods; and
- 5 user classes.

6.3 Link and Junction Coding

6.3.1 Speed-Flow Curves

The application of speed-flow curves has been previously discussed in this report in Chapter 4. Speed-flow curves have been applied to simulated delay on links with sparse junction delay. A list of default 'fixed speed' and 'variable' speed-flow curves used in this model can be found in Appendix A.

6.3.2 Junction Turning Saturation Flows

The following tables provide a quick reference guide to default recommended values that have been used when coding turning saturation flows at simulation junctions. In special circumstances (e.g. due to junction geometries or junction visibility) it has been apparent that junction turns may operate to a saturation flow outside of these defaults. In each of these circumstances where coded, the appropriateness of the application of this has been checked.

Table 6-1. Standard Turning Saturation Flows (PCUs) for Signalised Junctions

Standard	1 Lane			2 Lanes			3 Lanes	4 Lanes
	Left Turn	Straight	Right Turn	Left Turn	Straight	Right Turn	All	All
Tight	1,300	1,500	1,360	2,610	3,000	2,730	-	-
Average	1,550	1,700	1,580	3,090	3,400	3,160	6,000	8,000
Wide	1,860	2,000	1,890	3,720	4,000	3,770	6,000	8,000

Source: LLITM LMVR, AECOM

Table 6-2. Standard Turning Saturation Flows (PCUs) for Signalised Junctions

Standard	Major-to-Minor			Minor-to-Major		
	Left Turn	Straight	Right Turn	Left Turn	Straight	Right Turn
Tight	1,300	1,500	1,300	1,300	1,500	1,360
Average	1,550	1,700	1,550	1,550	1,700	1,580
Wide	1,860	2,000	1,860	1,860	2,000	1,890

Source: LLITM LMVR, AECOM

Table 6-3. Standard Coding for Roundabouts

Type of Roundabout	Circulating Capacity (PCUs/hr)	GAPR Values (sec)	Lanes at Stop-line	Time to Circulate (sec)	Total Sat. Flow (PCUs/hr)
Mini	1,440	2.5	1	5	1,100
Normal (Single-lane entry)	1,600	2.25	1	10	1,100
Normal (Flared approach)	1,800	2.0	2	10	1,650
Large (Dual 2+ lane approach)	3,200	1.125	2	15	2,200
			3	15	3,200

Source: LLITM LMVR, AECOM

6.4 Network Checks

An audit on the model network was carried out by an individual who was independent of the network creation process. The following network coding was checked:

- Link length
- Link speeds
- Number of lanes
- Junction type
- Turning saturation flows
- Signal timings

Any concerns were logged and appropriate changes were made where potential issues were identified.

6.4.1 Error Messages

When running SATURN, it undertakes a check of the network coding against a set of internal rules. For example SATURN will check that all lanes are used for at least one turn at a junction and that the left turn does not take place from the right hand lane, etc. Where something does not pass one of these rules, SATURN produces an error message. Some of these are simple warnings which indicate that the coding is perhaps unusual but not necessarily wrong. Others are fatal errors, which SATURN feels are so serious that the program cannot continue until the problem is corrected.

All of the error messages have been checked and, where appropriate, action has been taken to resolve the issue.

7. Base Trip Matrix Development

7.1 Overview

The approach to building the highway trip matrices for the Blyth SATURN model used the following basic methodology:

- Development of partial trip matrices from road side interview records;
- Development of a set of synthetic matrices, calibrated using the partial trip matrices; and
- Merging of the partial and synthetic trip matrices to form a prior matrix.

All of the matrices were built as production attraction matrices in order to satisfy the requirements of any future demand modelling for the scheme.

7.2 Observed Data Matrix Creation

Road side interview (RSI) surveys, undertaken at four locations in September 2016, were used to develop the observed trip matrices. The surveys recorded trip origin and trip destination by journey purpose and user-class for each time period.

7.2.1 Cleaning the Dataset

The origins and destinations of each RSI record were plotted using GIS software to show a crow-fly route between origin (O) and destination (D). The records were then examined on a site-by-site basis to determine logical trip movements. O-D pairs which were deemed to have logically travelled through that site were kept and illogical movements were removed. Examples of illogical movements include internal trips within Blyth and external trips which would have been unlikely to enter Blyth. Trips which followed illogical routing patterns and could not be re-created within a SATURN assignment were also removed. In total, 431 records were removed from the dataset; the deletion rates are shown in below. This gave a clean set of data to use for the observed matrix building process.

Table 7-1. Blyth Model Matrices Deletion Rates

RSI Site	Total Observations	Records Deleted	Deletion Rate
Site 1	1,401	160	11.4%
Site 2	1,329	56	4.2%
Site 3	1,101	115	10.4%
Site 4	1,159	100	7.9%
	5,090	431	8.5%

Due to the location of RSI Site 2, the trips which passed through the site had a known origin. These were checked to ensure that their origin lay in zones 160, 161 or 162. For trips which passed through Site 2, but which had an origin not in zones 160, 161, or 162, the O-D pairs were manually adjusted. Due to the presence of the ASDA supermarket in zone 162, it was deemed likely that these trips could have been 'pass-by' trips to ASDA. The trip origins were therefore transferred to zone 162. This resulted in partially observed trips from zone 162 to the destination, leaving the origin to zone 162 portion of the trip to be calculated by the trip synthesis process. The total number of trips with origins adjusted to zone 162 was 140.

7.2.2 Addressing Bias

Due to operational reasons, it was not possible to have a single site on A193 Cowpen Road to capture all trip movements coming from the A189 / A193 interchange. Therefore, two sites were established: Site 1 interviewing eastbound trips on A193 to the east of Chase Farm Drive, and Site 2 interviewing northbound trips on Chase Farm Drive. There remained in the cleaned dataset the potential for bias of trips which have passed through Site 2 and Site 1. These would include trips making a right turn out of Chase Farm Drive onto A193 Cowpen Road.

This bias needed to be addressed to prevent this movement becoming dominant. The area is mostly residential and car trips represent the highest volume, with small numbers of LGV and HGV, so it was decided to address the bias in car trips only.

An index of dispersion method was applied to estimate a weighted average of trips. This was undertaken for all trips with an origin in zones 160, 161, and 162, (as they would pass through Site 2) and with a destination in any internal zone (Zones 101 to 173).

The calculations are shown below:

$$Site\ 1\ Index\ of\ Dispersion = 1 - \left(\frac{Duplicated\ trips\ at\ Site\ 2}{Total\ Observed\ Cars\ at\ Site\ 2}\right) = 1 - \left(\frac{453}{1{,}162}\right) = 0.61$$

$$Site\ 2\ Index\ of\ Dispersion = 1 - \left(\frac{Duplicated\ trips\ at\ Site\ 1}{Total\ Observed\ Cars\ at\ Site\ 1}\right) = 1 - \left(\frac{141}{1{,}088}\right) = 0.87$$

The 0.61 was applied to trips from 160, 161 and 162 at Site 1 and 0.87 was applied to trips from 160, 161, and 162 at Site 2. This gave a weighted average of the total trips using the formula:

$$\frac{(Duplicate\ trips\ at\ Site\ 1 * 0.61) + (Duplicate\ trips\ at\ Site\ 2 * 0.87)}{(0.61 + 0.87)} = \frac{(141 * 0.61) + (453 * 0.87)}{0.61 + 0.87}$$
$$= 324.42$$

These trips were then split so 24% of 324.42 (77.86) were assigned to Site 1 and 76% (246.56) to Site 2, based on the duplicate trips (141 and 453). Thus when site 1 and 2 are added together, the newly calculated total of 324.42 is the result.

7.2.3 Processing the Data

Following the data cleaning process, the resultant dataset was processed to extract trip purpose types for each site. Matrices for the 12 hour survey period (0700 to 1900) were extracted for the following trip purpose types. LGV and HGV were assumed to be on employers business.

Table 7-2. <Caption>

Vehicle Type	O-D Purpose	P-A Purpose	Model User Class
Car	Home to Work	Home based Work	Car Commute
	Work to Home		
	Home to Employers Business	Home based Employers Business	Car Employers Business
	Employers Business to Home		
	Non-home based Employers Business	Non-home based Employers Business	
	Home to Education	Home based Education	Car Other
	Education to Home		
	Home to Shopping	Home based Shopping	
	Shopping to Home		

Vehicle Type	O-D Purpose	P-A Purpose	Model User Class
	Home to Other	Home based Other	
	Other to Home		
	The P-A matrices were expanded to 24 hours using the ATC count and then summed by site to provide 24 hour matrices for each car PA-Purpose, LGV and HGV. Non-home based Other	Non-home based Other	
LGV	Employers Business	Employers Business	LGV
HGV	Employers Business	Employers Business	HGV

Trips were extracted in O-D format before being converted to P-A format. This is important for the demand model so that all home ends of home based trips are held as productions.

Observed trips were expanded up to the total observed count at each site (i.e. the sample was being expanded to represent the population). The ATC undertaken at each RSI site was used to calculate an expansion factor between the surveyed vehicles and the weekday average at the two-week ATC (the ATC weekday average excluded the day of the RSI survey). The total ATC count was split by the proportions of car, LGV, and HGV observed at the MCC undertaken on the survey day. Matrices were also transposed and expanded by the opposite direction ATC count to account for trips travelling in the opposite direction to the survey. For example, the Home to Work matrix was transposed to become a Work to Home matrix and expanded by the opposite direction. The surveyed direction was then added to the un-surveyed direction to provide a matrix containing all the observed internal to external and external to internal movements for each user class and for each site.

	Un-surveyed direction
Surveyed direction	

7.3 Synthesised Matrix Creation

Synthetic matrices were created with the purpose of estimating the volume of 24 hour PA trips which were not observed or properly accounted for in the above observed data snapshot. Synthetic matrices were therefore created using a gravity model and a set of calculated trip ends to calculate zone to zone movements. In order for the synthetic matrices to be compatible with the observed matrices, trip ends were retrieved by similar journey purposes, displayed below in Table 7-3.

Trip Production is defined as the home end of a Home Based (HB) trip or as the origin of a Non-home Based (NHB) trip. Trip Attraction is defined as the non-home end of a Home Based trip or the destination end of a Non Home Based trip. A production and attraction for a home-based trip takes the time period of the from-home trip. This includes the out-trip and the return-trip. For example, a person travelling to work in the AM peak period and returning home in the PM peak will produce two AM peak productions at home and two AM peak attractions at work.

Table 7-3. TEMPro 7 Journey Purposes Groupings into Blyth Model Journey Purposes

Blyth Model Journey Purpose	TEMPro 7 Journey Purpose
HB Work	HB Work
HB Shopping	HB Shopping
HB Education	HB Education
HB Business	HB Employers Business (EB)
HB Other	HB Personal Business (PB) HB Recreation/Social HB Visiting friends and relatives HB Holiday/Day Trip
NHB Business	NHB Employers Business (EB)
NHB Other	NHB Work NHB Education NHB Shopping NHB Personal Business (PB) NHB Recreation/Social NHB Holiday/Day Trip

7.3.1 Calculating Estimated Base Trip Ends

The basis for car trip ends used in the synthetic matrices derived originally from DfT's TEMPro v7.0. 2016 Production/Attraction (PA) trip ends were retrieved by journey purpose for an average weekday (24hrs).

Trip ends from TEMPro were retrieved for the spatial scale of the zone, allowing for individual zones to be identified and the respective MSOA, LA or Regional volume of trip ends to be retrieved. The smallest spatial scale which is available from TEMPro is MSOA. Specifically relating to the Blyth area, these trip ends needed to be disaggregated into the smaller LSOA or OA. Census 2011 data on 'Location of usual residence and place of work' and 'Household composition' was retrieved at OA and MSOA level in order to calculate percentage splits and therefore total households and jobs in each OA.

Table 7-4. Example of MSOA Disaggregation

Zone	OAs	MSOA	MSOA HHs (TEMPRO)	MSOA Jobs (TEMPRO)	Summed OA HHs (Census)	Summed OA Jobs (Census)
101	E00139586 E00139585 E00139582	Northumberland 025	2914	1375	371	11
102	E00176337 E00139650 E00176339	Northumberland 026	2736	310	432	17

The total of the OAs households and jobs was then input into the 'Alternative Assumptions' tool in TEMPro, using the respective parent MSOA which contains the OAs. TEMPro therefore calculates trip ends for these summed OA planning assumptions, based upon the characteristics of that MSOA.

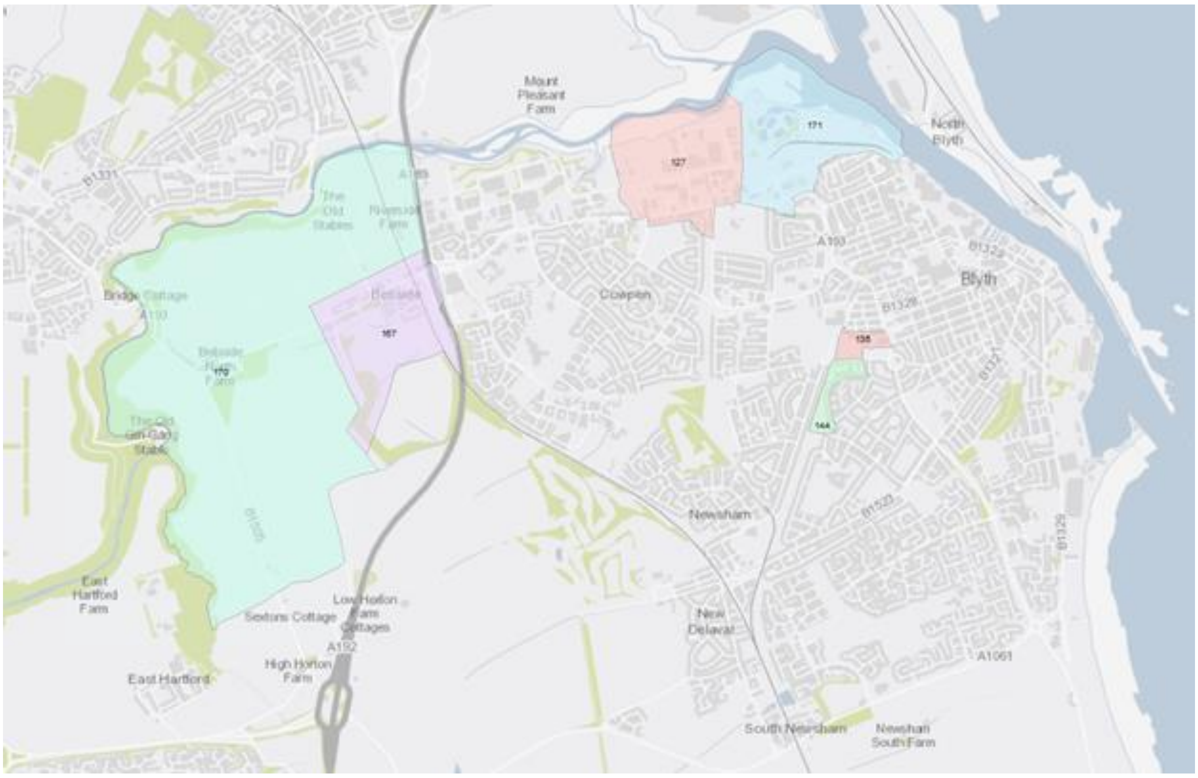
HB trip ends were needed to be multiplied by two to represent the return leg of the journey, as per TEMPRO guidance.

It should be noted that there were three instances where an OA had been further disaggregated, where a professional judgement, based on estimates of what structures could be seen on site, was made in order to calculate splits of this data. This split can be seen in Table 7-5 and geographically in Figure 7-1 below.

Table 7-5. Zonal Planning Allocation Assumptions when Spatially Smaller than Output Area

Zone No	2011 Output Area	Households Weighting	Jobs Weighting	Households	Jobs
135	E00139602	0.6	0.7	80	189
144		0.4	0.3	53	81
167	E00139576	0.8	0.8	132	69
170		0.2	0.2	33	17
171	E00139394	0.1	0.3	16	241
127		0.9	0.7	143	562

Figure 7-1. Location of Split Output Areas



It was understood that from observations taken in Blyth that the trip rates provided by TEMPro needed uplifting in order to accurately represent base traffic flows in the model. It was decided to uplift the trip ends for all zones at OA spatial level with a trip rate provided by TRICS. All trip rates retrieved followed the below characteristics:

- All regions; except London and Northern Ireland,
- Weekday surveys only,
- NOT located in the Town Centre or Free Standing; and
- Surveys carried out from 2013 onwards.

Trip rates for jobs vary heavily depending on the type and therefore Business Register and Employment Survey (BRES) 2011 data was retrieved at a 3-digit job type split level. This allowed for the number of separate job types to be matched up to a suitable TRICS trip rate. Resulting car trip rates were applied to both households and jobs, where the total TRICs trips were compared to the total TEMPro trip rates. In all instances it was found that the TRICs trip ends was larger to the TEMPRO trip ends and was therefore used to uplift the original TEMPRO trip ends.

An added advantage of gathering TRICs data was that the surveys used provided a split between vehicle types. Total vehicle trip rates which were applied to households and jobs were split into Car, LGV and HGV based upon percentage splits of vehicles observed in the surveys. This allowed for the calculation of LGV and HGV trip ends.

7.3.2 Gravity Model

A gravity model is a process whereby trip ends are allocated into a trip matrix depending on the cost and likelihood of that movement. Multiple gravity models were used to account for the different journey purposes. The gravity models were processed in Microsoft Excel to improve accessibility and visibility of calculations which were carried out.

A distance skim was extracted from the Blyth SATURN model. This was extracted from SATURN using a dummy matrix and had no network delay, meaning that this skim represented simply the shortest distance between zonal pairs. (Once the first prior matrix was assigned to the network, a new distance skim was extracted). This skim was multiplied by vehicle level user class PPK and the average of AM, IP and PM time skim in seconds, which was multiplied by user class PPM. In addition to each other, this formed an estimated generalised cost for movements between zonal pairs.

A generalised cost still needed to be calculated for intra-zonal movements where, especially in larger zones outside of the Blyth area, traffic is likely stay internal to the zone. The zoning system was displayed on GIS and an estimated distance was taken from the centre to the edge of each zone. The exception to this was for Local Authority or Regional zones, where it is unlikely most journeys cover the span of these larger zones. In these instances, 'average distance travelled to work' data was retrieved from the 2011 Census and was used to formulate the generalised cost.

For these intra-zonal movements, an average speed had to be assumed in order to calculate a complete generalised cost of these movements, shown below in Table 7-6. This was based on the size and the primary road network within that zone.

Table 7-6. Intra-zonal Assumed Speed for Calculating Generalised Costs

Zones	Assumed Intra-Zonal Average Speed
101-173; 201; 203-204; 208-213; 218-222; 224; 301-303; 306-310; 329	48kph/30mph
202; 205-207; 214-217; 223; 304-305; 311-328	96kph/60mph

The gravity model constrains to both the Production trip ends and Attraction trip ends of a PA pair based upon an attractiveness factor. A macro in the spreadsheet ensures that this constraining is an iterative process, looped 1000 times until the movements within the matrix balances itself and matches the intended total trip ends. Minor differences were noted with the trip ends during the furnessing process and can be seen in Table 7-7 below. These minor differences were constrained to the Destination trip ends.

Table 7-7. Synthetic Gravity Model Furnessing Accuracy Results

Journey Purpose	Total Destination Difference	% Total Destination Difference	Max Destination Difference	% Max Destination Difference
HB Work	2808	0.014%	516	0.032%
HB Shopping	3086	0.027%	278	0.245%
HB Education	626	0.016%	90	0.127%

Journey Purpose	Total Destination Difference	% Total Destination Difference	Max Destination Difference	% Max Destination Difference
HB Business	181	0.006%	32	0.010%
HB Other	6102	0.035%	2475	0.283%
NHB Business	388	0.019%	59	0.040%
NHB Other	500	0.008%	164	0.031%
LGV	33	0.000%	6	0.000%
HGV	0	0.000%	0	0.000%

The attractiveness factor is calculated using the following formula:

$$F(C_{ij}) = \frac{1}{(C_{ij} \times o)\sqrt{2\pi}^{\frac{-(ln(C_{ij}-m))^2}{2o^2}}}$$

Where:

C_{ij} = Generalised cost of movement

o = Calibration Factor

m = Calibration Factor

The calibration factors 'o' and 'm' allowed for adjustment in the attractiveness factors and changed the distribution of journey lengths. These factors were therefore different for each journey purpose allowing us to calibrate these factors against observed journey lengths for this journey purpose from the RSI survey data. The calibration factors for each journey purpose is shown below in Table 7-8.

Table 7-8. Synthesised Gravity Model Calibration Parameters by Journey Purpose

Journey Purpose	'o' Parameter	'm' Parameter
HB Work	0.83	2
HB Shopping	0.5	1.9
HB Education	0.55	1.9
HB Business	0.65	2.6
HB Other	0.7	1.65
NHB Business	0.7	1.95
NHB Other	0.75	1.76
LGV	1.4	0.7
HGV	1.8	1.4

Appendix B contains graphs which show the resultant percentage of trip lengths by journey purpose as a result of the gravity model calibration process, with the observed graph of journey distances for comparison.

7.4 Merging Observed and Synthesised Matrices

In order to merge the synthetic and observed matrices a variance factor needs to be calculated in order for observed movements to be given more weighting than synthetic. This was carried out individually to the different journey purpose matrices.

When considering the observed, it was important to recognise the difference between which trips could and could not have been recorded by our RSI site surveys. The movements which passed through the RSI sites were therefore split between 'Inbound Observed', for movements which were picked up in the RSIs, and 'Outbound Unobserved', for the transposed movements which could have the potential to be observed for the reverse of the RSI sites. Even if no physical movement was captured in the duration of the surveys, a movement was allocated into one of these categories if it was realistic or probable for some movements to go through our study area. Variances were therefore also calculated for movements which had the potential to be observed, but were not during our surveys.

The following calculation below has been used to determine the observed variance.

$$oV = (Xo \div o)^2 \times Xo$$

Where:

oV = Observed variance

o = Observed

Xo = Expanded observed

If no physical movement was observed during the survey period but had the potential to be observed (i.e. 'Inbound Observed' or 'Outbound Unobserved') the observed matrix total and expanded observed matrix total was used to calculate the variance.

The below calculation has been used to calculate the synthetic variance for all movements in the matrices:

$$sV = oV + (0.5 \times s)^2$$

Where:

sV = Synthetic variance

s = Synthetic

oV = Observed variance

Once both sets of variance for the observed and synthetic matrices had been calculated, it was necessary to merge these into a single matrix. Movements which were considered to not have been possible to be recorded during the RSI surveys took 100% from the synthetic matrix, as the observed matrix will have no data representing this. Movements which were considered 'Inbound Observed' or 'Outbound Unobserved' used the below formula to weight the final merged movement using the two sets of variances:

$$m = \frac{((Xo \times sV) + (s \times oV))}{(oV + sV)}$$

Where:

m = Merged movement

oV = Observed variance

sV = Synthetic variance

Xo = Expanded observed

s = Synthetic

The resulting merged matrices by journey purpose were then furnessed in Microsoft Excel. The merged matrices were furnessed to the synthetic trip ends by Production and Attraction. An extra step in the furnessing iterative process saw all movements considered to be 'Inbound Observed' to be constrained back to the original total of the 'Inbound Observed' movements. A similar function in the iterative process then saw all movements considered to be 'Outbound Unobserved' to be constrained back to the original total of the 'Outbound Unobserved' movements. This was so both inbound and outbound movements from the study area were not skewed by furnessing to the trip ends, and were brought back to the original total of these movements. It should be noted that the total of these movements are still weighted across individual movements based upon the total trip ends of each individual zone in the overall furnessing process. The result of a number of iterations saw the process balance through the furnessing process to the total trip ends, whilst preserving the total inbound and outbound movements.

7.5 Obtaining Assignment Matrices

For assignment in SATURN, it was necessary to adjust the production attraction matrices to three individual peak hour OD matrices which, used the user classes laid out in the SATURN model.

7.5.1 Converting 24hr PA Matrices to Three Individual Peak Hour OD Matrices

The Blyth SATURN model required the assignment matrices to be in OD format for the AM, IP and PM peaks. As the current matrices were in 24hr PA format, it was necessary to go through a process of translating these into the necessary format for assignment in the SATURN model.

Factors for peak traffic were established based on the volume of traffic observed in these peaks in the 24hr ATC surveys. This factor was the average of the percentage of traffic in these peaks across all ATC sites. A set a factors for 'Production to Attraction' for AM, IP and PM was therefore calculated for each journey purpose, as well as a separate set of factors for 'Attraction to Production' for AM, IP and PM. These can be seen below in Table 7-9.

Table 7-9. Journey Purpose Factors Derived from Surveys to Split 24hrs into Modelled Peaks

Journey Purpose	Production to Attraction			Attraction to Production		
	AM	IP	PM	AM	IP	PM
HB Work	0.1135	0.0149	0.0087	0.0072	0.0155	0.1397
HB Shopping	0.0125	0.0487	0.0458	0.0092	0.0446	0.0319
HB Education	0.1223	0.0316	0.0101	0.0288	0.0395	0.0108
HB Business	0.0575	0.0387	0.0357	0.0295	0.0379	0.0686
HB Other	0.0265	0.0346	0.0336	0.0266	0.0354	0.0329
NHB Business	0.0440	0.0864	0.0547	-	-	-
NHB Other	0.0652	0.0715	0.0787	-	-	-
LGV	0.0715	0.0710	0.0520	-	-	-
HGV	0.0773	0.0991	0.0256	-	-	-

It should be noted that the process of PA translation only related to 'home bound' journey purposes. PA 'non-home bound' journeys, LGV and HGV represent the same number of movements as OD, and therefore it was not necessary to transpose the matrices, simply apply a single peak factor to convert from 24hr.

The intended matrix was copied and transposed; both the Productions and Attractions from the regular un-transposed matrix were first multiplied by the respective peak 'Production to Attraction' factor. Both the Productions and Attractions from the transposed matrix were then multiplied by the respective peak 'Attraction to Production' factor. Origin trips were therefore a sum of both the un-transposed and transposed post-peak factor Production movements. Destination trips were a sum of both the un-transposed and transposed post-peak factor Attraction movements. This process was applied to all journey purposes, creating specific OD matrices for all three peaks for each of these purposes. An example of this process is shown below in Figure 7-2.

Figure 7-2. Example of the PA Translation Process

Home Based Work

P to A Factors	**AM:** 0.1135	**IP:** 0.0149	**PM:** 0.0087
A to P Factors	**AM:** 0.0072	**IP:** 0.0155	**PM:** 0.1397

	Normal Matrix	
	Production	**Attraction**
101	409	10
102	524	27
103	235	7
104	746	220
105	509	17

	Transposed Matrix	
	Production	**Attraction**
101	10	409
102	27	524
103	7	235
104	220	746
105	17	509

AM

	Origin			Destination			Origin Trip Ends	Destination Trip Ends
	Production	**Attraction**		**Production**	**Attraction**			
101	46	1	**101**	0	3	**101**	47	4
102	60	3	**102**	0	4	**102**	60	7
103	27	1	**103**	0	2	**103**	27	2
104	85	25	**104**	2	5	**104**	86	30
105	58	2	**105**	0	4	**105**	58	6

LGV and HGV matrices were created solely from TRICS data and were therefore already in OD format. A peak factor for LGV and HGV was applied to break these apart from the greater 24hr matrices.

7.5.2 Combining Journey Purposes

In order for the matrices to be suitable for assignment, the journey purposes were summed and merged to match the user classes set out in the SATURN model. Table 7-10 below shows how these journey purposes were merged into the model user classes.

Table 7-10. Journey Purposes Merged into User Classes

Model User Class Matrices	Journey Purpose Matrices
Commute	HB Work
Business	HB Business NHB Business
Other	HB Shopping HB Education HB Other NHB Other
LGV	LGV
HGV	HGV

7.5.3 Altering LGV/HGV Matrices

It was deemed from an initial comparison between the entirely synthesised LGV and HGV matrices and the observed flows that the matrix was representative of almost two times the vehicles than was observed in the Blyth study area. As both the LGV and HGV matrices did not derive from TEMPro these matrices are estimated. To bring these more in line with observed flows, OD trip ends for zones 101 – 173 were halved in order to output the final prior matrices.

8. Trip Matrix Calibration and Validation

8.1 Trip Matrix Calibration

The purpose of this section of the report is to show that the calibration of the Blyth SATURN model trip matrix is sufficient to meet the purpose of the traffic model, comply with national guidance and that the steps taken to achieve this level of calibration have not substantially distorted the prior matrices. The calibration process (from prior to final matrices), and the comparisons carried out using data were as follows:

- assigned model flows using the prior matrix were compared with individual counts and screenlines
- assigned model routes using the prior matrix were compared with journey time observations
- an estimation using the prior matrix was run in SATME2 for six iterations, using a set of calibration counts which were used to form a set of screenlines
- assigned model flows using the post estimation matrix were compared with validation individual counts
- a comparison was made between the observed and modelled journey times
- a comparison was made between the prior and post estimation matrices

8.2 Running Matrix Estimation (ME2)

Matrix estimation has been run. This involves undertaking a calibration of the network (as described in previous sections of this report) followed by applying matrix estimation to the prior matrix in order to improve its fit against observed flows; this estimation applies constraints at only the calibration sites, with the validation sites being used to validate the model. The observed data has therefore been split into two groups:

- Calibration screenlines; and
- Validation counts

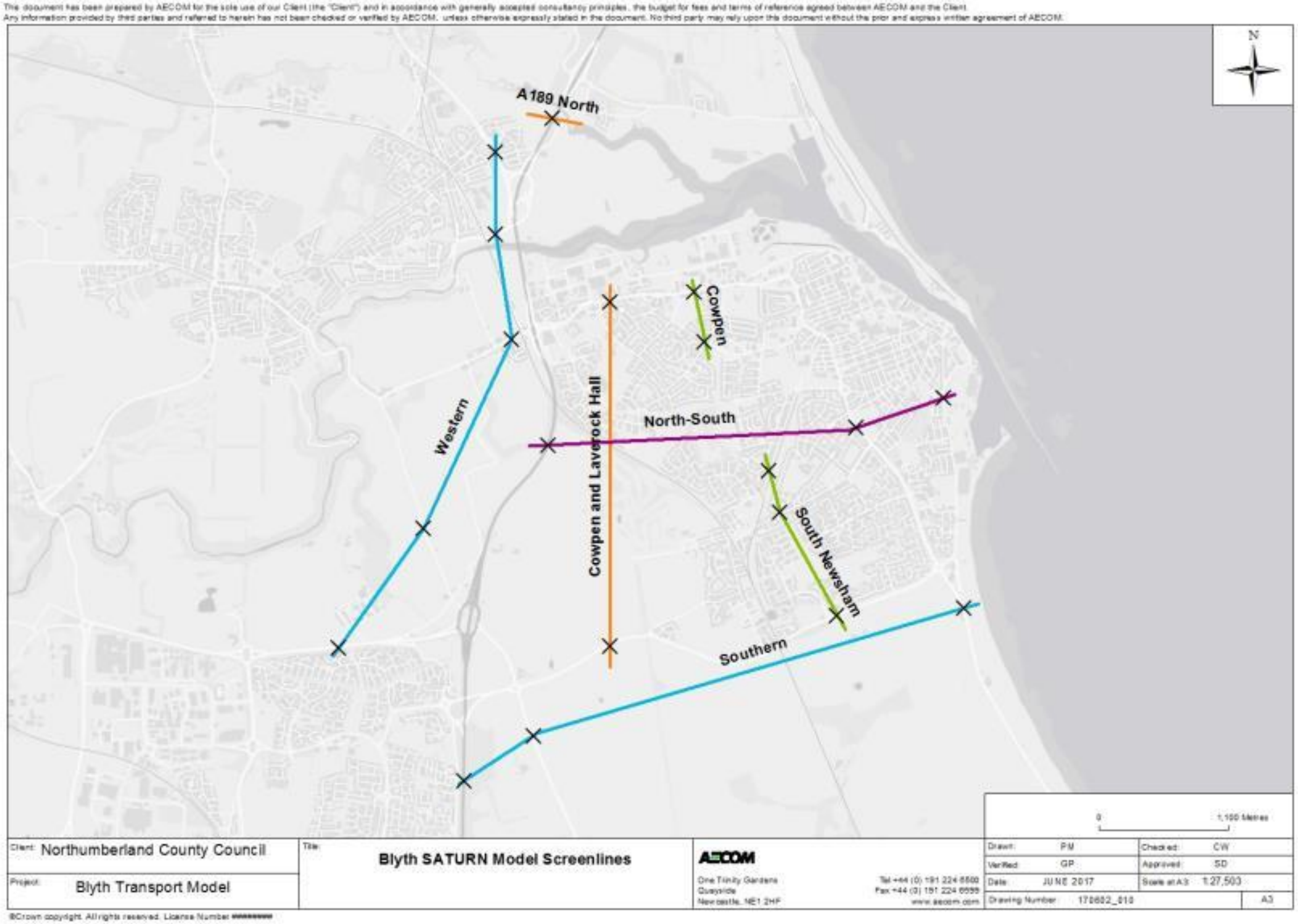
The main purpose of matrix estimation is to refine estimates of movements which have been partly synthesised, rather than derived from surveys. Validation counts are then used to measure the accuracy of the resultant changes on other parts of the network.

Individual calibration counts have been used to form screenlines to control the estimation process. All counts that formed the screenlines were used in the ME process, consisting of ATCs which have gathered data over two weeks. This provides us with a reasonably accurate estimate of average flow volume by vehicle type in each of the three modelled hours. A smaller amount of CTCs were also used to constrain the ME process. These counts were also split by vehicle type. As none of the counts specified between journey purpose for the car vehicle classification, the ME process was ran for the three car matrices as a single group. Three groups of counts were therefore used per peak; Car, LGV and HGV.

Figure 8-1 shows the location of the screenlines referred to within the calibration process.

DRAFT

Figure 8-1. Blyth Model Screenline Locations



8.3 Comparison between Prior Matrix assigned Flows and Observed Flows

Prior to applying matrix estimation, a comparison between the prior matrix assigned flows and the observed counts was carried out. The purpose of this comparison is to show that the prior matrix is a reasonable starting point for matrix estimation. As the screenlines in the model are relatively short, it was considered appropriate to use the following acceptability guidelines shown below in Table 8-1.

"Graduated criterion" below in Table 8-1 is a relaxed criteria, which reflects the number of count sites in the screenline. Where a screenline consists of less than 5 count sites it is reasonable to apply a relaxed set of criteria. It has been assumed that if the screenlines consisted of only one count then an individual count criterion would apply i.e. within 15%.

Table 8-1. Acceptability Criteria in Shorter Screenlines

Number of counts in Screenline	Acceptability Criteria
5	5%
4	7.5%
3	10%
2	12.5%
1	15%

The model network flows were calibrated against observed counts until there was until there was a reasonable level of confidence in the model flows. Table 8-2 below shows the performance of the screenlines based off the prior demands. The tests are undertaken separately for cars and then for all vehicles combined.

Table 8-2. Prior ME2 Modelled Screenline Flow Performance

Screenline	Name	Counts in Screenline	Direction	Car - AM	All - AM	Car - IP	All - IP	Car - PM	All - PM
1	A189 North	1	NB	-12%	-4%	-4%	10%	-1%	1%
		1	SB	9%	18%	-4%	7%	-12%	-9%
2	Southern	3	NB	7%	16%	12%	25%	-2%	1%
		3	SB	-6%	1%	-2%	6%	-11%	-9%
3	Western	5	EB	-7%	-12%	-1%	-4%	-20%	-20%
		5	WB	-14%	-11%	8%	9%	-1%	-2%
4	Cowpen and Laverock Hall Road	2	EB	-4%	-6%	-7%	-10%	-4%	-7%
		2	WB	21%	16%	-4%	-6%	1%	3%
5	Cowpen	2	EB	-7%	-15%	-20%	-25%	-11%	-13%
		2	WB	-2%	-8%	-26%	-29%	-19%	-21%
6	South Newsham	3	EB	-26%	-29%	-12%	-16%	-28%	-30%
		3	WB	9%	4%	-6%	-8%	-13%	-16%
7	North-South	3	NB	-7%	-2%	-14%	-5%	-20%	-17%
		3	SB	-12%	-6%	-15%	-7%	-12%	-10%
	Total Counts			14	14	14	14	14	14
	Criteria Met			9	7	7	9	7	8
	Validation			64%	50%	50%	64%	50%	57%

The initial prior matrix is considered an initial estimate based upon observed flows but still has a heavy influence from synthetic and estimated trips and therefore did not replicate all observed traffic flows. The following Figure 8-2 to Figure 8-13 displays the observed flows against the prior modelled flows.

Figure 8-2. AM Car Inbound Screenlines Prior Matrix Assignment

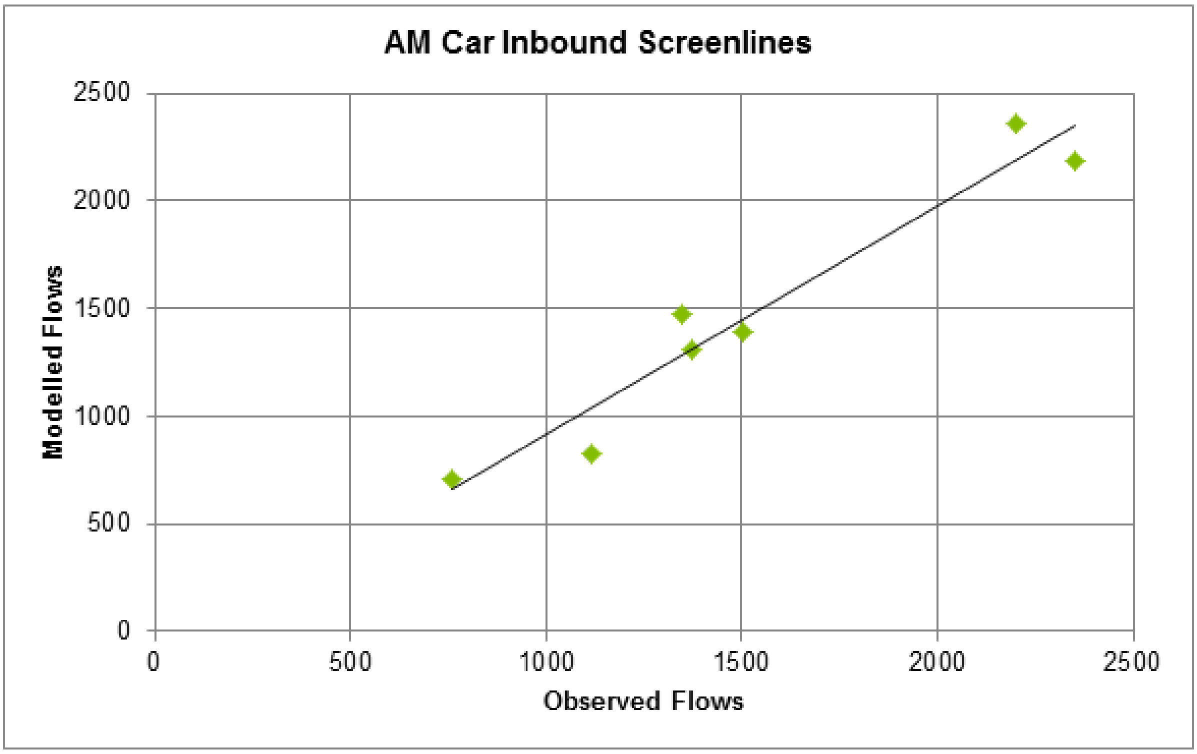


Figure 8-3. AM All Vehicles Inbound Screenlines Prior Matrix Assignment

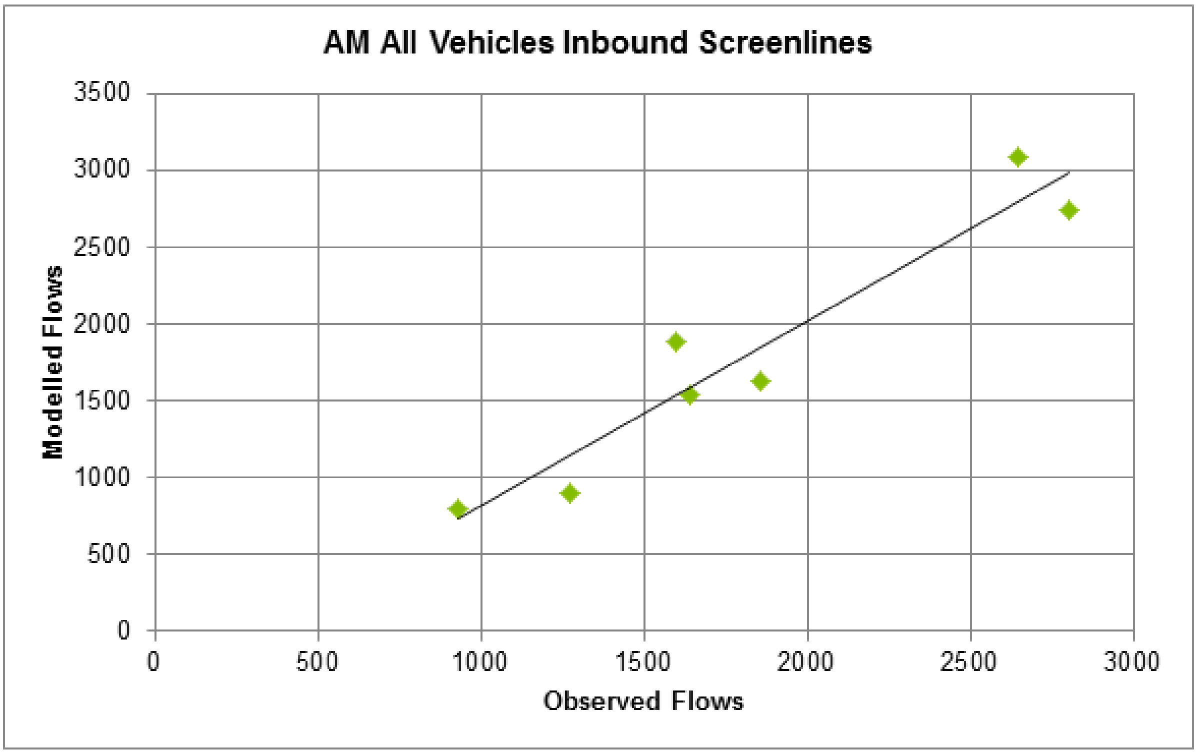


Figure 8-4. AM Car Outbound Screenlines Prior Matrix Assignment

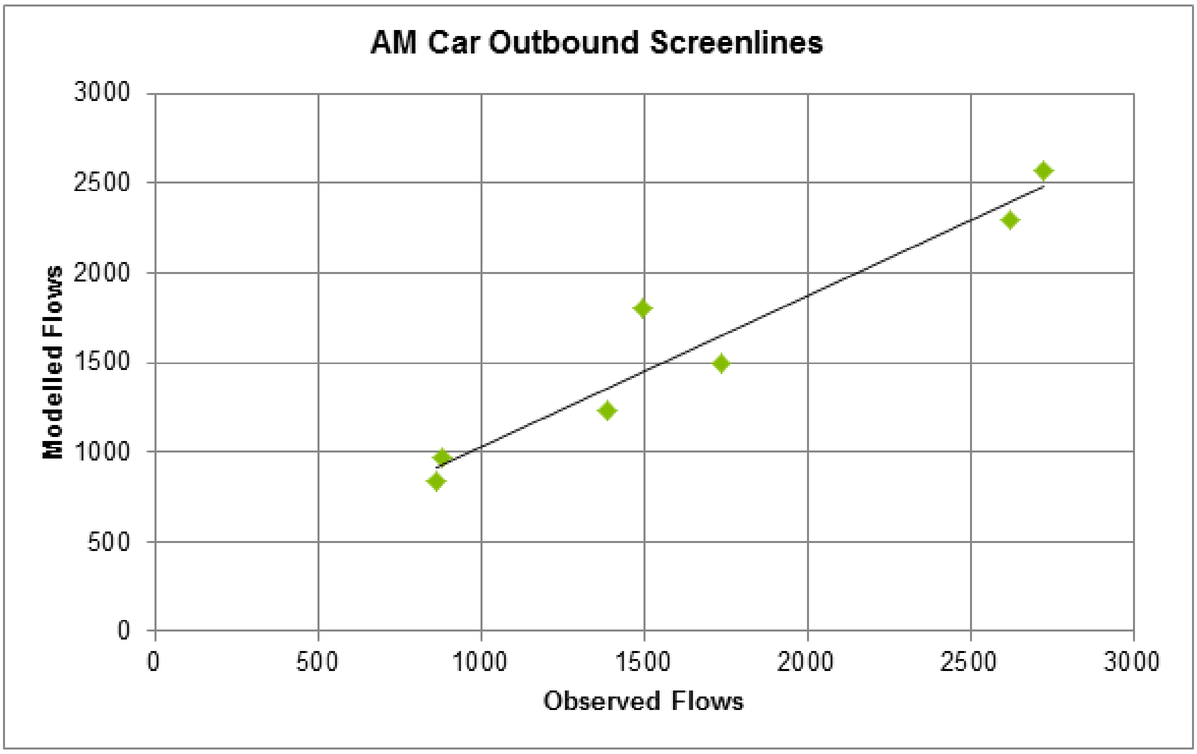


Figure 8-5. AM All Vehicles Outbound Screenlines Prior Matrix Assignment

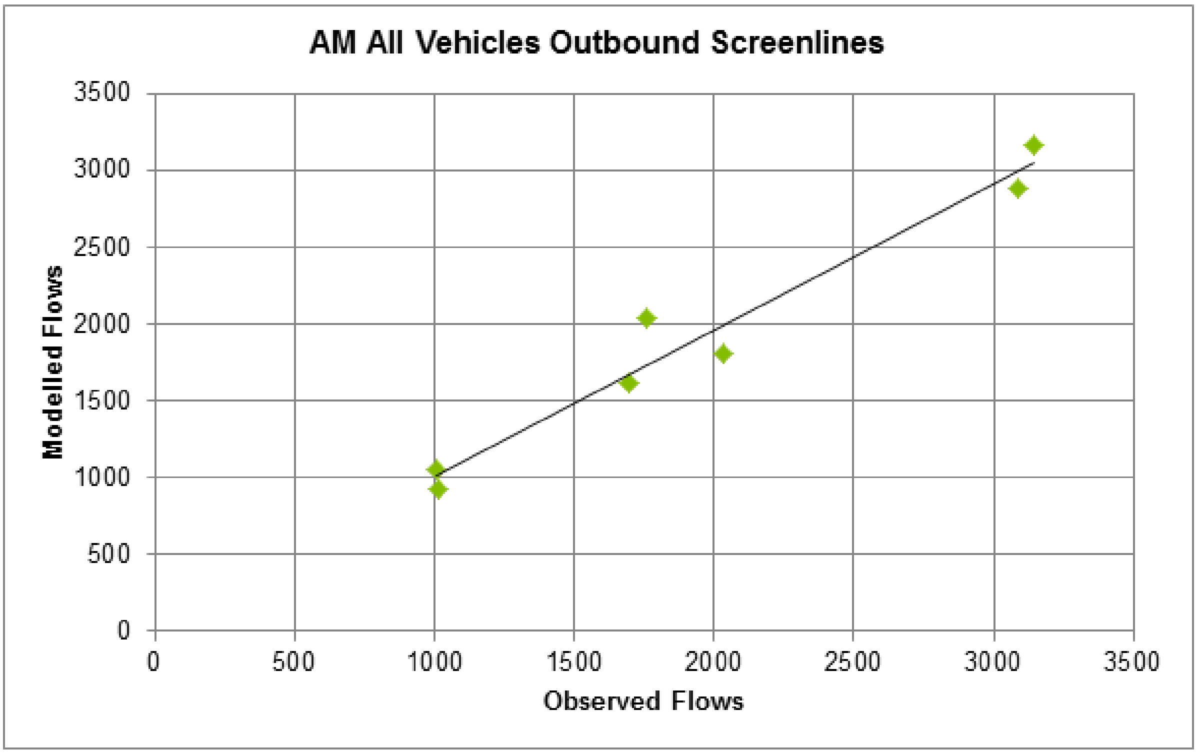


Figure 8-6. IP Car Inbound Screenlines Prior Matrix Assignment

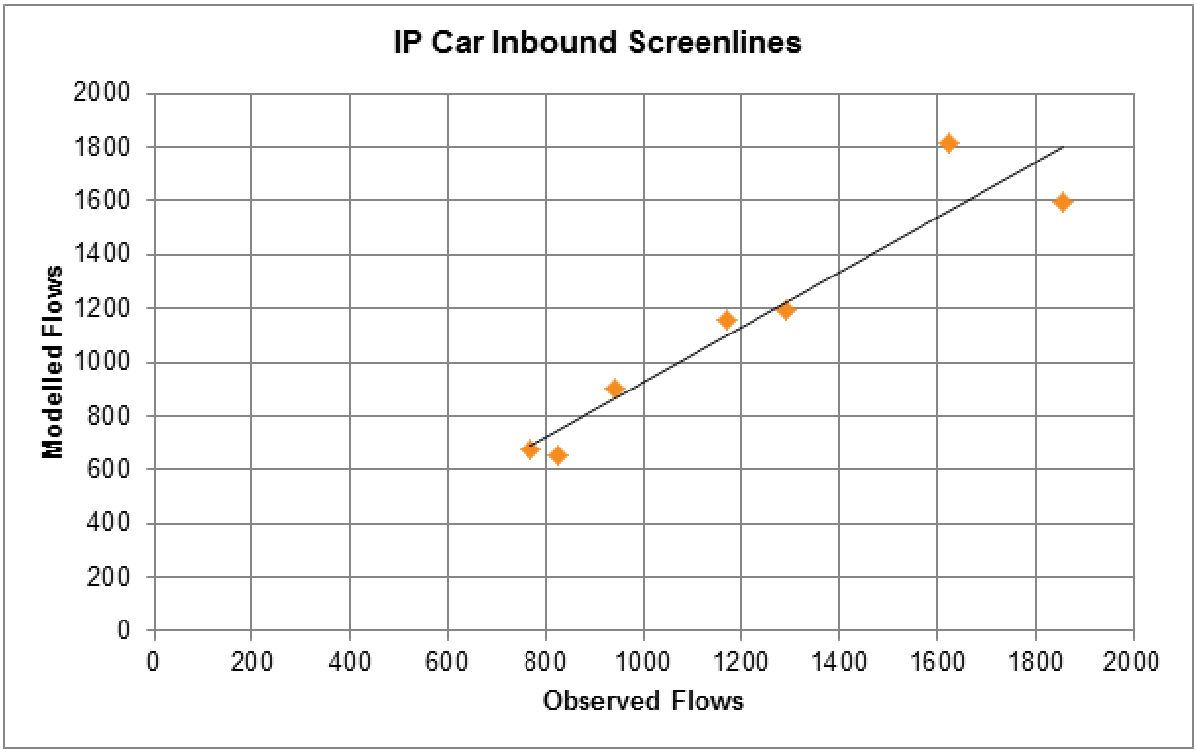


Figure 8-7. IP All Vehicles Inbound Screenlines Prior Matrix Assignment

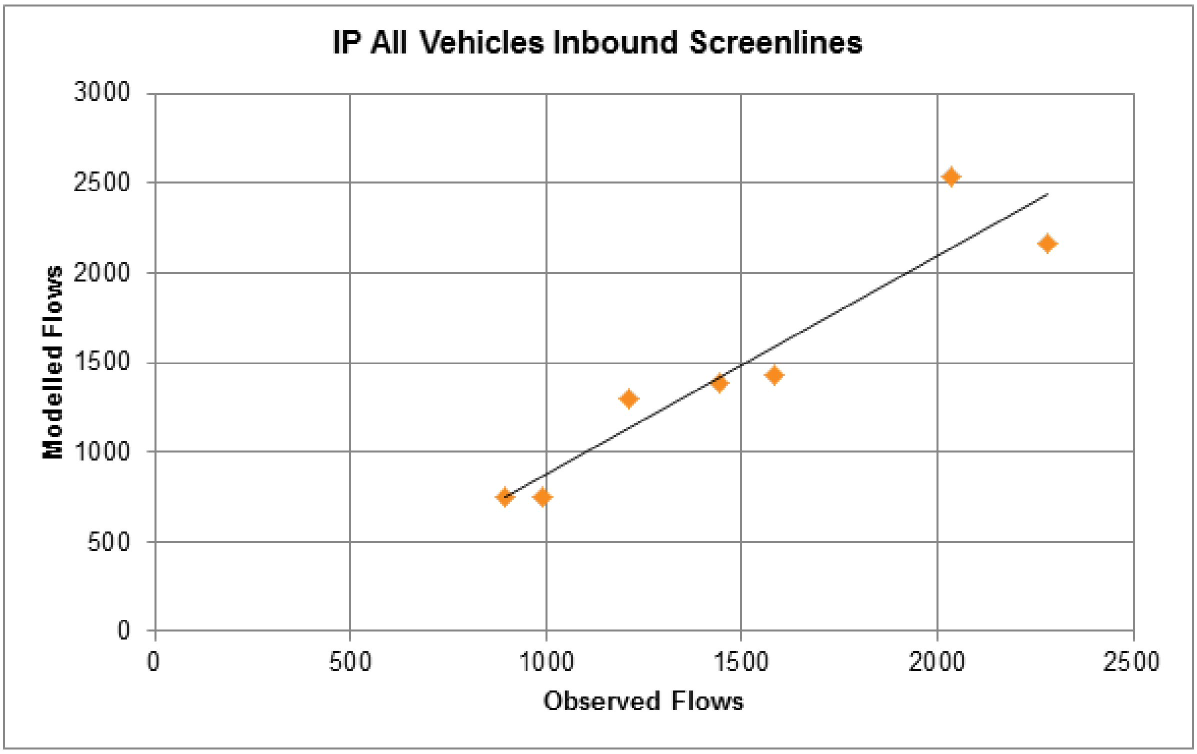


Figure 8-8. IP Car Outbound Screenlines Prior Matrix Assignment

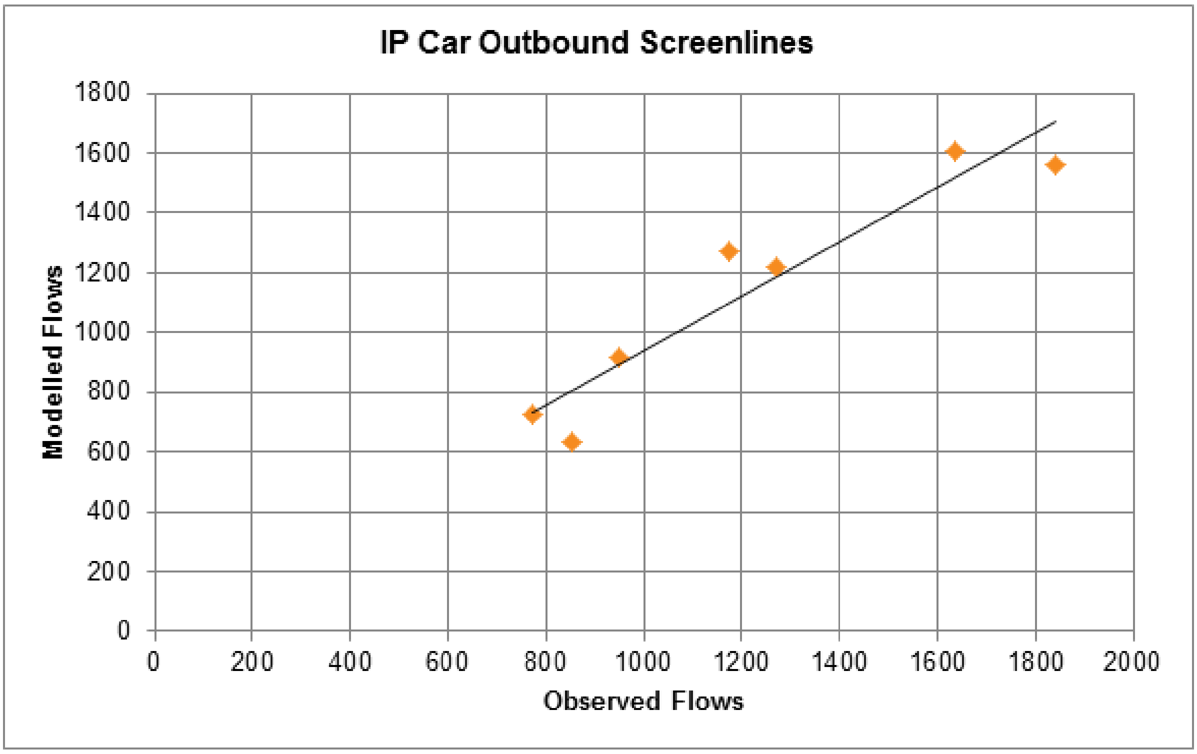


Figure 8-9. IP All Vehicles Outbound Screenlines Prior Matrix Assignment

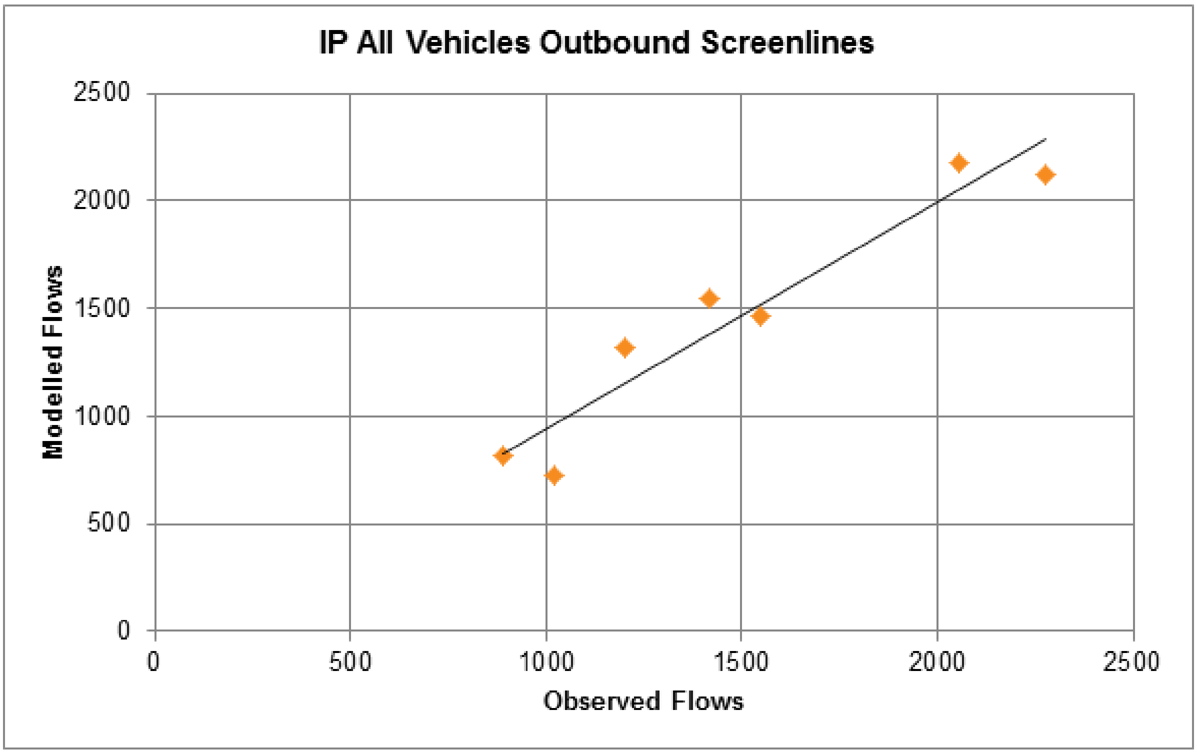


Figure 8-10. PM Car Inbound Screenlines Prior Matrix Assignment

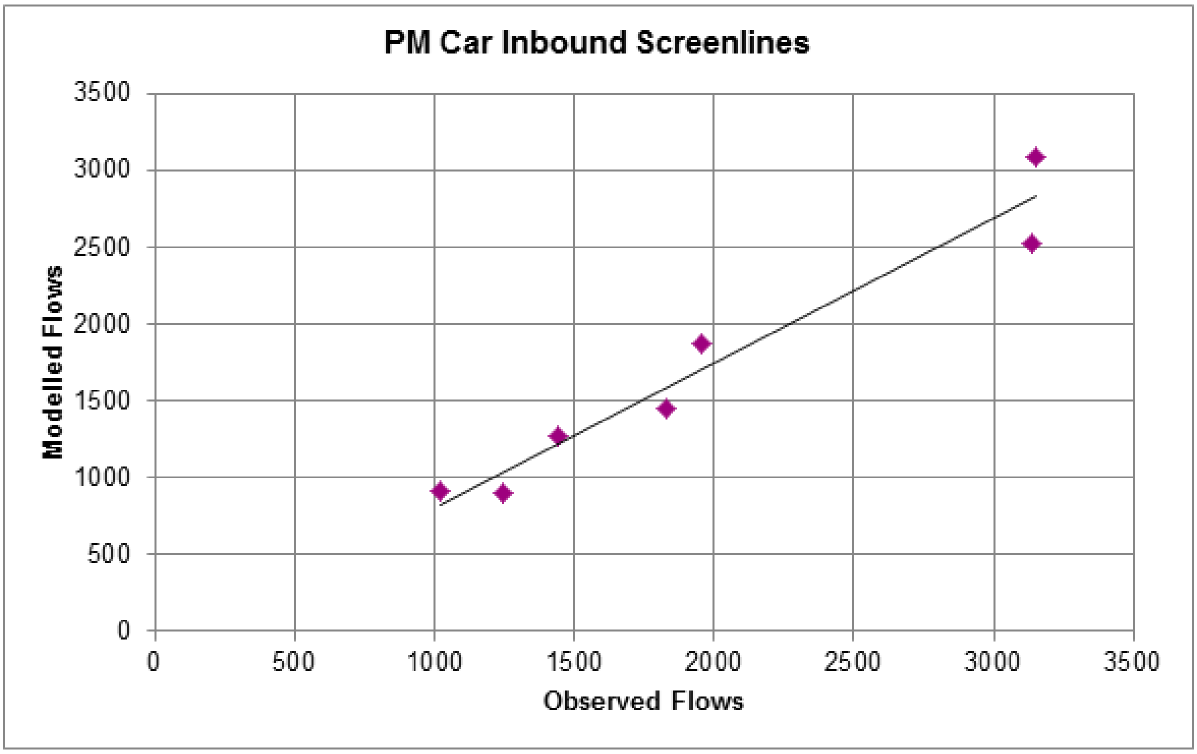


Figure 8-11. PM All Vehicles Inbound Screenlines Prior Matrix Assignment

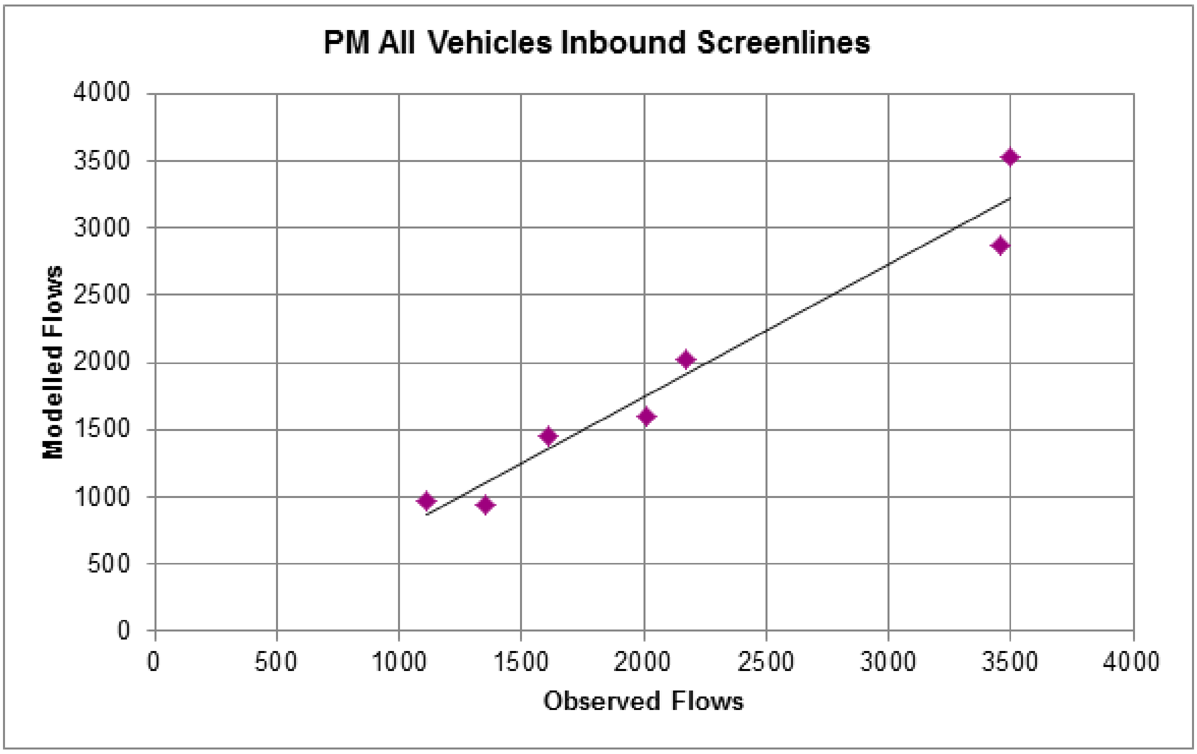


Figure 8-12. PM Car Outbound Screenlines Prior Matrix Assignment

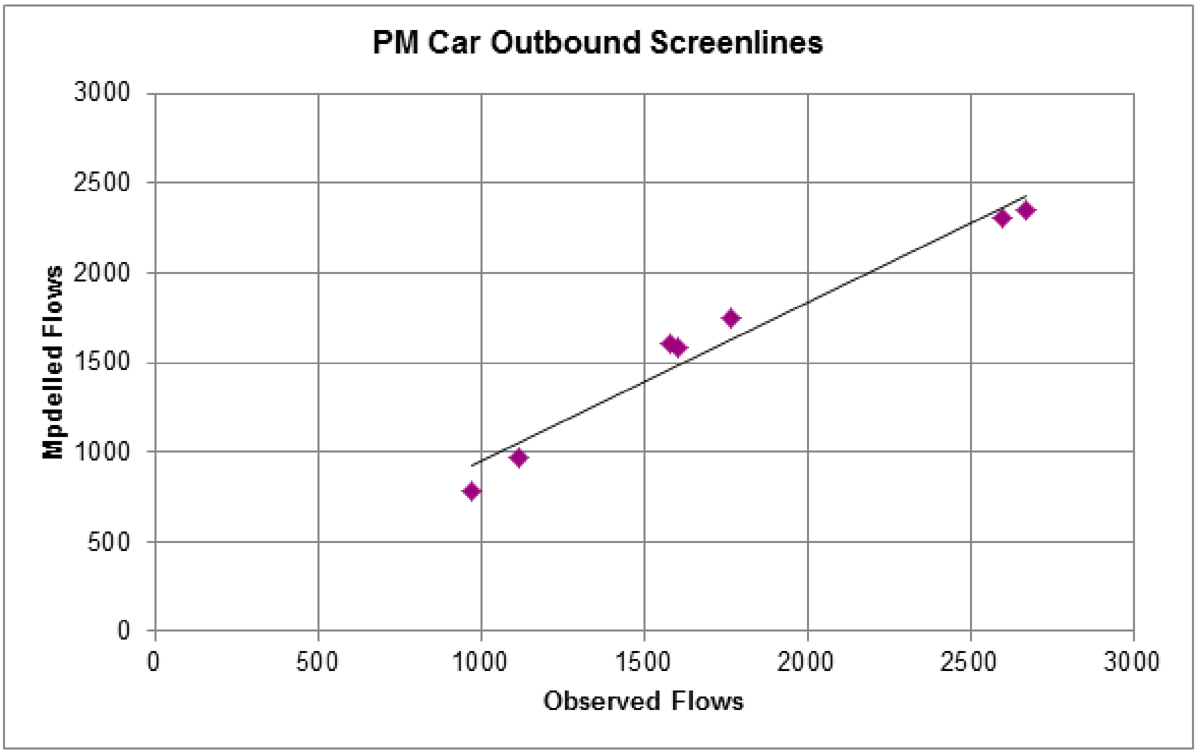
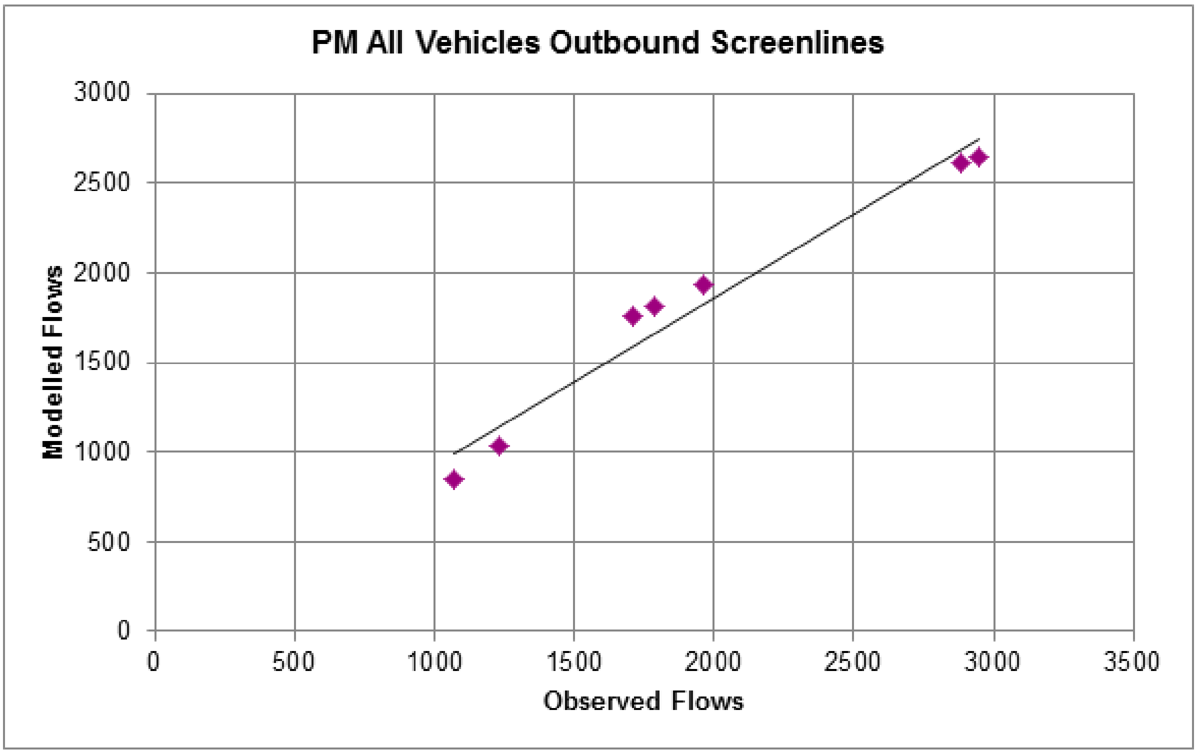


Figure 8-13. PM All Vehicles Outbound Screenlines Prior Matrix Assignment



8.4 Impact of Matrix Estimation on the Prior Matrix

This section summarises how matrix estimation has been applied and then considers the changes made to the prior matrix as a result of matrix estimation.

The purpose of matrix estimation is to refine the prior matrix rather than making wholesale changes to it or to make compensating adjustments in the matrix in order to compensate for network routing errors.

When applying matrix estimation the following principles were used:

- counts were grouped into screenlines and applied as a constraint;
- counts were applied at vehicle type level i.e. Car, LGV and HGV; this required the three car purpose matrices to be estimated as a combined matrix; no estimation was undertaken at individual purpose level;
- no constraints were applied to trip ends; and
- no movements were frozen in the estimation process.

The comparison between the pre and post ME2 matrices aims to establish the amount of change that has taken place due to matrix estimation. The comparison covers the following areas:

- matrix zonal cell values;
- trip end totals by origin and destination zone;
- trip length distributions; and
- sector to sector movements.

All of these checks have been carried out separately for each model time period and each vehicle type. Table 8-3 below summarises the tests to be carried out and the criteria that was set out by DfT guidance to achieve. The results of these tests are shown below.

Table 8-3. Significance Criteria of ME2 Change Measures

Measure	Significance Criteria
Matrix zonal cell values	Slope within 0.98 and 1.02 Intercept near zero R^2 in excess of 0.95
Matrix zonal trip ends	Slope within 0.99 and 1.01 Intercept near zero R^2 in excess of 0.98
Trip length distributions	Means within 5% Standard deviations within 5%
Sector to sector level matrices	Differences within 5%

Source: WebTAG Unit M3.1

8.4.1 AM Matrix Comparisons

Table 8-4 below shows the slope, intercept and R^2 zonal cell values output from the AM SATURN model post ME process.

Table 8-4. AM Matrix Estimation Zone to Zone Regression

Vehicle Type	Slope	Intercept	R^2
Car	0.9986	0.6159	0.9986
LGV	1.0037	-0.5194	0.9985
HGV	0.9931	-0.1058	0.9920

Comparing the values in Table 8-4 to the DfT guidance in Table 8-3 indicates that there has been an acceptable amount of change as a result of the ME process. Table 8-5 below shows the slope, intercept and R^2 zonal trip ends output from the AM SATURN model post ME process.

Table 8-5. AM Matrix Zonal Trip End Comparison

Vehicle Type	Trip End	Slope	Intercept	R^2
Car	Origins	1.0000	5.8041	1.0000
	Destinations	1.0000	5.7514	1.0000
LGV	Origins	1.0000	-0.6515	1.0000
	Destinations	1.0000	-0.7006	1.0000
HGV	Origins	1.0000	-0.4918	1.0000
	Destinations	1.0000	-0.5060	1.0000

Comparing the values in Table 8-5 to the DfT guidance in Table 8-3 indicates there has been an acceptable amount of change as a result of the ME process.

The four graphs below show the change in trip ends for all AM trip ends in the 100 series. The 100 series are zones which are internal to the detailed Blyth study area (zones 101-173). This therefore does not display any of the zone 201+ or zone 301+ larger zones trip ends due to the high volume of movements.

Figure 8-14. AM Car Origin Trip End Change by Zone

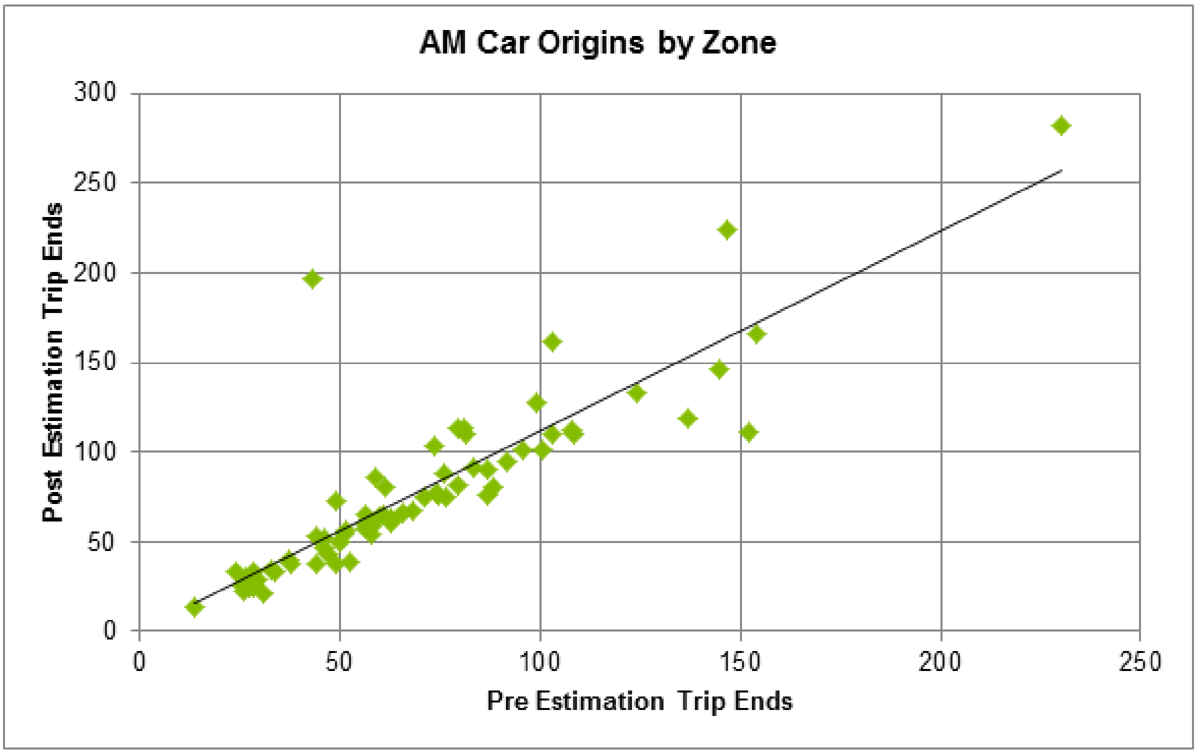


Figure 8-15. AM Car Destination Trip End Change by Zone

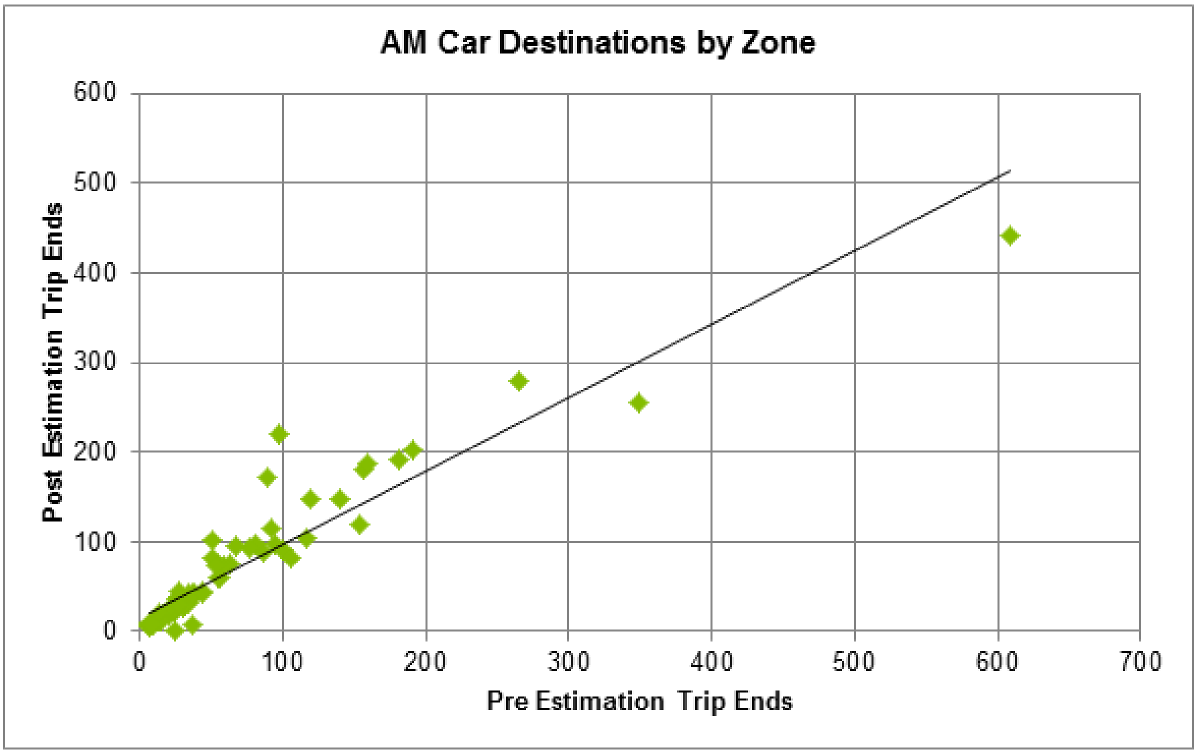


Figure 8-16. AM All Vehicles Origin Trip Ends by Zone

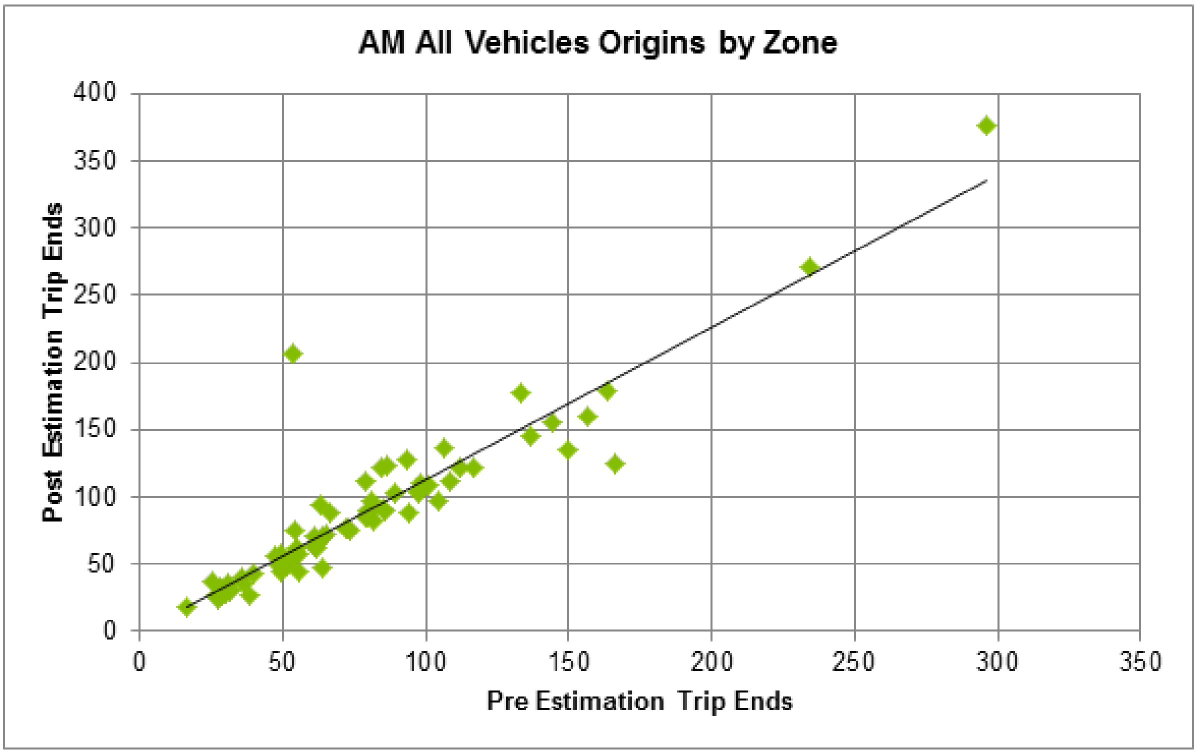
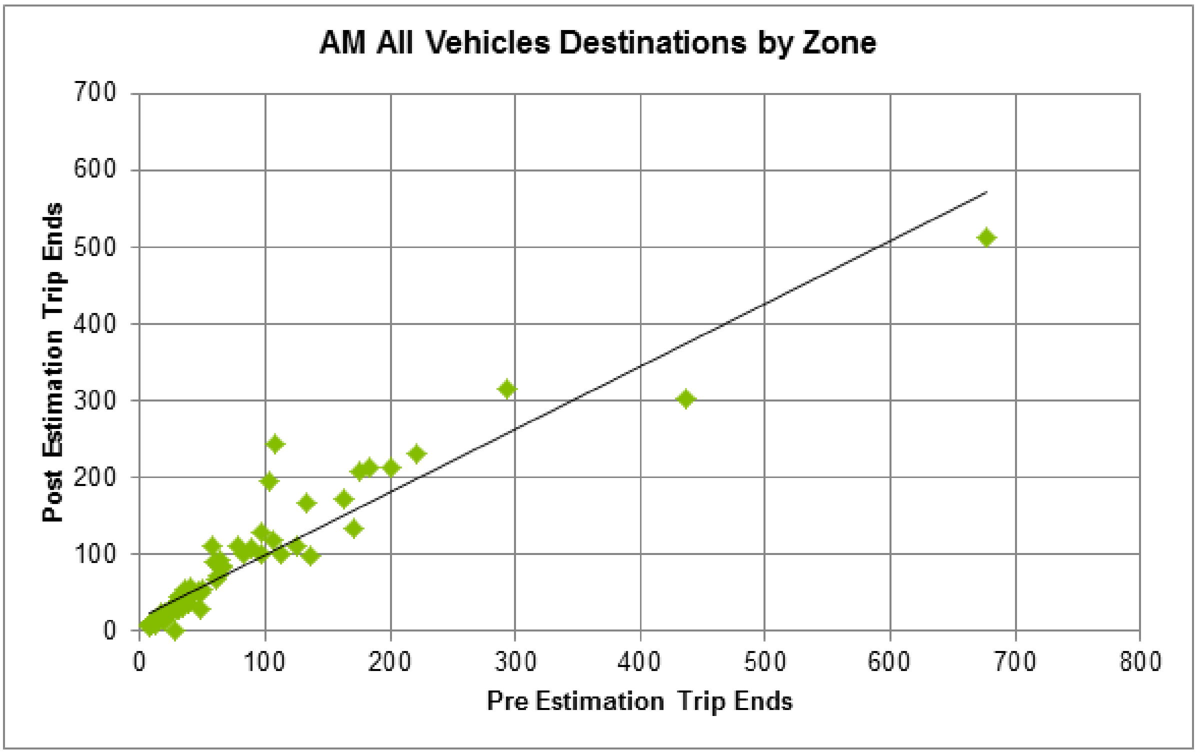


Figure 8-17. AM All Vehicle Destination Trip Ends by Zone



The graphs above show that there is no substantial deviations from the trend set by the change to zonal trip ends in the AM SATURN model. It should be noted that there is one obvious point plot on the Origin trip ends graphs which does not conform to the apparent trend. It has been noted that this point represents zone 167 in Bebside. This zone in the AM has experienced a large change in origin trip ends during the ME process due to its location and proximity to a count site defined in the constraining ME file.

Table 8-6 below show distance changes for the AM peak for all OD movements between the 129 zones of the 100 series (101-179).

Table 8-6. AM Trip Length Distribution Comparison

Vehicle Type	Prior Average Distance (km)	Post Average Distance (km)	% Difference	Prior Standard Deviation	Post Standard Deviation	% Difference
Car	21.66	21.66	0.01%	20.85	20.85	0.00%
LGV	23.07	23.05	0.06%	28.85	28.83	0.06%
HGV	30.82	30.81	0.04%	52.86	52.83	0.03%

This table shows that the alterations as a consequence of the ME process are minor in the AM scenario, and conform to the DfT guidance in Table 8-3.

The two graphs below show trip length distributions for all AM OD movements which pass through Blyth. This therefore does not include any of the zone 301+ to zone 301+ OD movements due to the high volume of traffic in these larger zones.

Figure 8-18. AM Car Trip Length Distribution Change

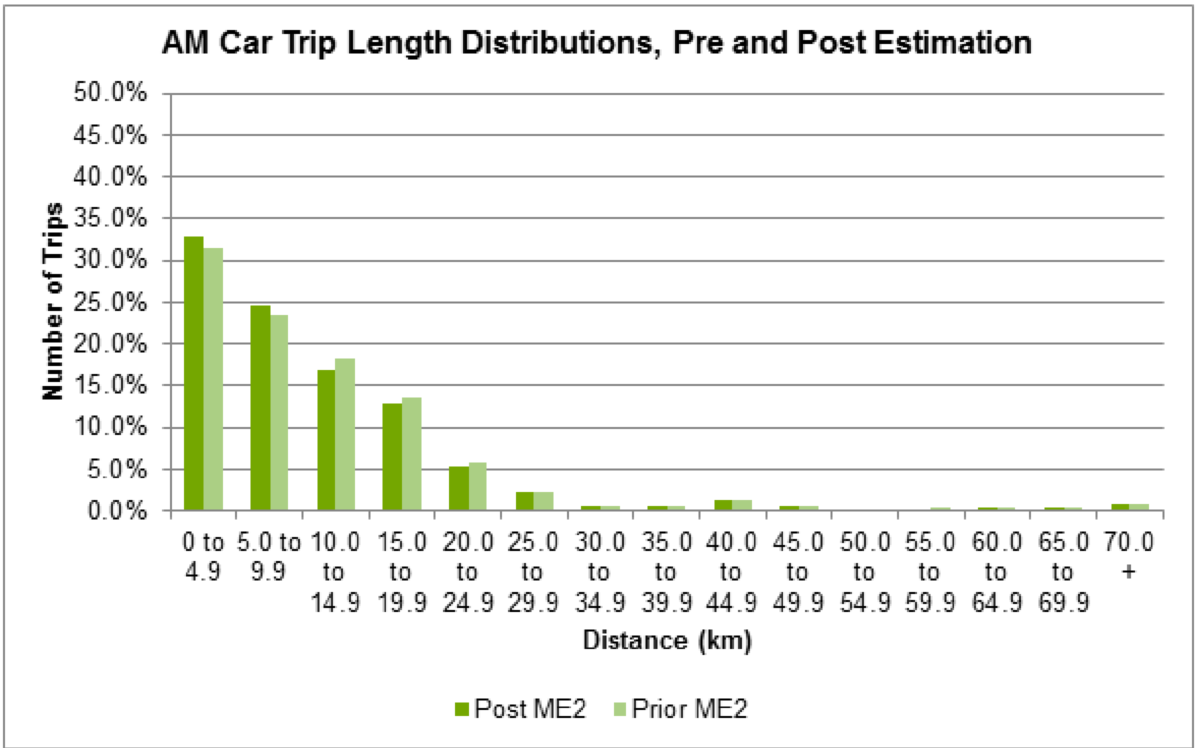
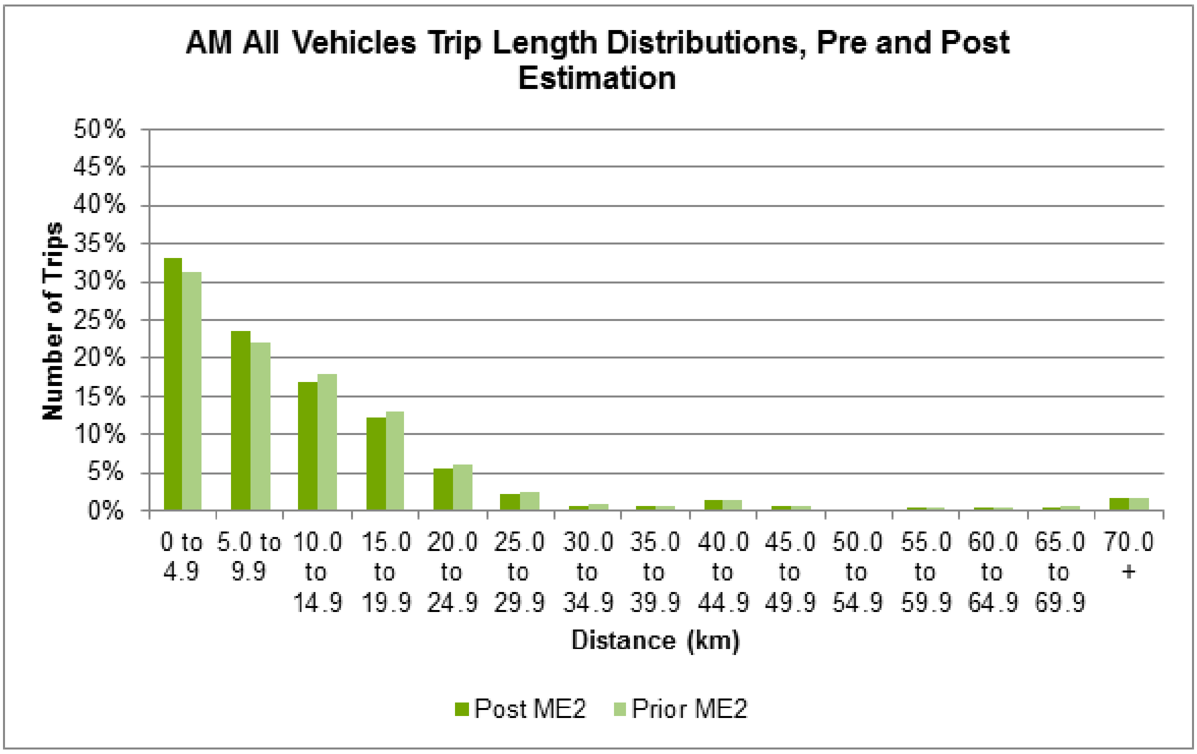


Figure 8-19. AM All Vehicles Trip Length Distribution Change



The two tables above also shows that there has been no major shift in journey length as a consequence of the ME process. There has been a small shift between different trip length bandings between 0 and 24.9km.

Table 8-7 and Table 8-8 below show the AM matrix change for all OD movements between the total 129 zones.

Table 8-7. AM OD GEH Change Post ME2

Vehicle Type	Number of OD Pairs Changing with a GEH of More than 5	Proportion of OD Pairs changing with a GEH of Less than 5
Car	8	99.05%
LGV	1	99.09%
HGV	0	100%

Table 8-8. AM Matrix Totals Change Post ME2

Vehicle Type	Matrix	Total Trips	Total Trip Difference	% Total Trip Difference	Average OD Difference GEH
Car	Prior	5,108,465	623	0.012%	0.19
	Post	5,109,088			
LGV	Prior	1,034,630	100	0.010%	0.12
	Post	1,034,530			
HGV	Prior	265,826	66	0.025%	0.04
	Post	265,760			

Table 8-7 above shows that there is no noticeable amount of OD pairs which have experienced a change of GEH greater than 5. Table 8-8 above also shows that there have been no noticeable changes to the AM matrix totals after the running of the ME process.

8.4.2 IP Matrix Comparisons

Table 8-9 below shows the slope, intercept and R^2 zonal cell values output from the IP SATURN model post ME process.

Table 8-9. IP Matrix Estimation Zone to Zone Regression

Vehicle Type	Slope	Intercept	R^2
Car	0.9965	1.9963	0.9997
LGV	0.9989	0.1649	0.9999
HGV	1.0169	-0.3848	0.9977

Comparing the values in Table 8-9 to the DfT guidance in Table 8-3 indicates that there has been an acceptable amount of change as a result of the ME process. Table 8-10 below shows the slope, intercept and R^2 zonal trip ends output from the IP SATURN model post ME process.

Table 8-10. IP Matrix Zonal Trip End Comparison

Vehicle Type	Trip End	Slope	Intercept	R^2
Car	Origins	1.0000	6.9530	1.0000
	Destinations	1.0000	6.9009	1.0000
LGV	Origins	1.0000	-1.6901	1.0000
	Destinations	1.0000	-1.7531	1.0000
HGV	Origins	1.0000	-0.5185	1.0000
	Destinations	1.0000	-0.5465	1.0000

Comparing the values in Table 8-10 to the DfT guidance in Table 8-3 indicates there has been an acceptable amount of change as a result of the ME process.

Figure 8-20 to Figure 8-23 below show the change in trip ends for all AM trip ends in the 100 series. The 100 series are zones which are internal to the detailed Blyth study area (zones 101-173). This therefore does not display any of the zone 201+ or zone 301+ larger zones trip ends due to the high volume of movements.

Figure 8-20. IP Car Origin Trip Ends by Zone

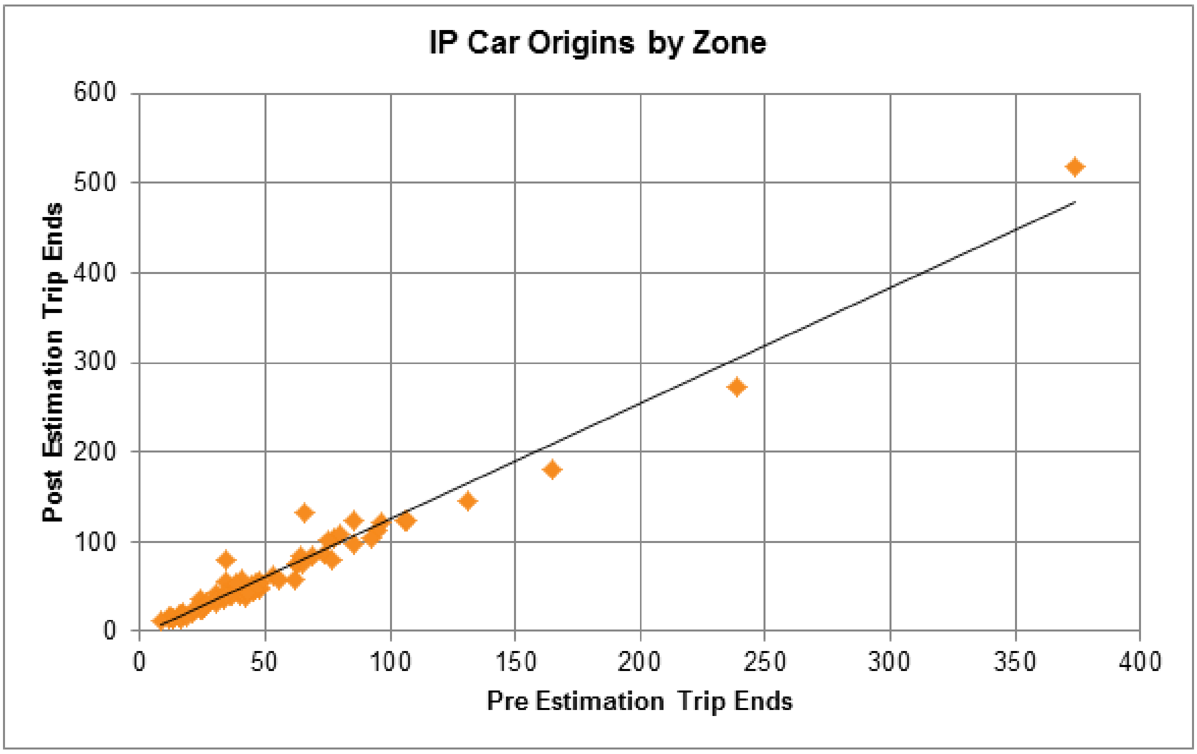


Figure 8-21. IP Car Destination Trip Ends by Zone

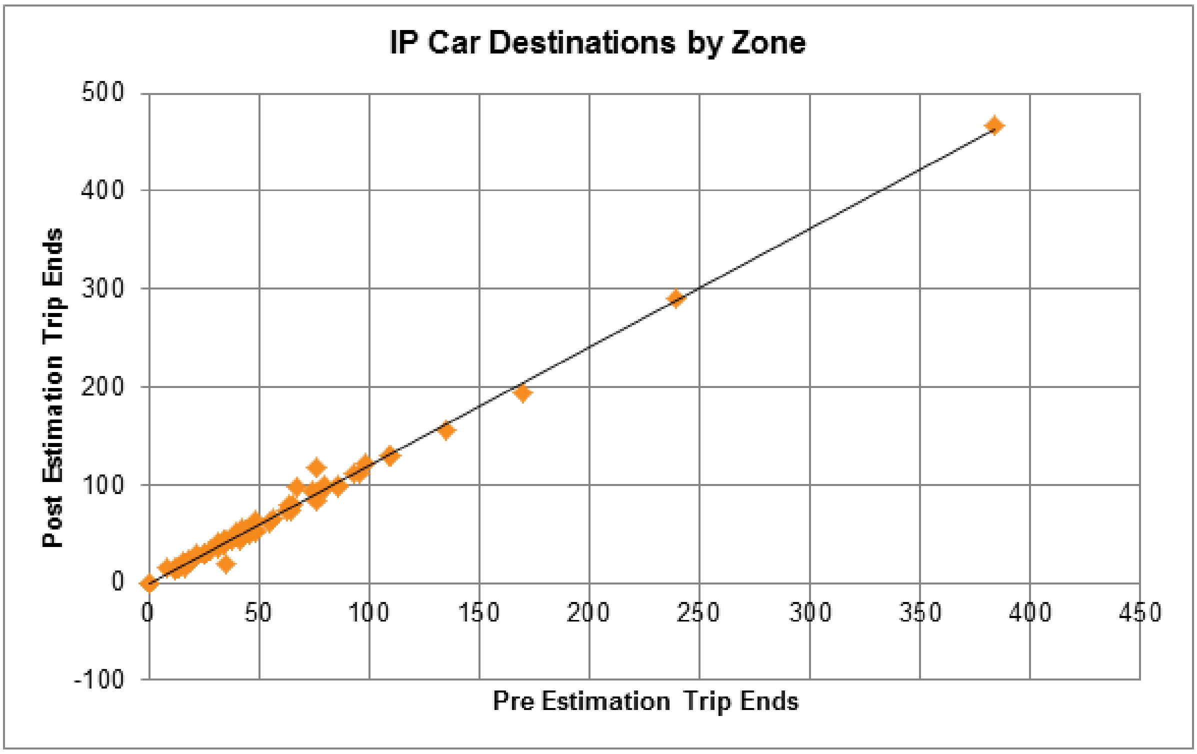


Figure 8-22. IP All Vehicles Origin Trip Ends by Zone

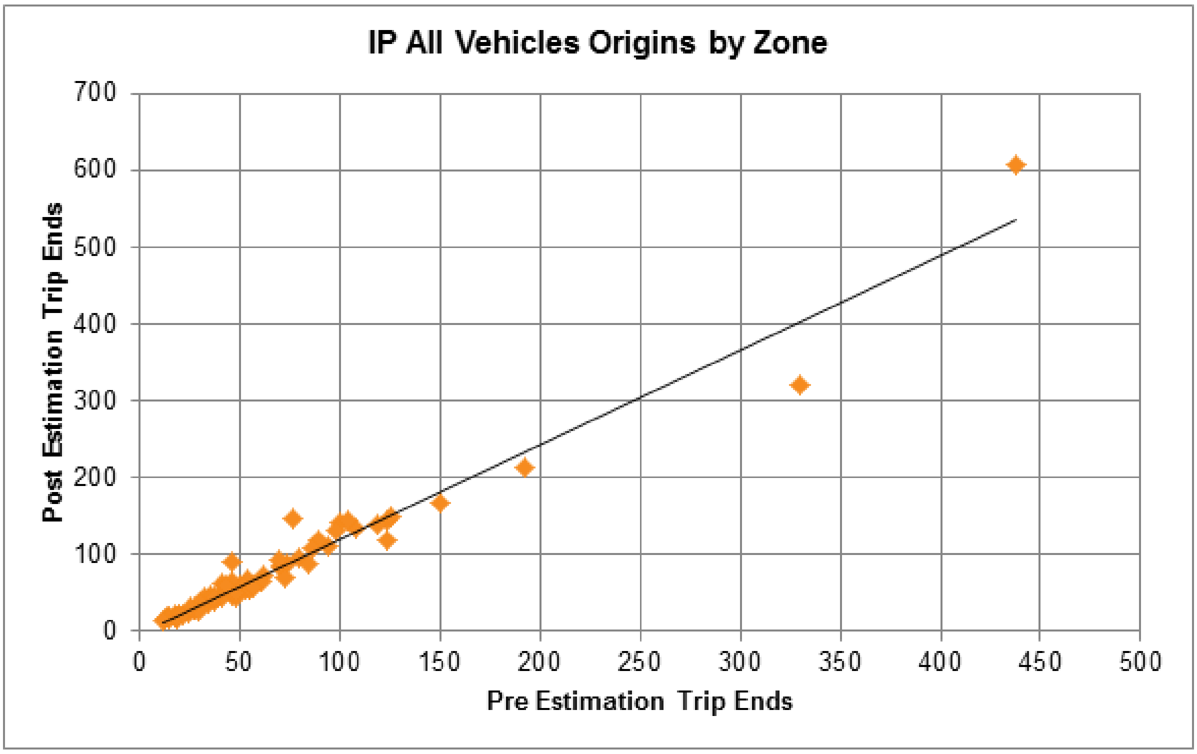
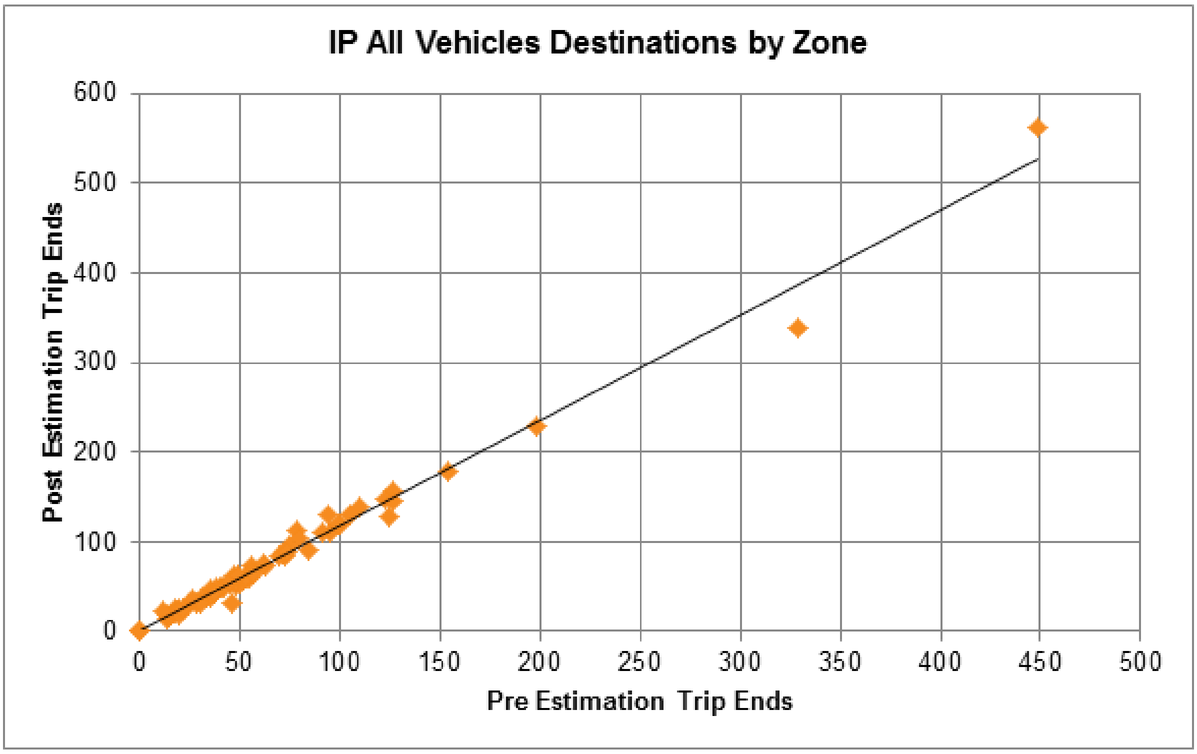


Figure 8-23. IP All Vehicles Destination Trip Ends by Zone



The graphs above show that there is no noticeable deviations from the trend set between pre to post estimation trip ends in the IP matrices.

Table 8-11 below show distance changes for the IP peak for all OD movements between the 129 zones.

Table 8-11. IP Trip Length Distribution Comparison

Vehicle Type	Prior Average Distance (km)	Post Average Distance (km)	% Difference	Prior Standard Deviation	Post Standard Deviation	% Difference
Car	22.48	22.48	0.02%	22.68	22.68	0.00%
LGV	23.07	23.05	0.06%	28.86	28.84	0.05%
HGV	30.83	30.81	0.05%	52.86	52.84	0.03%

Table 8-11 shows that the alterations as a consequence of the ME process are minor in the IP scenario, and conform to the DfT guidance in Table 8-3.

The two graphs below show trip length distributions for all IP OD movements which pass through Blyth. This therefore does not include any of the zone 301+ to zone 301+ OD movements.

Figure 8-24. IP Car Trip Length Distribution Change

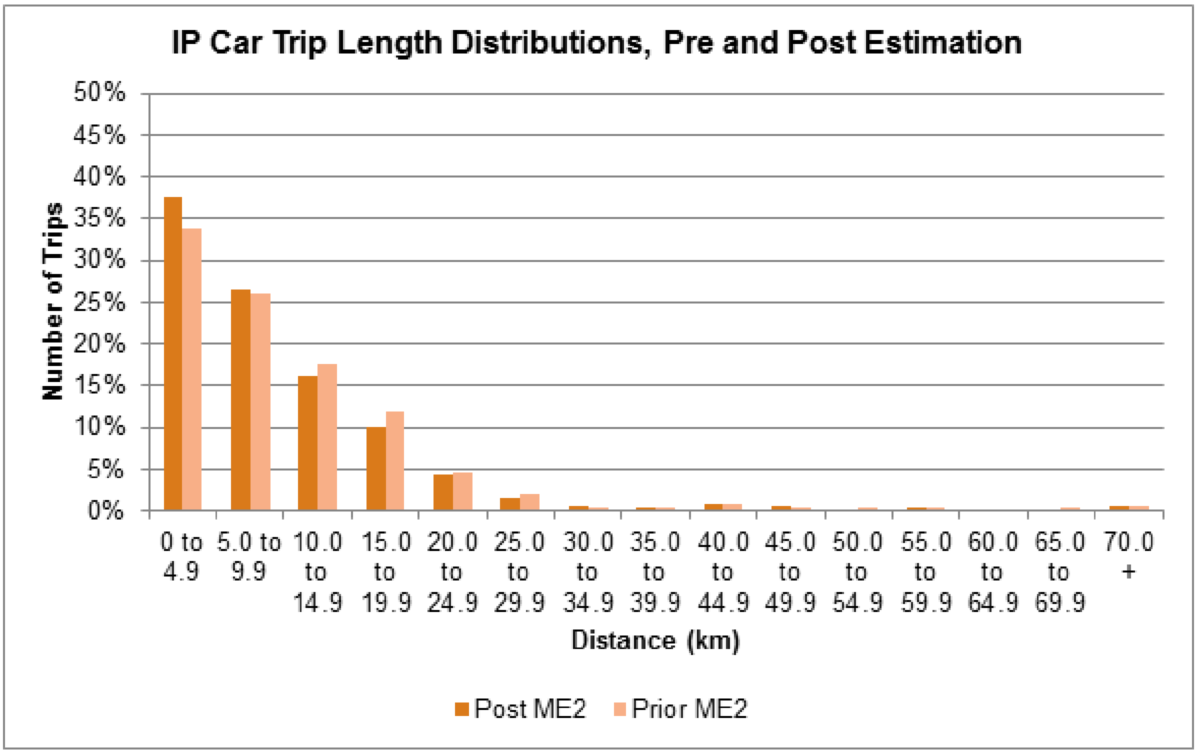


Figure 8-25. IP All Vehicles Trip Length Distribution Change

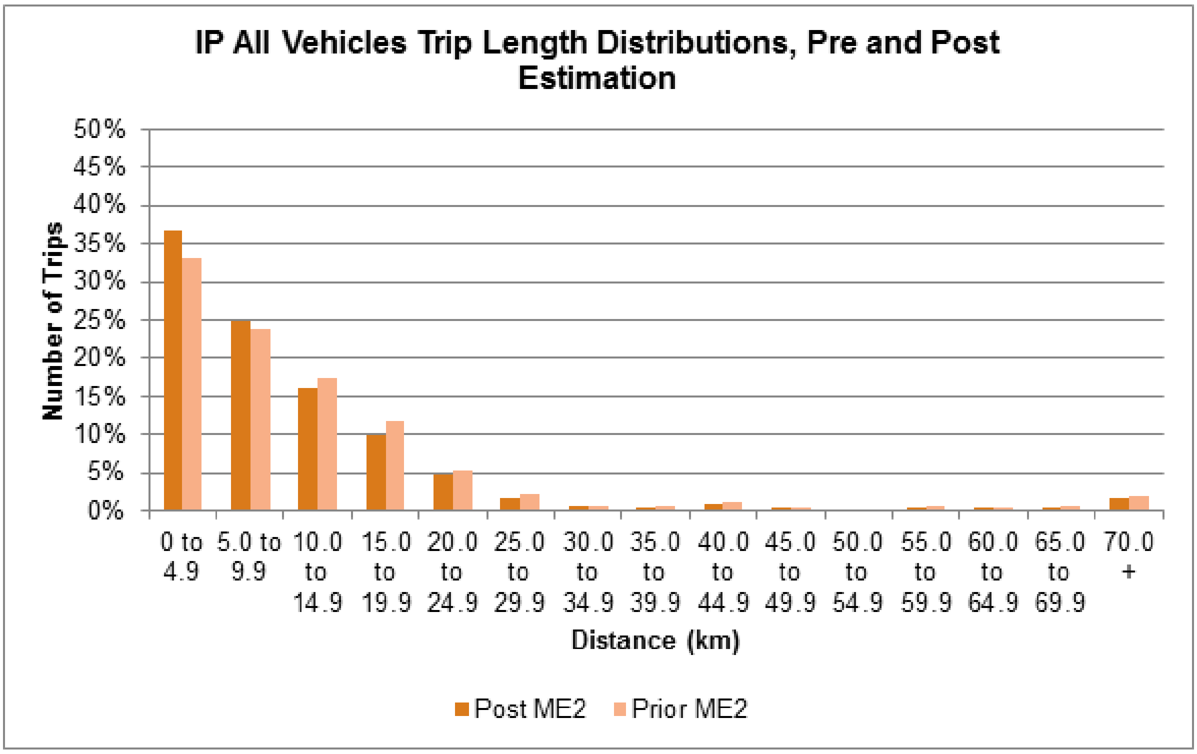


Figure 8-24 and Figure 8-25 above also shows that there has been no major shift in journey length as a consequence of the ME process. However there has been a more noticeable increase in journeys in the 0 to 4.9km band. This is a minor shift between 0 and 24.9km and is likely due to the inherent short nature of type of journey purpose trips made during the IP.

Table 8-12 and Table 8-13 below show the PM matrix change for all OD movements between the total 129 zones.

Table 8-12. IP OD GEH Change Post ME2

Vehicle Type	Number of OD Pairs Changing with a GEH of More than 5	Proportion of OD Pairs changing with a GEH of Less than 5
Car	4	99.07%
LGV	0	100%
HGV	0	100%

Table 8-13. IP Matrix Totals Change Post ME2

Vehicle Type	Matrix	Total Trips	Total Trip Difference	% Total Trip Difference	Average OD Difference GEH
Car	Prior	4,088,897	796	0.019%	0.16
	Post	4,089,694			
LGV	Prior	915,715	215	0.023%	0.10
	Post	915,500			
HGV	Prior	294,251	70	0.024%	0.05
	Post	294,181			

Table 8-12 above shows that there is no noticeable amount of OD pairs which have experienced a change of GEH greater than 5. Table 8-13 above also shows that there have been no noticeable changes to the IP matrix totals after the running of the ME process.

8.4.3 PM Matrix Comparisons

Table 8-14 below shows the slope, intercept and R^2 zonal cell values output from the PM SATURN model post ME process.

Table 8-14. PM Matrix Estimation Zone to Zone Regression

Vehicle Type	Slope	Intercept	R^2
Car	0.9986	-0.3523	0.9999
LGV	0.9968	0.3549	0.9961
HGV	0.9923	0.1571	0.9760

Comparing the values in Table 8-14 to the DfT guidance in Table 8-3 indicates that there has been an acceptable amount of change as a result of the ME process. Table 8-15 below shows the slope, intercept and R^2 zonal trip ends output from the PM SATURN model post ME process.

Table 8-15. PM Matrix Zonal Trip End Comparison

Vehicle Type	Trip End	Slope	Intercept	R^2
Car	Origins	1.0000	14.7157	1.0000
	Destinations	1.0000	14.5929	1.0000
LGV	Origins	1.0000	0.9158	1.0000
	Destinations	1.0000	0.8881	1.0000
HGV	Origins	1.0000	-0.0241	1.0000
	Destinations	1.0000	-0.0369	1.0000

Comparing the values in Table 8-15 indicates that the slope and R^2 values for the PM matrices comply with the DfT guidance in Table 8-3. However the intercept values for the combined car matrices, for both origin and destination have experienced a distinguishable change. The nature of traffic flow around the PM is complex due to a noticeable volume of shift workers. It has been observed that the PM peak fluctuates over a longer period than an hour peak. As a result, there has been a larger volume of change required during ME to bring modelled flows in line with observed.

Figure 8-26 to Figure 8-29 below show the change in trip ends for all PM trip ends in the 100 series. This therefore does not display any of the zone 201+ or zone 301+ trip ends due to the high volume of movements.

Figure 8-26. PM Car Origin Trip Ends by Zone

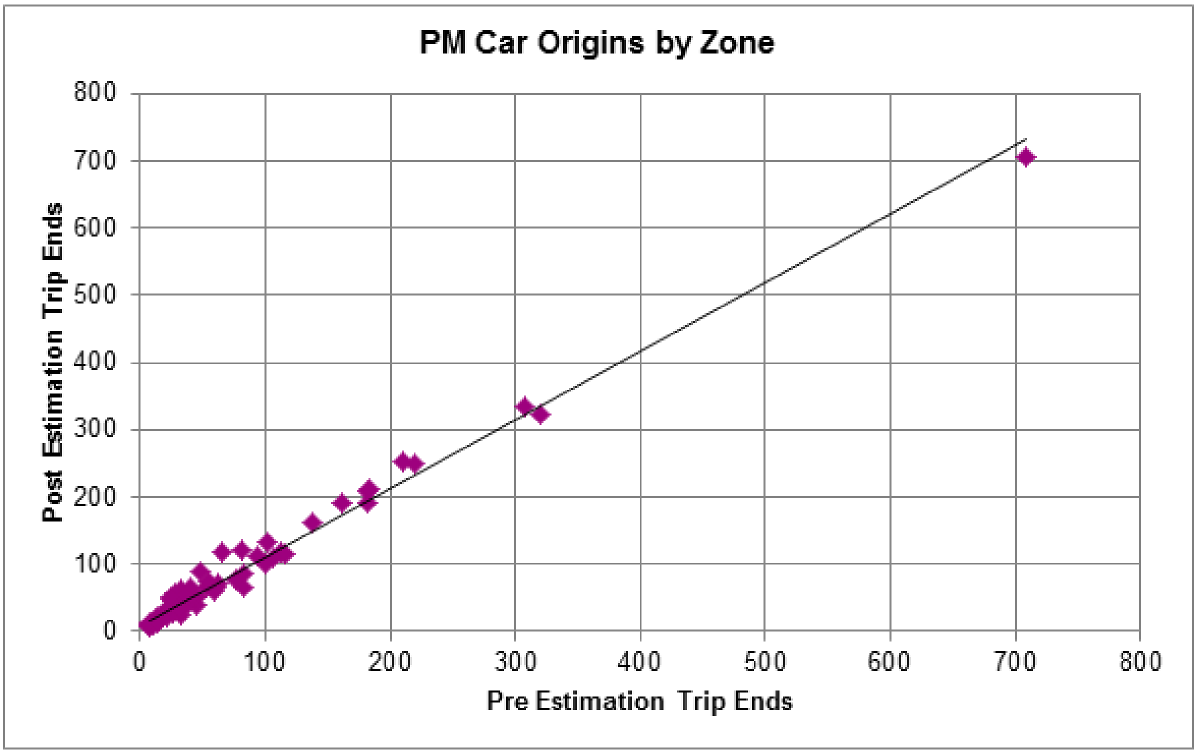


Figure 8-27. PM Car Destination Trip Ends by Zone

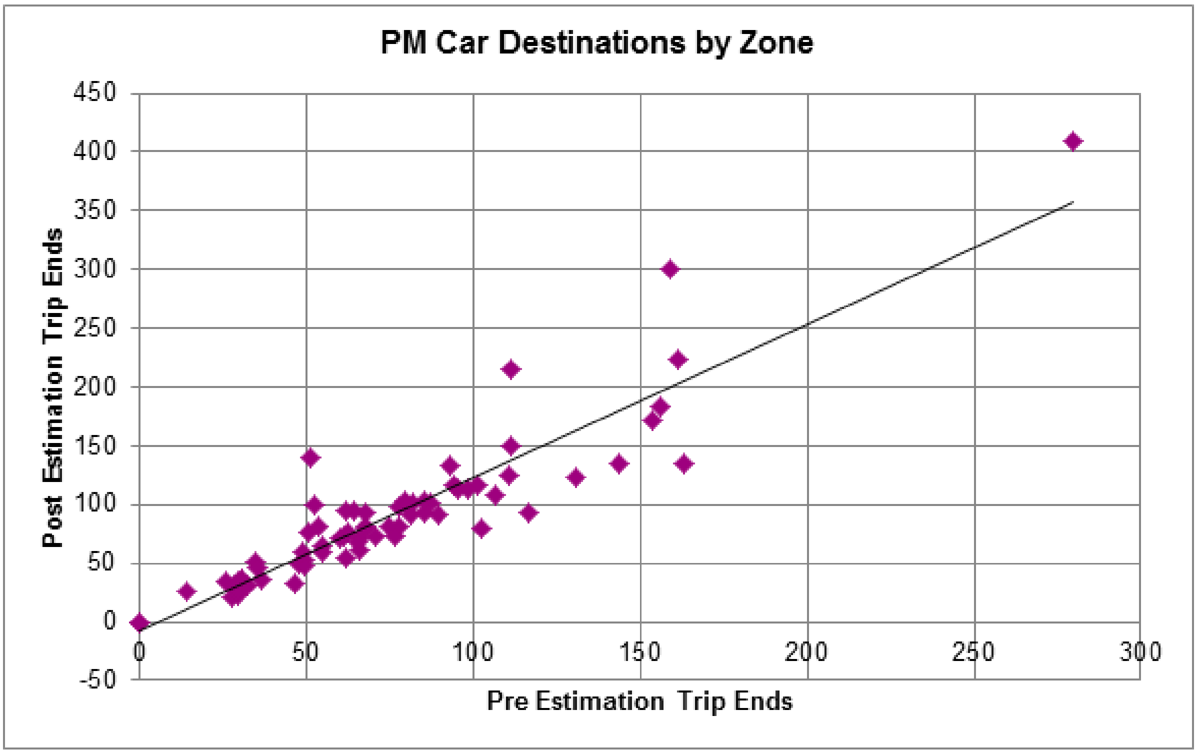


Figure 8-28. PM All Vehicles Origin Trip Ends by Zone

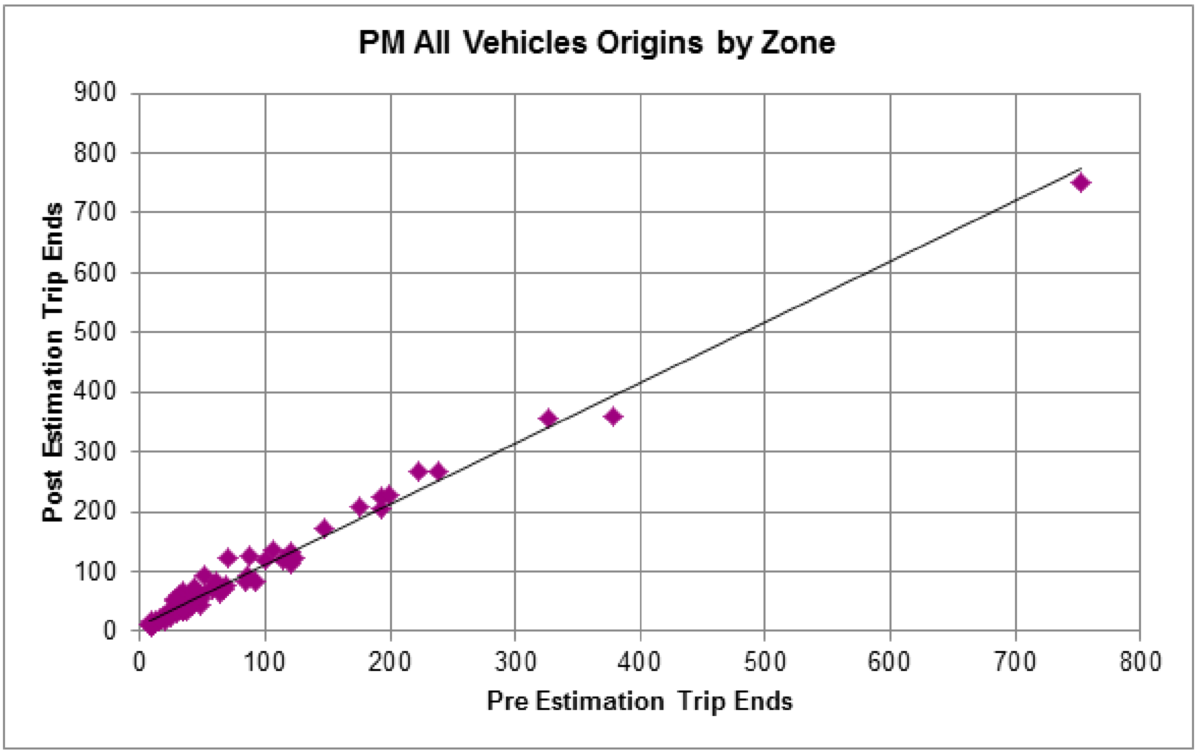
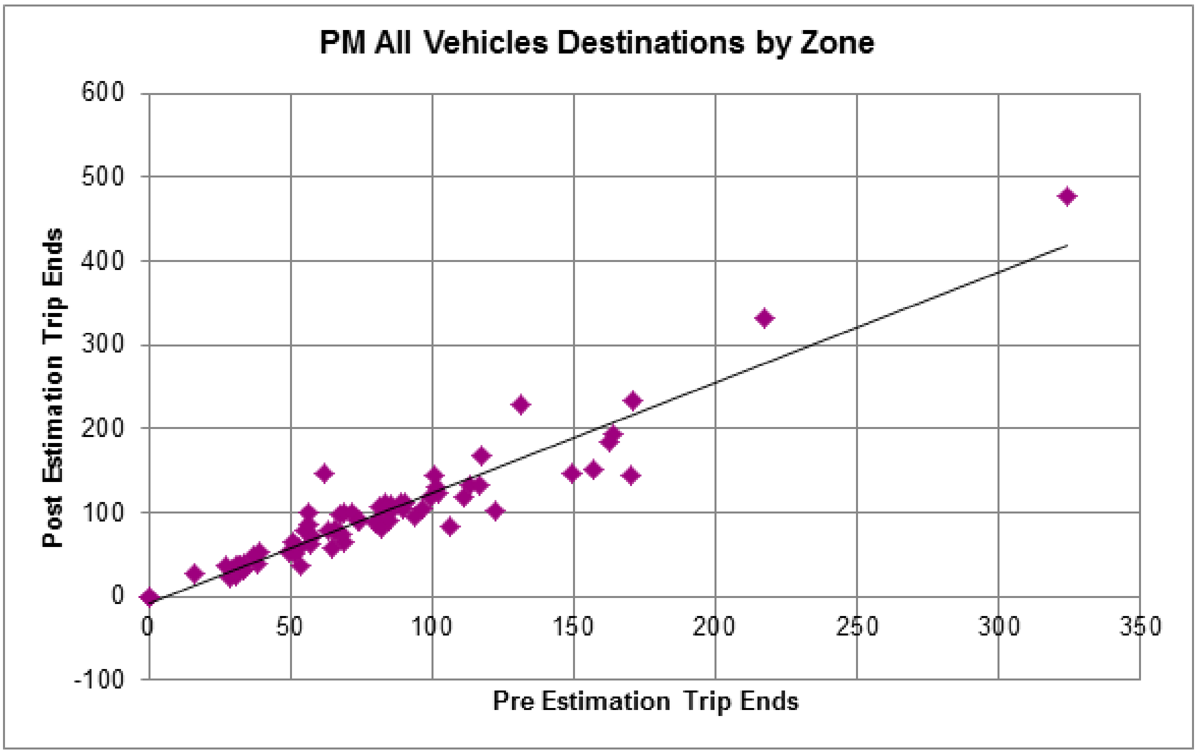


Figure 8-29. PM All Vehicles Destination Trip Ends by Zone



The graphs above show that there is no noticeable deviations from the trend set by the change to zonal trip ends in the PM SATURN model. It should be noted that there are two points which indicate a larger changes in the PM origins graph. These points represent zones 161 and 162, to the south end of Chase Farm Drive. These points have experienced change during the ME process due to their location and proximity to a ME link flow count constraint on Chase Farm Drive. As this site is segregated from the network except through Chase Farm Drive, these zones have been more heavily factored to match observed flows destined for these zones.

Table 8-16 below show distance changes for the PM peak for all OD movements between the 129 zones.

Table 8-16. PM Trip Length Distribution Comparison

Vehicle Type	Prior Average Distance (km)	Post Average Distance (km)	% Difference	Prior Standard Deviation	Post Standard Deviation	% Difference
Car	21.82	21.81	0.02%	21.13	21.13	0.01%
LGV	23.07	23.06	0.03%	28.86	28.85	0.02%
HGV	30.82	30.81	0.03%	52.85	52.84	0.02%

Table 8-16 shows that the alterations as a consequence of the ME process are minor in the PM scenario, and conform to the DfT guidance in Table 8-3.

Figure 8-30 and Figure 8-31 below show trip length distributions for all PM OD movements which pass through Blyth. This therefore does not include any of the zone 301+ to zone 301+ OD movements.

Figure 8-30. PM Car Trip Length Distribution Change

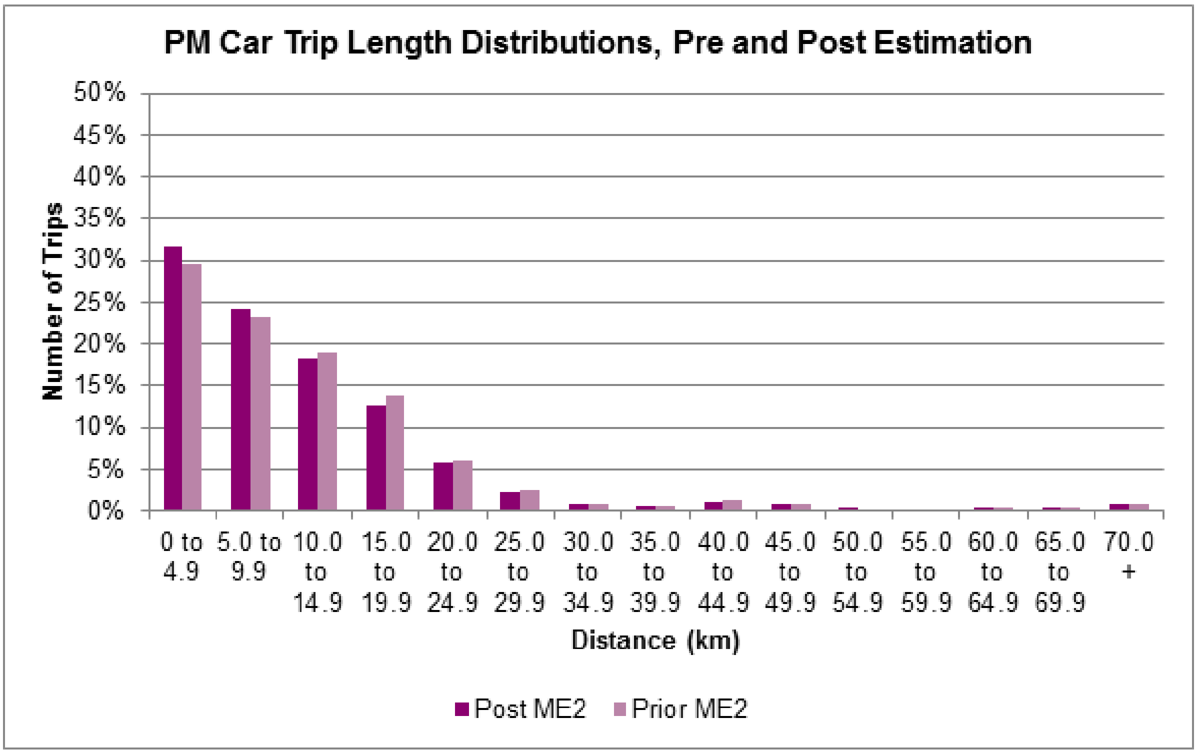
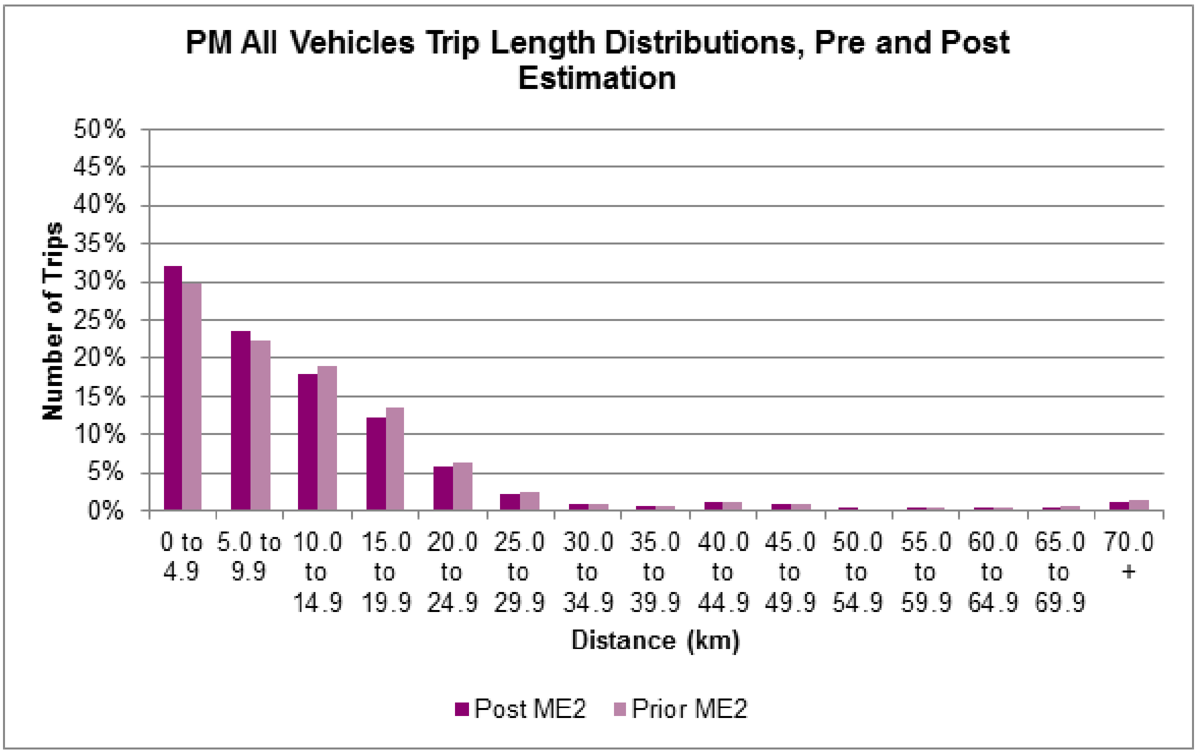


Figure 8-31. PM All Vehicles Trip Length Distribution Change



The two figures above also shows that there has been no major shift in journey length as a consequence of the ME process. There has been a small shift between different trip length bandings between 0 and 24.9km.

Table 8-17 and

Table 8-18 below show the PM matrix change for all OD movements between the total 129 zones.

Table 8-17. PM OD GEH Change Post ME2

Vehicle Type	Number of OD Pairs Changing with a GEH of More than 5	Proportion of OD Pairs changing with a GEH of Less than 5
Car	6	99.06%
LGV	0	100%
HGV	0	100%

Table 8-18. PM Matrix Totals Change Post ME2

Vehicle Type	Matrix	Total Trips	Total Trip Difference	% Total Trip Difference	Average OD Difference GEH
Car	Prior	5,629,696	1,704	0.030%	0.20
	Post	5,631,401			
LGV	Prior	749,627	101	0.013%	0.09
	Post	749,728			
HGV	Prior	100,464	5	0.005%	0.03
	Post	100,459			

Table 8-17 above shows that there is no noticeable amount of OD pairs which have experienced a change of GEH greater than 5. Table 8-18 above also shows that there have been no noticeable changes to the PM matrix totals after the running of the ME process.

9. Network Calibration and Validation

9.1 Network Calibration

In this section of the report we look at how the ME process has resulted in the calibration of modelled counts within the screenlines.

Figure 9-1 to Figure 9-4 show the combined change in screenline modelled flows in the AM peak as a result of the ME process.

Figure 9-1. AM Car Inbound Screenlines ME2 Change

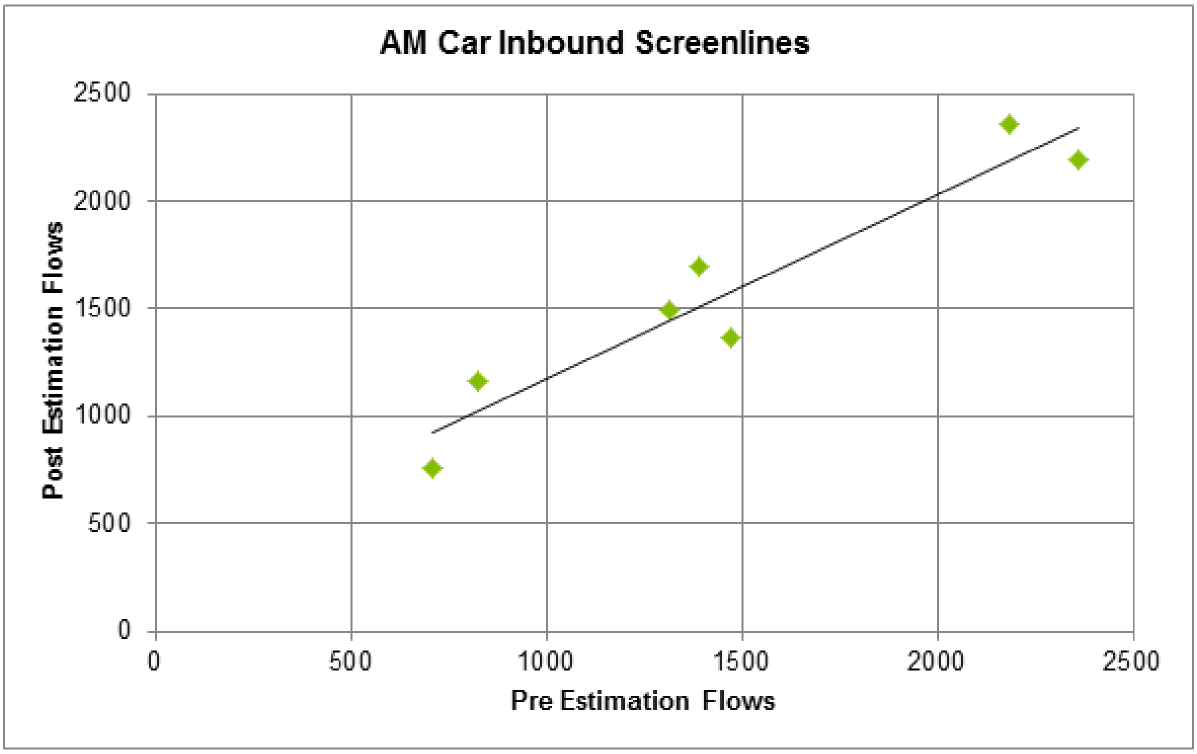


Figure 9-2. AM Car Outbound Screenlines ME2 Change

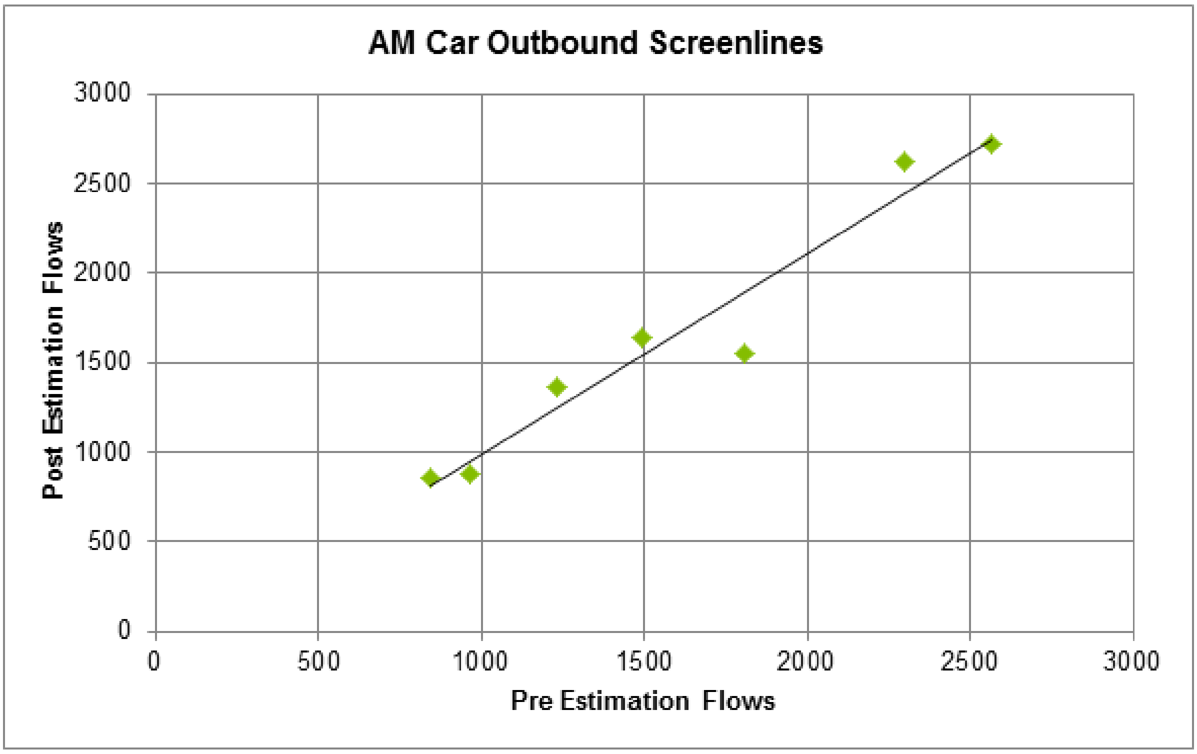


Figure 9-3. AM All Vehicles Inbound Screenlines ME2 Change

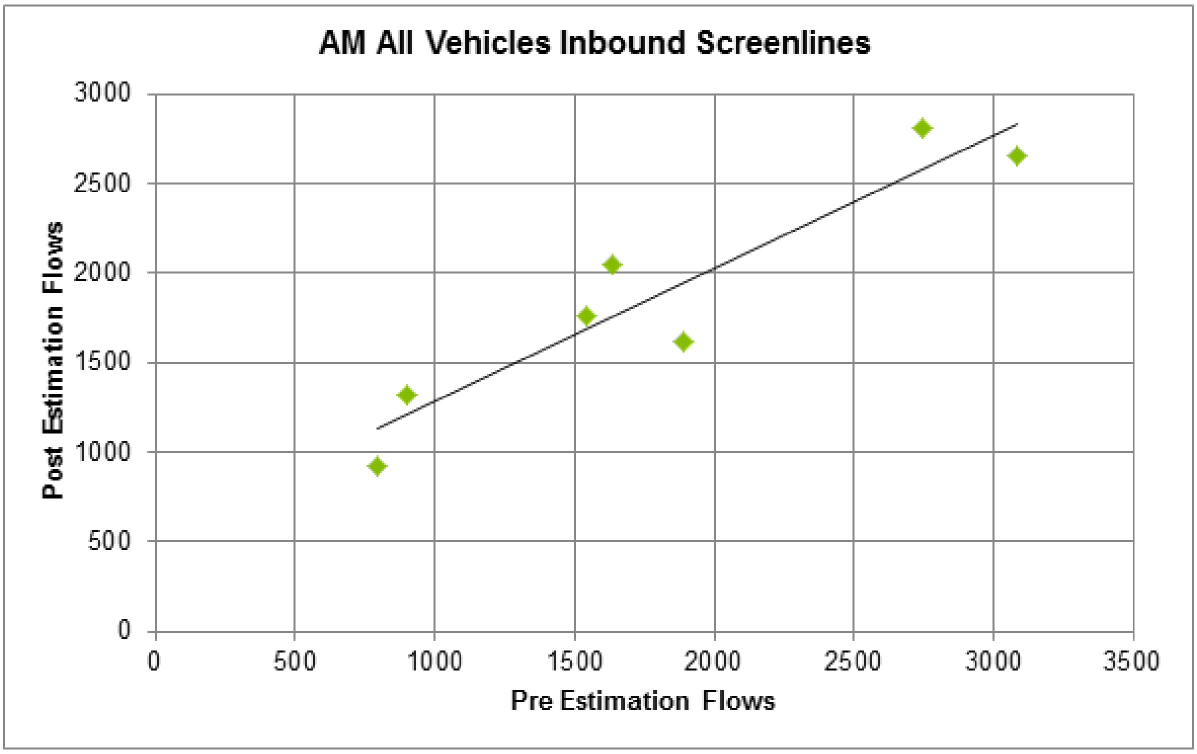


Figure 9-4. AM All Vehicles Outbound Screenlines ME2 Change

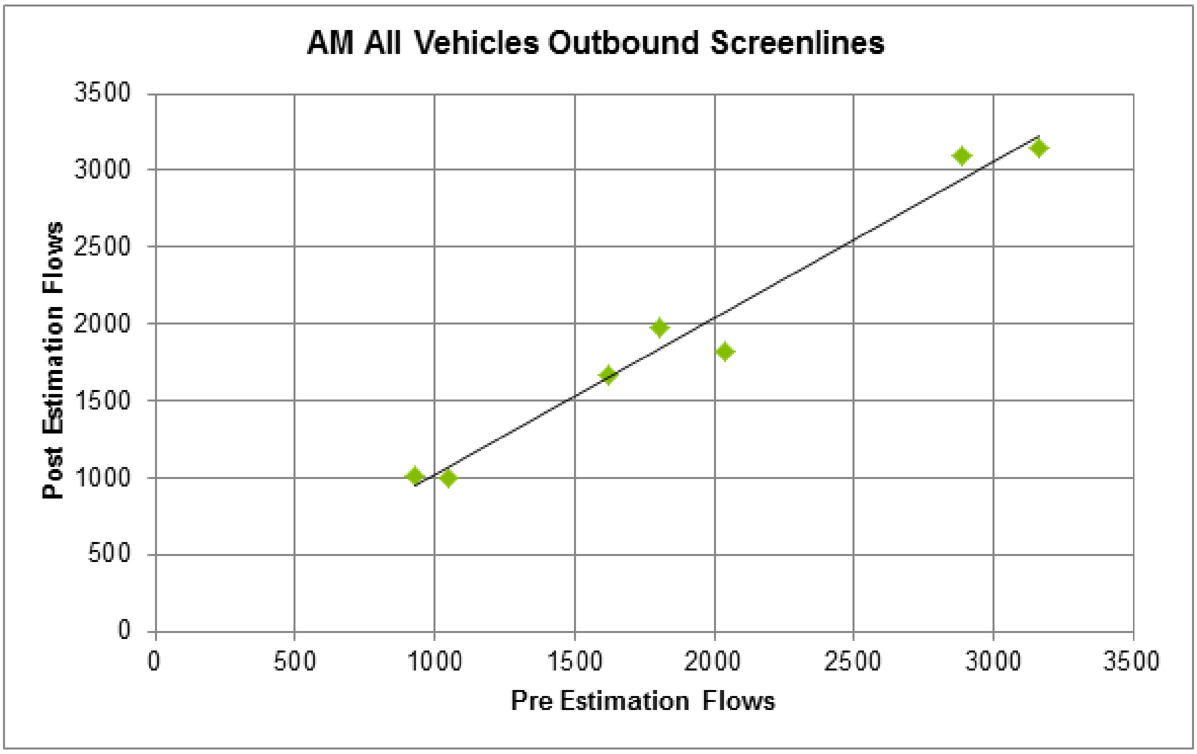


Figure 9-5 to Figure 9-8 show the combined change in screenline modelled flows in the IP as a result of the ME process.

Figure 9-5. IP Car Inbound Screenlines ME2 Change

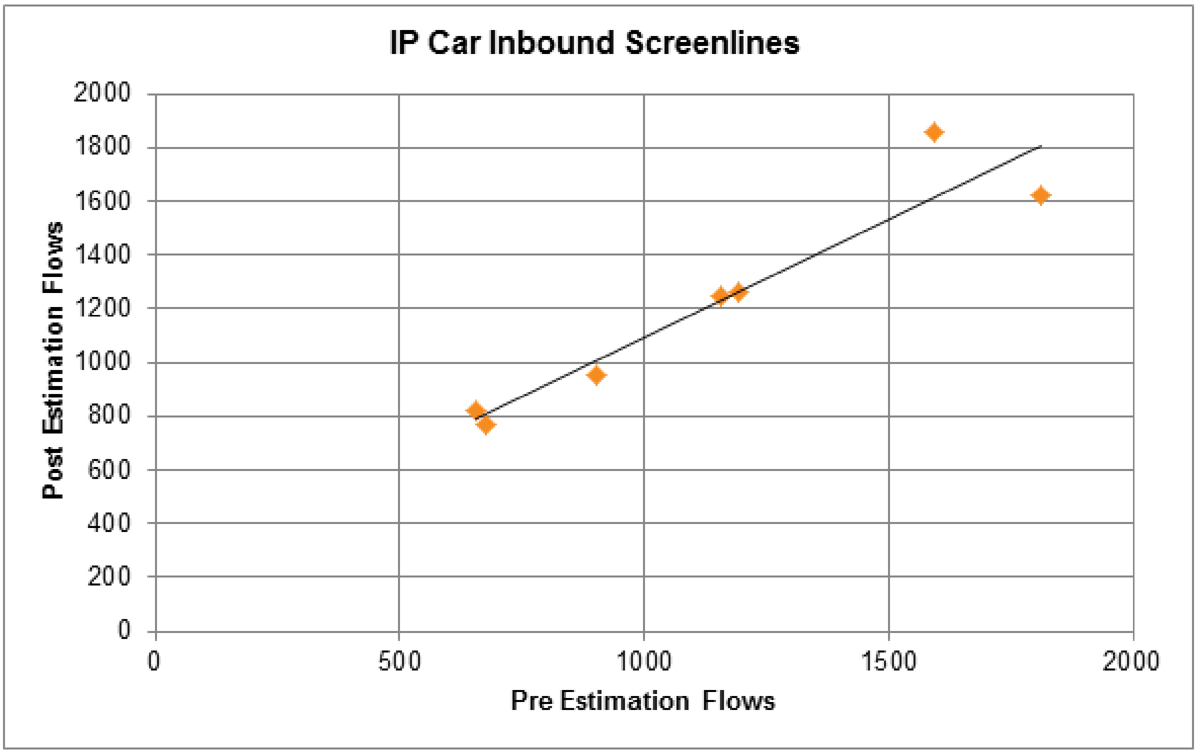


Figure 9-6. IP Car Outbound Screenlines ME2 Change

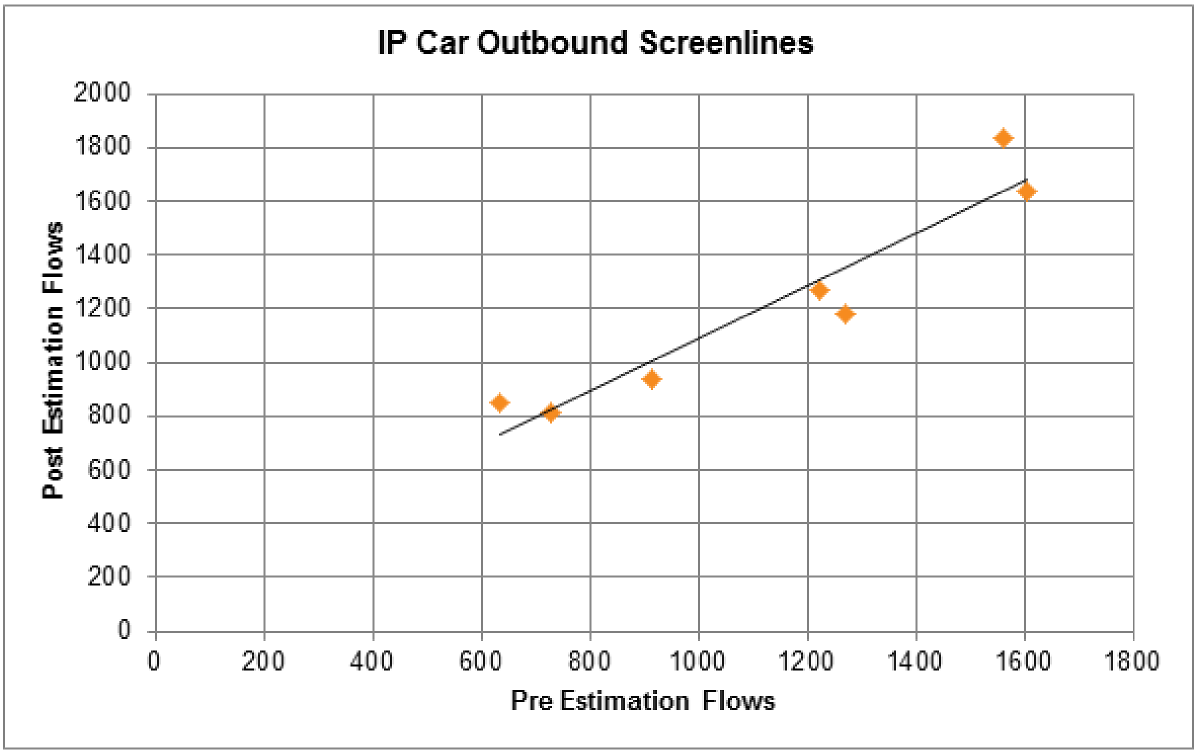


Figure 9-7. IP All Vehicles Inbound Screenlines ME2 Change

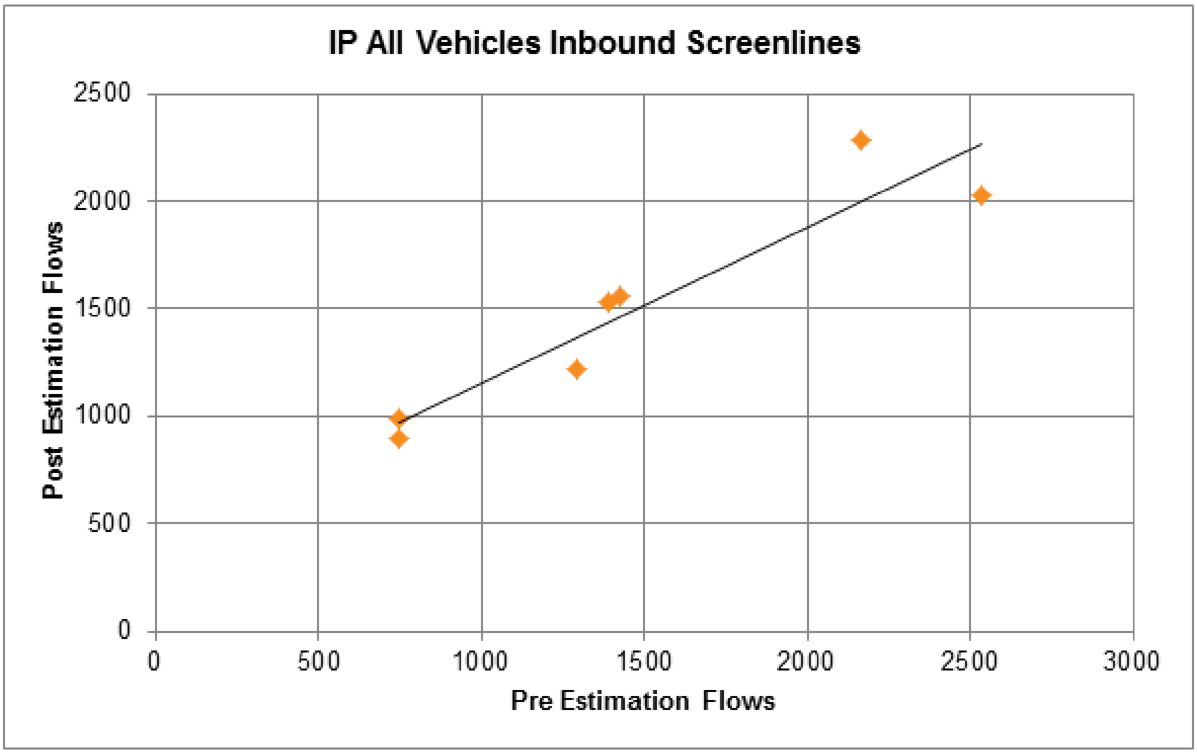


Figure 9-8. IP All Vehicles Outbound Screenlines ME2 Change

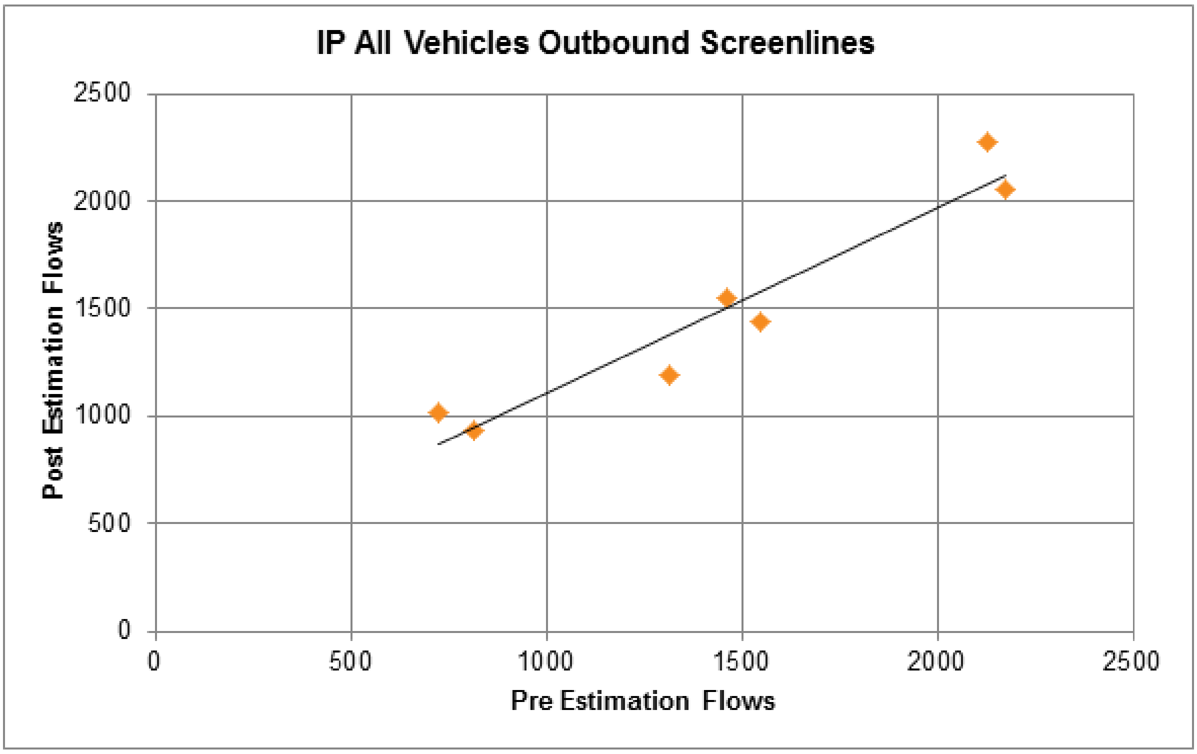


Figure 9-9 to Figure 9-12 show the combined change in screenline modelled flows in the PM peak as a result of the ME process.

Figure 9-9. PM Car Inbound Screenlines ME2 Change

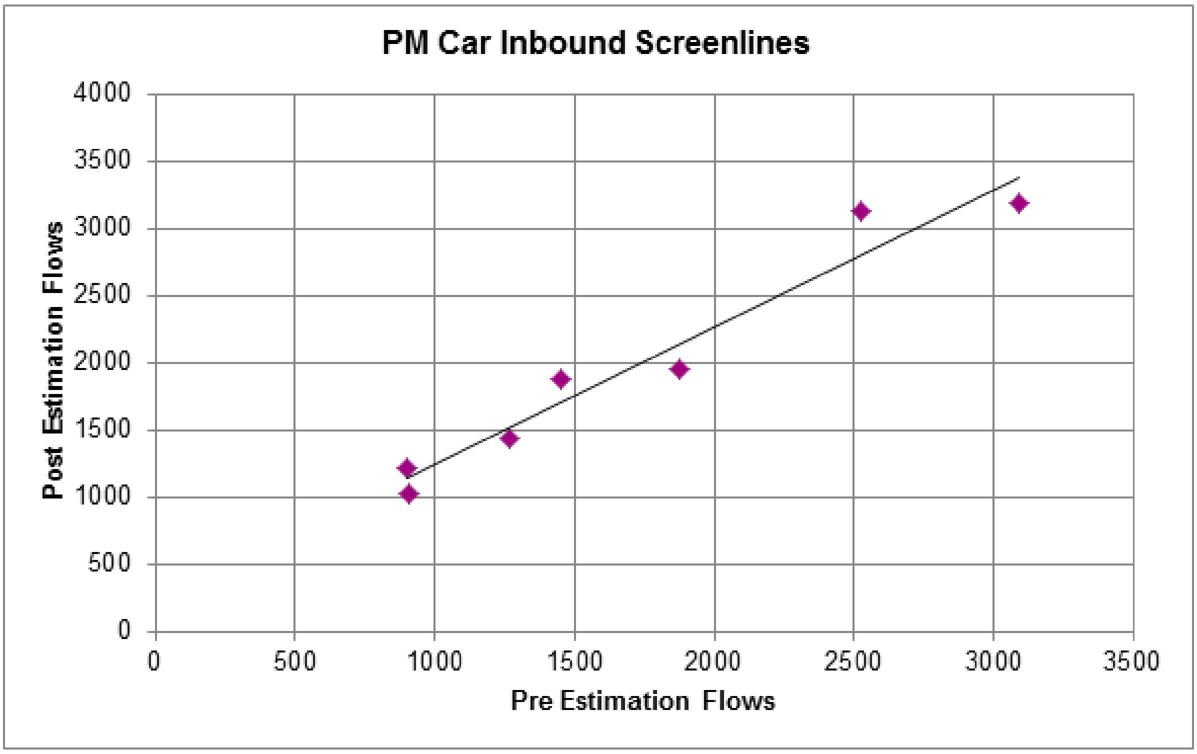


Figure 9-10. PM Car Outbound Screenlines ME2 Change

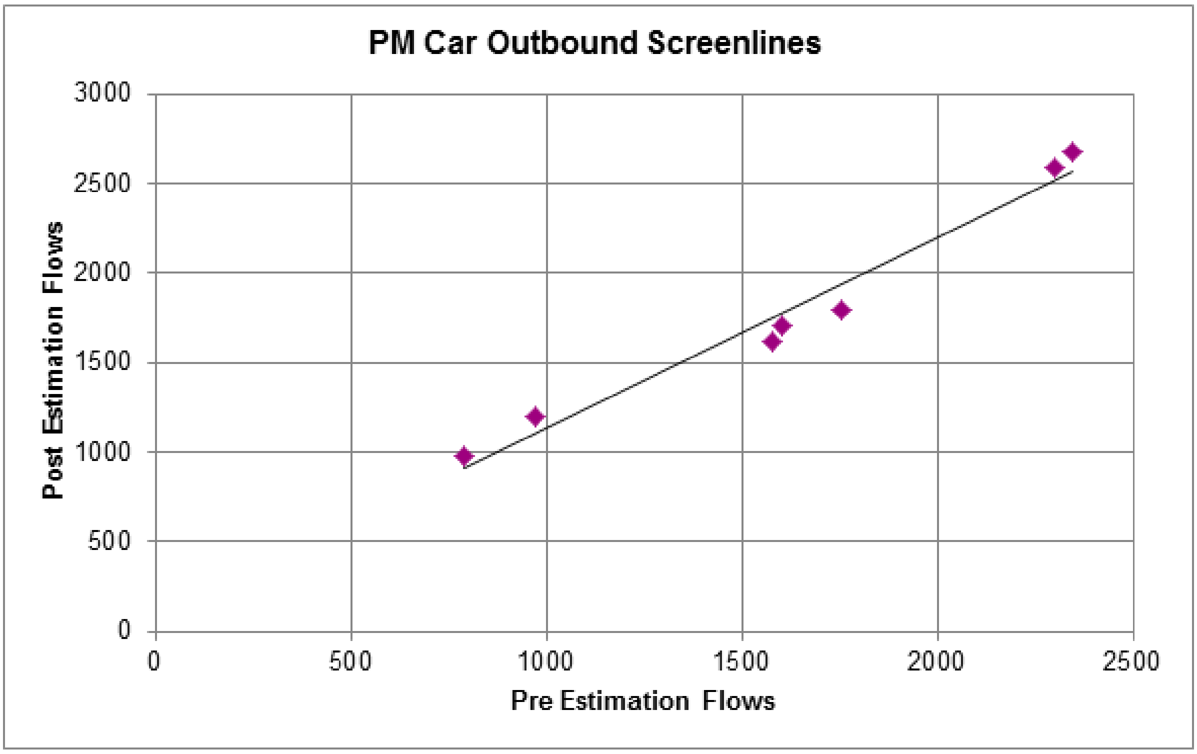


Figure 9-11. PM All Vehicles Inbound Screenlines ME2 Change

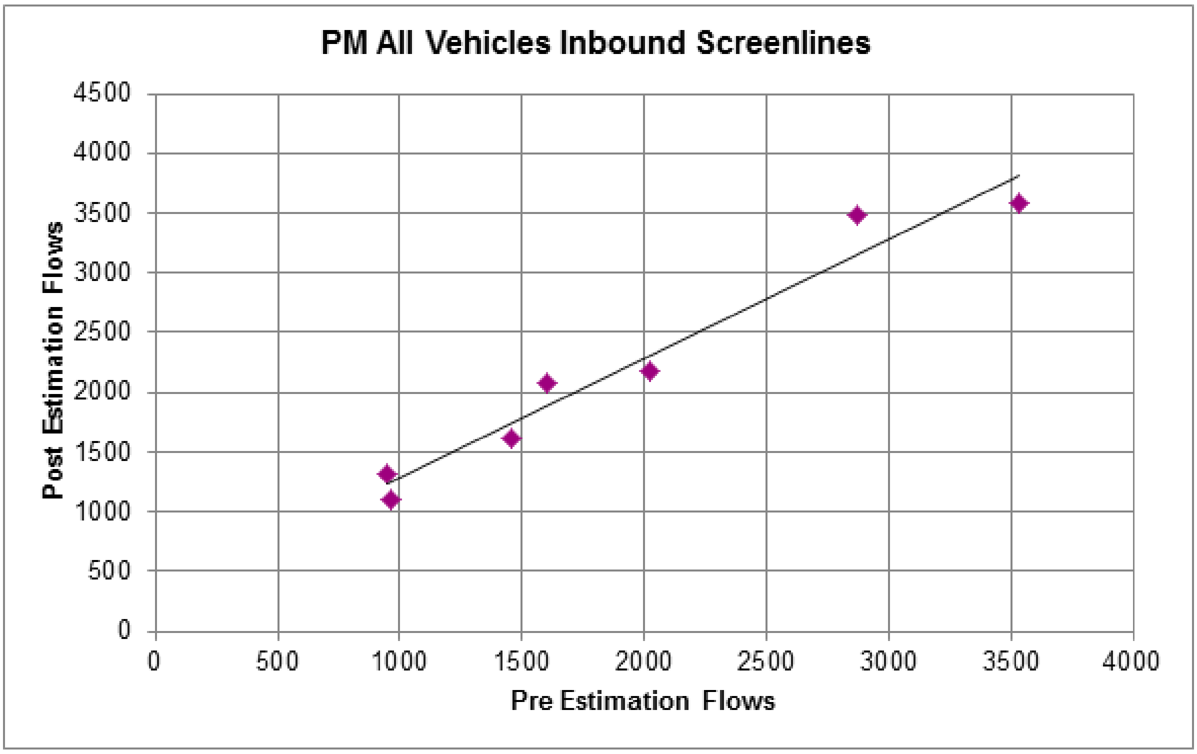


Figure 9-12. PM All Vehicles Outbound Screenlines ME2 Change

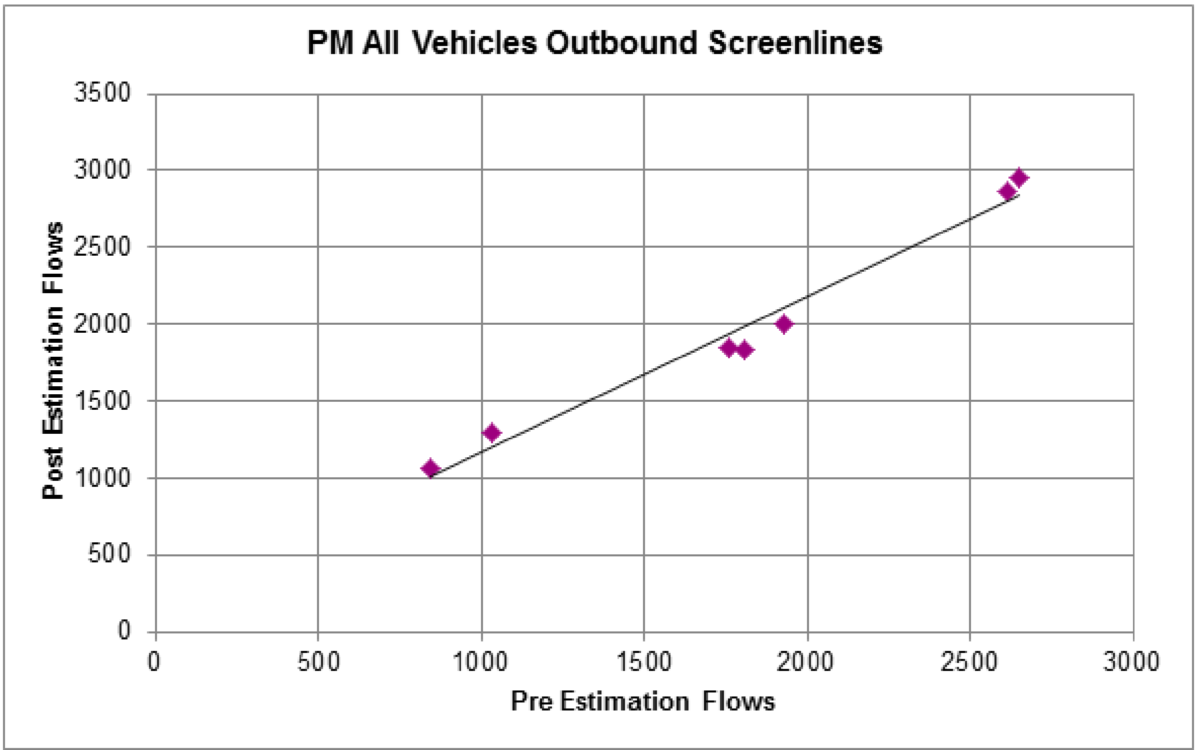


Table 9-1 below shows the performance of the screenlines in the three peaks post ME. The screenlines criteria refers to the relaxed guidance set out in Table 8-1.

Table 9-1. Post ME2 Modelled Screenline Flow Performance

Screenline	Name	Counts in Screenline	Direction	Car - AM	All - AM	Car - IP	All - IP	Car - PM	All - PM
1	A189 North	1	NB	-2%	-2%	-1%	1%	1%	3%
		1	SB	1%	1%	1%	1%	0%	0%
2	Southern	3	NB	0%	0%	0%	0%	1%	3%
		3	SB	0%	0%	0%	0%	-1%	-1%
3	Western	5	EB	13%	10%	6%	6%	3%	3%
		5	WB	-5%	-3%	0%	2%	2%	2%
4	Cowpen and Laverock Hall Road	2	EB	9%	7%	-2%	-2%	0%	0%
		2	WB	4%	3%	0%	0%	8%	8%
5	Cowpen	2	EB	0%	-1%	0%	0%	0%	0%
		2	WB	0%	0%	0%	0%	0%	0%
6	South Newsham	3	EB	5%	4%	0%	0%	-3%	-2%
		3	WB	0%	-1%	5%	5%	7%	5%
7	North-South	3	NB	0%	0%	0%	0%	0%	1%
		3	SB	0%	0%	0%	0%	0%	0%
	Total Counts			14	14	14	14	14	14
	Criteria Met			13	13	13	13	14	14
	% Calibration			93%	93%	93%	93%	100%	100%

As can be seen from the table above, the majority of counts calibrate against observed throughout the three modelled peaks. The only screenline counts which can be seen to not calibrate against guidance is the Western screenline for eastbound traffic. As part of our matrix creation process, the inbound and outbound movements for Blyth were constrained to the observed RSI counts. This Western screenline is west of where the RSIs were carried out. The large volume of traffic interacting with the A189 corridor between the RSI sites and the screenline has resulted in the modelled flows being slightly out.

9.2 Network Validation

This section compares the three modelled peaks traffic flows with observed counts to assess the general model validation post ME process.

Table 9-2 below shows the number of link counts which validated in the AM model. It also shows the GEH statistic of these links.

Table 9-2. AM Peak Model Link Validation Post ME

AM Validation	Count Validation		GEH Validation	
	Car	All Vehicles	Car	All Vehicles
Total Counts	151	151	151	151
Counts Meeting Criteria	130	127	132	133
% Link Validation	86%	84%	87%	88%

It can be seen that just below 85% of link 'All Vehicle' counts meet criteria for count validation, however 'All Vehicle' link counts is greater than 85% for overall percentage of GEH statistic validation and therefore still passes requirements set out in guidance. Overall, a high number of links in the AM model are shown to meet the individual criteria outlined by DfT guidance, shown in Table 3-2, for both link counts and for the link GEH statistic. It is worth noting that there are some inconsistencies in data sources which have influenced the level of validation possible on all links. This is likely due to some surveys being undertaken at a different point in time.

Figure 9-13 below shows a visual representation of link flows where observations were collected in the AM scenario. The green bars represent modelled all vehicles flow (PCUs) located adjacent to the blue bars representing observed all vehicles flow (PCUs). This figure shows that that the majority of modelled flows are in close proximity to their respective counterpart observed flows.

Figure 9-13. AM Network Actual Flow Compared to Observed Flow

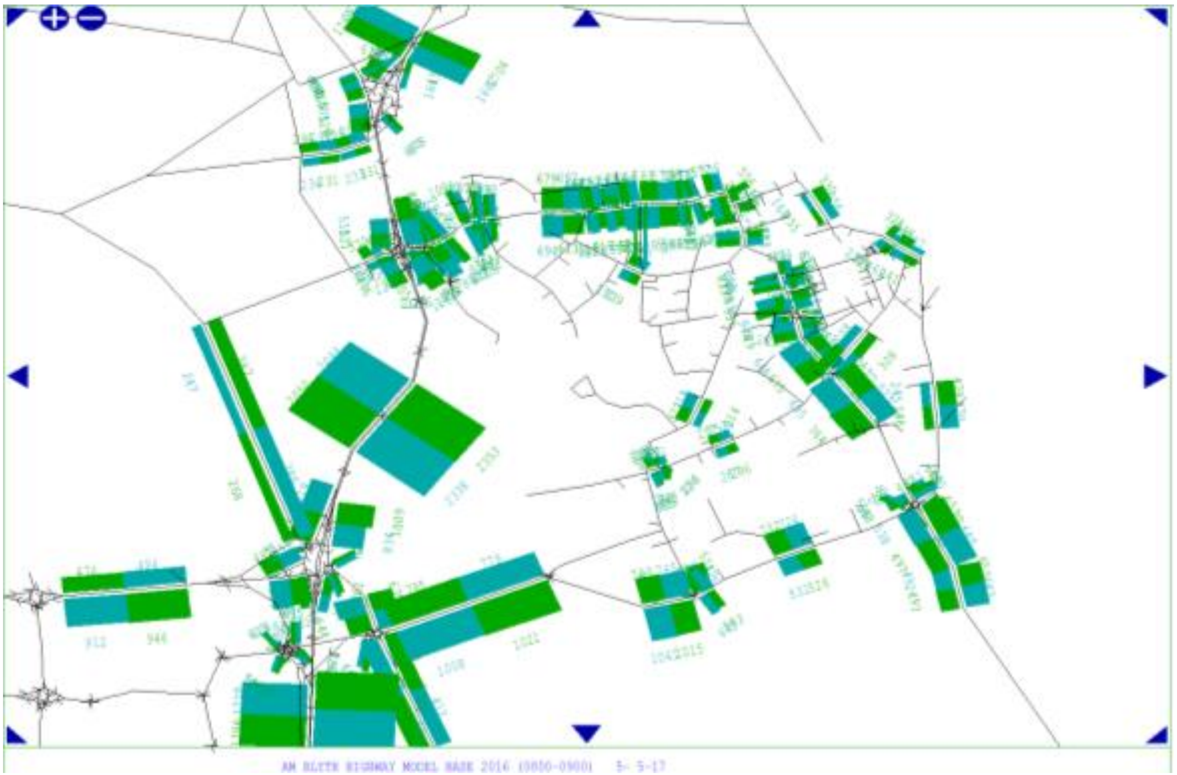


Table 9-3 below shows the number of link counts which validated in the IP model. It also shows the GEH statistic of these links.

Table 9-3. IP Model Link Validation Post ME

IP Validation	Count Validation		GEH Validation	
	Car	All Vehicles	Car	All Vehicles
Total Counts	151	151	151	151
Counts Meeting Criteria	145	149	144	145
% Link Validation	96%	99%	95%	96%

A high number of links in the IP model are shown to meet the individual criteria outlined by DfT guidance, shown in Table 3-2, for both link counts and for the link GEH statistic. Over 85% can be seen to pass these criteria for both counts and GEH statistics.

Figure 9-14 below shows a visual representation of link flows where observations were collected in the IP scenario. The green bars represent modelled all vehicles flow (PCUs) located adjacent to the blue bars representing observed all vehicles flow (PCUs). This figure shows that that the majority of modelled flows are in close proximity to their respective counterpart observed flows.

Figure 9-14. IP Network Actual Flow Compared to Observed Flow

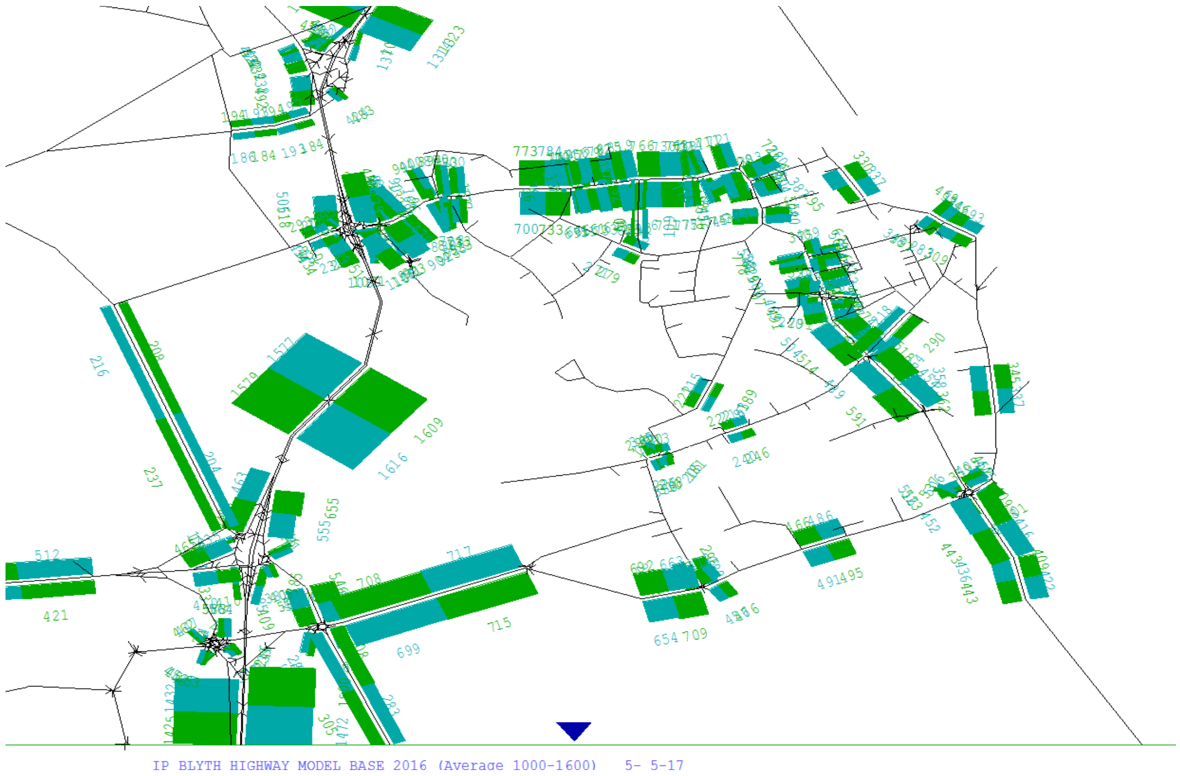


Table 9-4 below shows the number of link counts which validated in the PM model. It also shows the GEH statistic of these links.

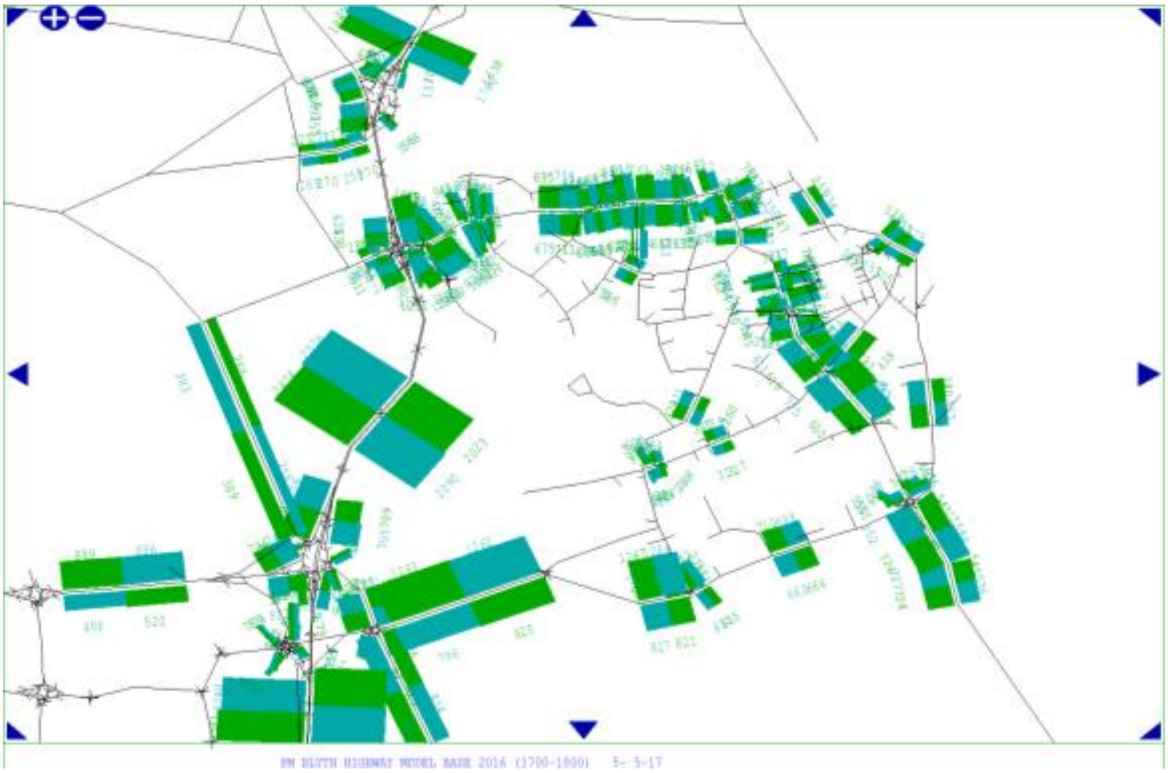
Table 9-4. PM Peak Model Link Validation Post ME

PM Validation	Count Validation		GEH Validation	
	Car	All Vehicles	Car	All Vehicles
Total Counts	151	151	151	151
Counts Meeting Criteria	135	133	135	137
% Link Validation	89%	88%	89%	91%

A high number of links in the PM model are shown to meet the criteria outlined by DfT guidance, shown in Table 3-2, for both link counts and for the link GEH statistic. Over 85% can be seen to pass these criteria for both counts and GEH statistics.

Figure 9-15 below shows a visual representation of link flows where observations were collected in the PM scenario. The green bars represent modelled all vehicles flow (PCUs) located adjacent to the blue bars representing observed all vehicles flow (PCUs). This figure shows that that the majority of modelled flows are in close proximity to their respective counterpart observed flows.

Figure 9-15. PM Network Actual Flow Compared to Observed Flow



9.2.1 Network Delay

Part of the SATURN modelling suite allows for an overview of link delay on the network to be displayed. Three screen dumps for the AM, IP and PM respectively have been extracted and presented below in Figure 9-16 to Figure 9-18.

Figure 9-16. AM Network Modelled Delay (Seconds) Plot

Figure 9-17. IP Network Modelled Delay (Seconds) Plot

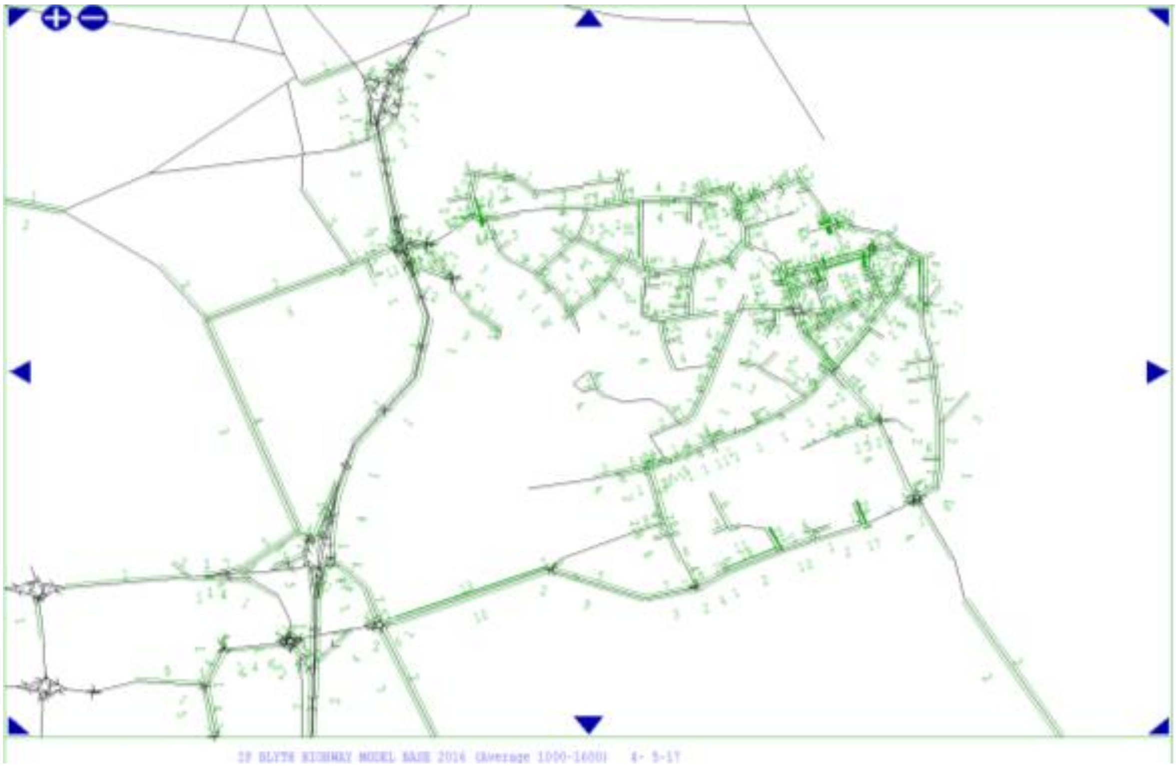


Figure 9-18. PM Network Modelled Delay (Seconds) Plot

These plots show that all noticeable link delay throughout the three time periods matches observed conditions, with link delay primarily located around busy junctions.

9.3 Sector to Sector Changes

This section of the report looks at any strategic changes in traffic behaviour, reviewing the changes in modelled flows between different sectors to look at any possible overall shifts in traffic OD trends. Figure 9-19 to Figure 9-24 below show the absolute change in sector to sector movements.

Figure 9-19. AM Car Sector to Sector Flow Changes Matrix

Cars	1	2	3	4	5	6	7
1	35	123	120	54	22	51	41
2	71	0	75	2	69	4	93
3	74	25	61	47	25	10	70
4	10	4	89	2	15	36	10
5	29	6	45	44	96	62	1
6	73	1	16	20	19	14	8
7	9	52	7	51	56	36	11

Figure 9-20. AM All Vehicles Sector to Sector Flow Changes Matrix

All Veh	1	2	3	4	5	6	7
1	75	288	149	73	27	68	59
2	240	0	152	3	77	19	99
3	94	30	65	48	28	28	71
4	12	5	101	3	18	38	11
5	37	13	48	49	114	79	12
6	93	31	20	26	38	23	26
7	32	62	15	56	67	37	19

Figure 9-21. IP Cars Sector to Sector Flow Changes Matrix

Cars	1	2	3	4	5	6	7
1	62	28	14	6	26	71	82
2	19	0	43	4	77	8	33
3	27	27	67	3	35	14	57
4	44	1	12	2	8	17	15
5	6	21	15	4	62	79	73
6	68	1	11	16	56	23	38
7	73	28	15	19	96	91	67

Figure 9-22. IP All Vehicles Sector to Sector Flow Changes Matrix

All Veh	1	2	3	4	5	6	7
1	64	164	30	22	41	80	113
2	234	0	108	4	92	36	42
3	42	30	73	5	40	18	66
4	48	2	19	3	14	19	19
5	12	28	17	7	73	89	82
6	82	30	16	19	65	38	54
7	92	30	19	22	102	102	82

Figure 9-23. PM Cars Sector to Sector Flow Changes Matrix

Cars	1	2	3	4	5	6	7
1	154	111	57	130	75	167	80
2	159	0	45	1	179	30	10
3	64	70	91	38	95	23	80
4	169	2	42	1	30	28	18
5	18	23	7	15	101	165	123
6	97	20	27	15	52	31	25
7	45	11	11	19	78	64	12

Figure 9-24. PM All Vehicles Sector to Sector Flow Changes Matrix

All Veh	1	2	3	4	5	6	7
1	171	153	66	142	90	171	97
2	199	0	93	2	185	40	17
3	80	71	93	45	109	29	90
4	191	3	49	2	46	32	19
5	20	26	9	17	117	175	132
6	98	35	31	17	64	40	30
7	52	15	11	20	90	68	22

It is noted that the above figures show that there are no obvious changes in any of the three modelled peaks for any sector to sector flow as a result of the ME process. The greatest differences occur for movements, which would not have been observed by the RSI surveys.

10. Route Choice Calibration and Validation

10.1 Route Choice

This section of the report explores the routing within the model, ensuring that traffic is taking sensible routing in the model, which would likely occur in a real world situation. This process was initially carried out when calibrating the model prior to the ME process. However, as a result of ME, key routes need to be checked to ensure the ME process has not altered routing considerably this has not altered considerably.

Figure 10-1 to Figure 10-6 below shows model screendumps which present a snapshot of OD pairs where modelled routing was checked in the AM peak. The inbound routing has been presented in the AM scenario for surrounding major conurbations.

Figure 10-1. AM Routing from Zone 213 to 131 (Cramlington)

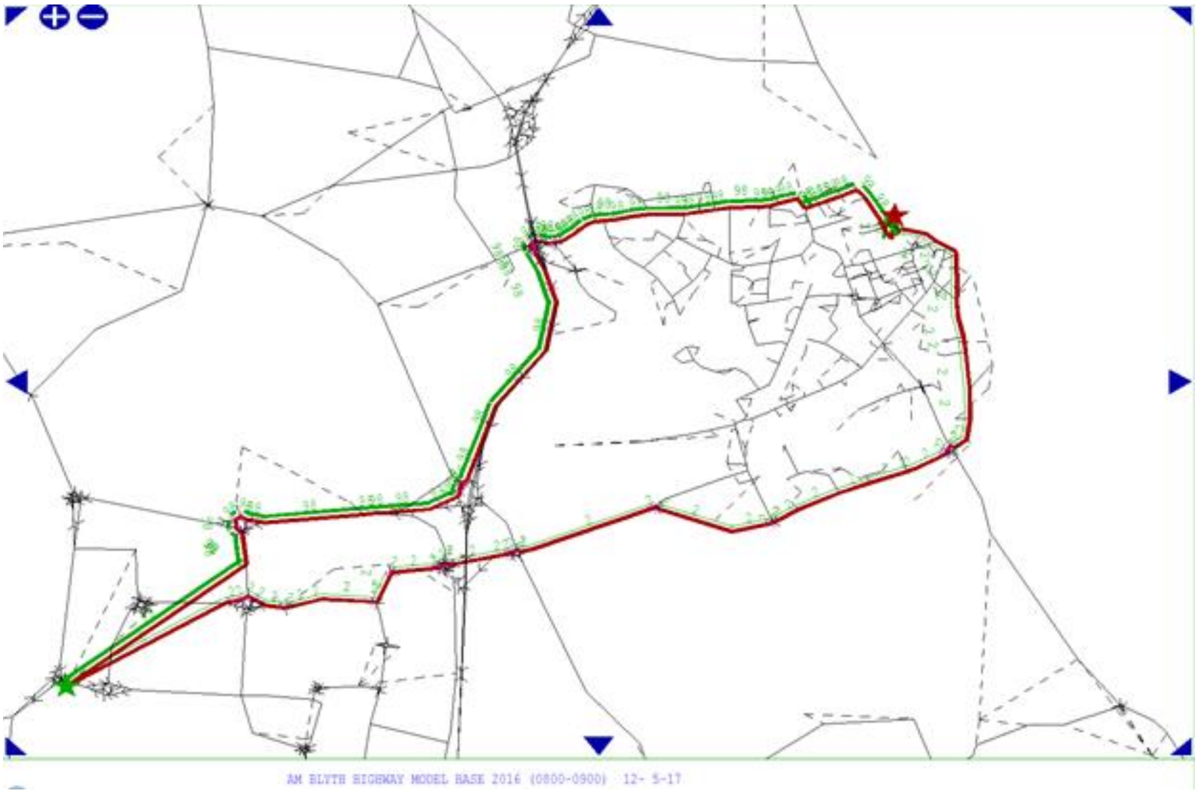


Figure 10-2. AM Routing from Zone 301 to 147 (Whitley Bay)

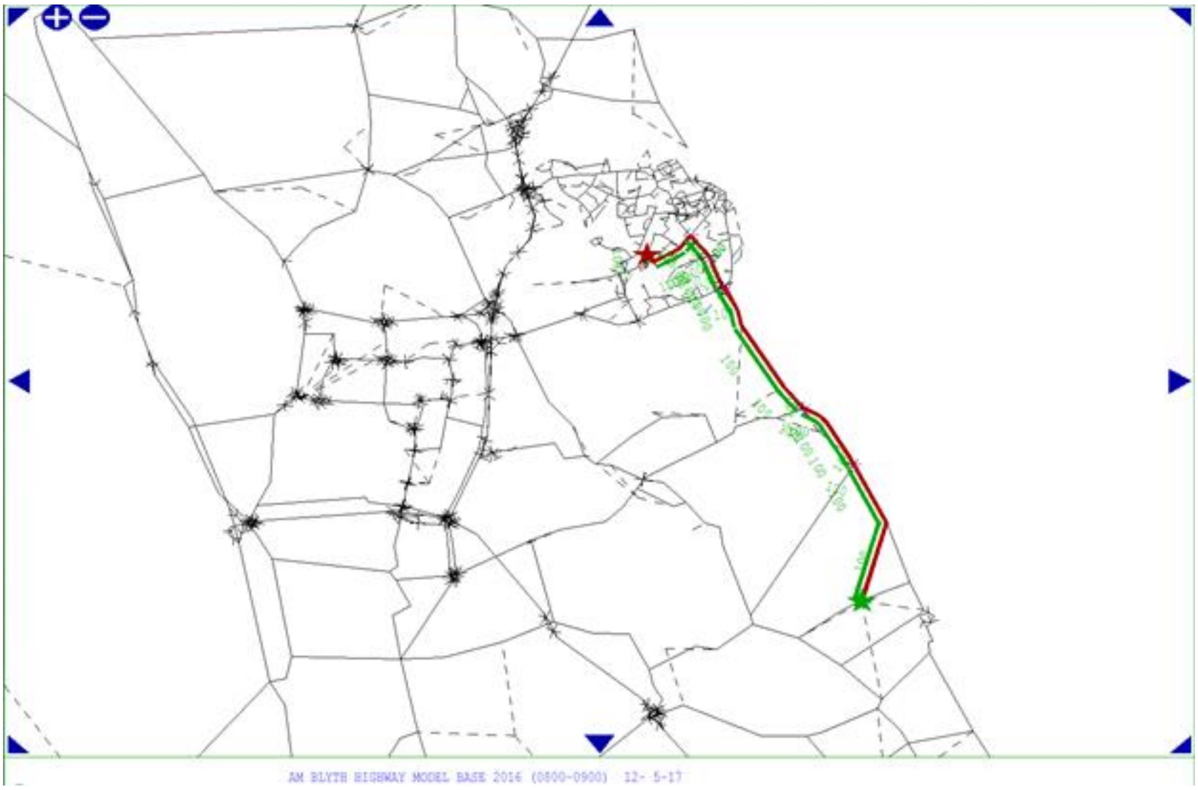


Figure 10-3. AM Routing from Zone 204 to 168 (Seaton Delaval)

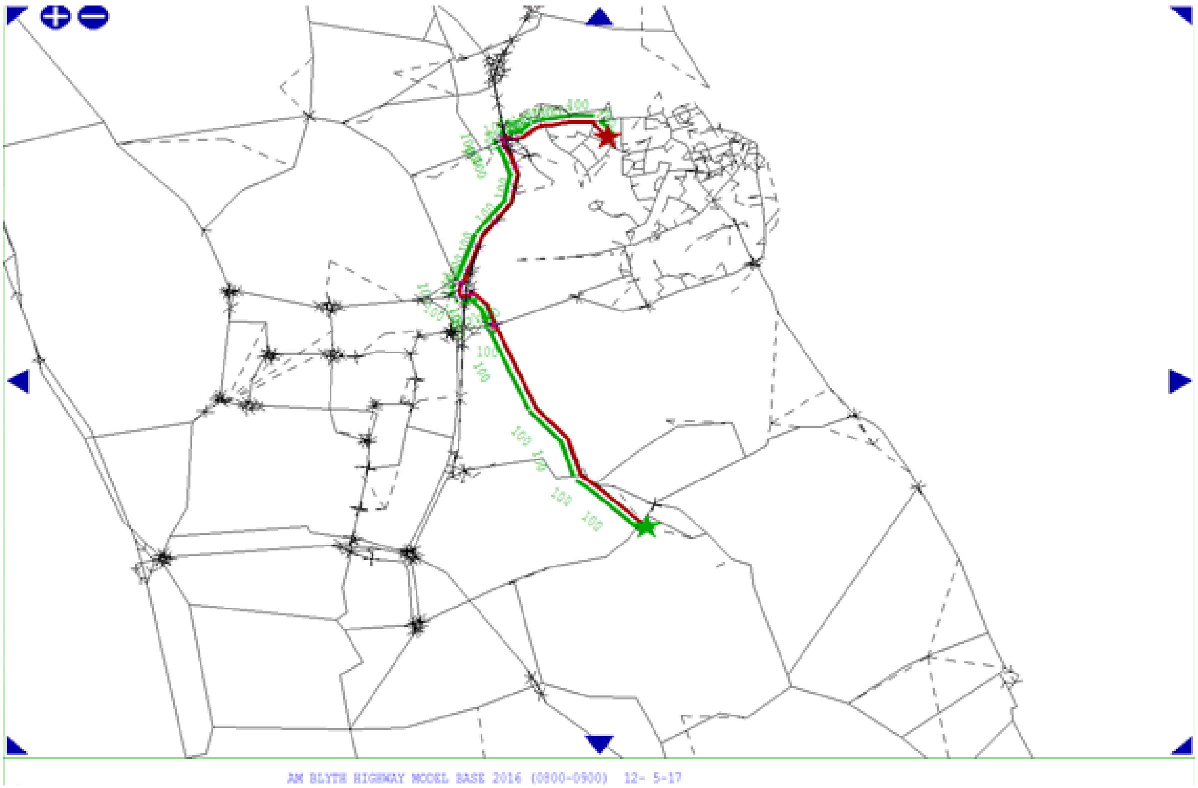


Figure 10-4. AM Routing from Zone 222 to 105 (Bedlington)

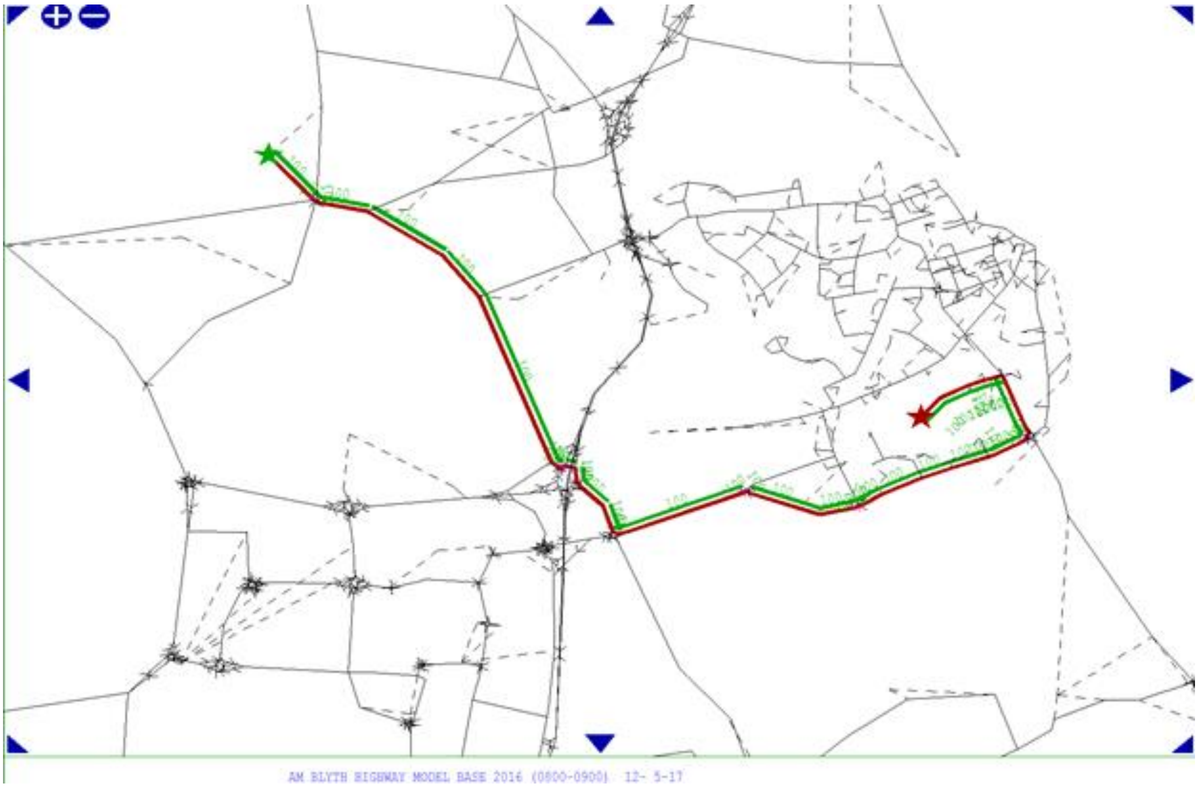


Figure 10-5. AM Routing from Zone 309 to 102 (Ashington)

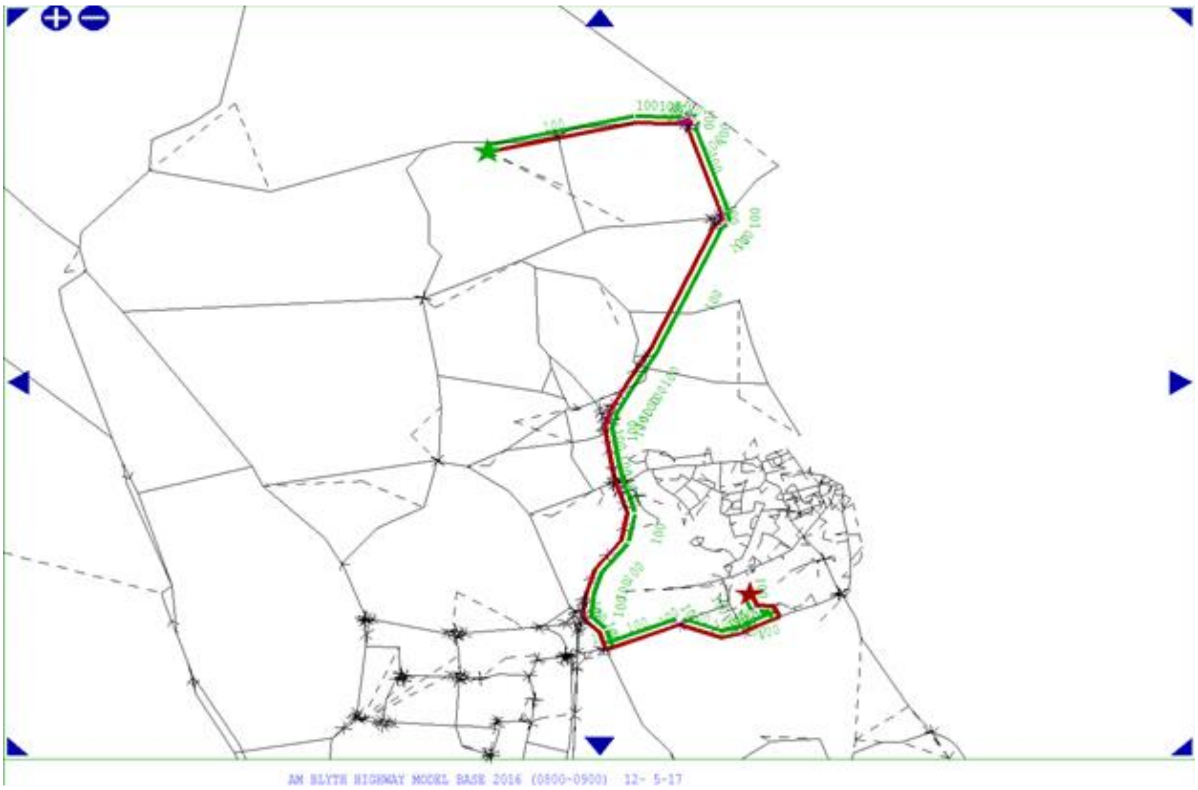
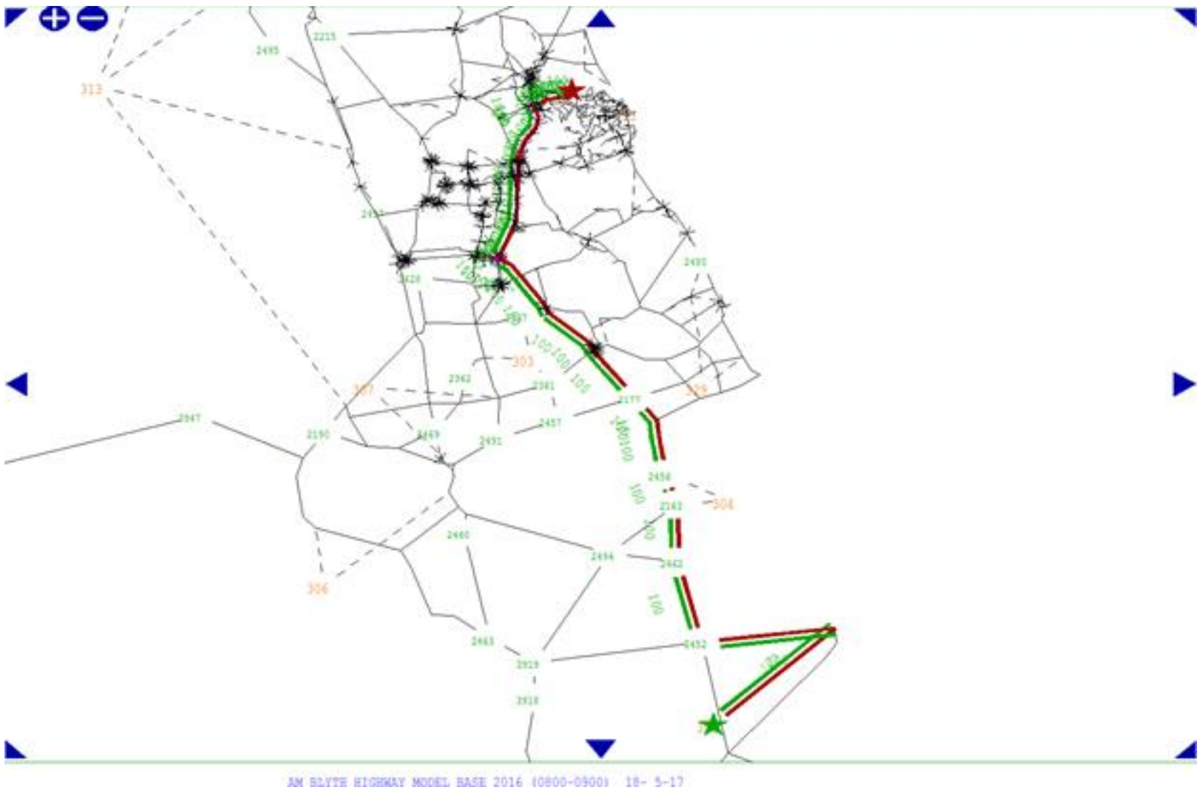


Figure 10-6. AM Routing from Zone 305 to 127 (Sunderland)



In all cases for the AM model, inbound and outbound movements were considered sensible. Traffic was seen to be using the primary routes between origin and destination. Where there was route choice, traffic continued to use sensible routes and was split sensibly based upon the apparent generalised cost of the alternative routes.

Figure 10-7 to Figure 10-12 below shows model screendumps which present a snapshot of OD pairs where modelled routing was checked in the IP time period. The inbound routing has been presented in the IP scenario for surrounding major conurbations.

Figure 10-7. IP Routing from Zone 213 to 131 (Cramlington)

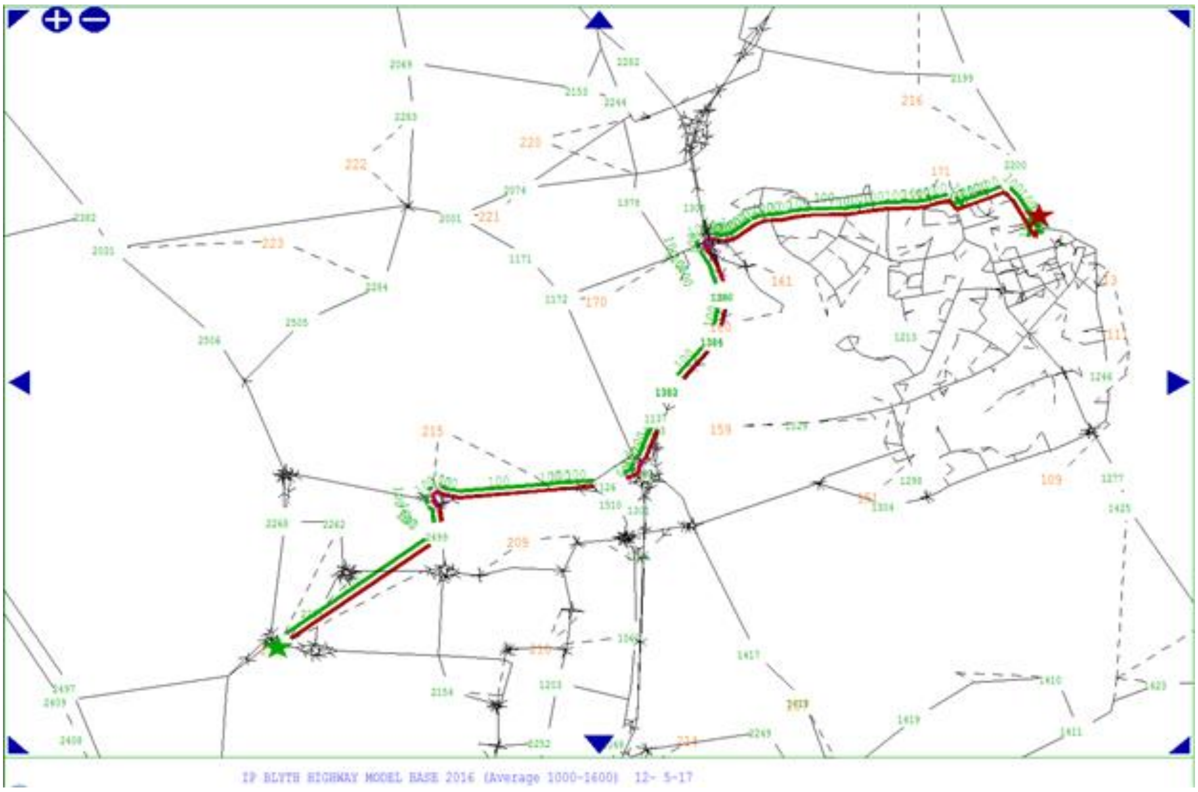


Figure 10-8. IP Routing from Zone 301 to 147 (Whitley Bay)

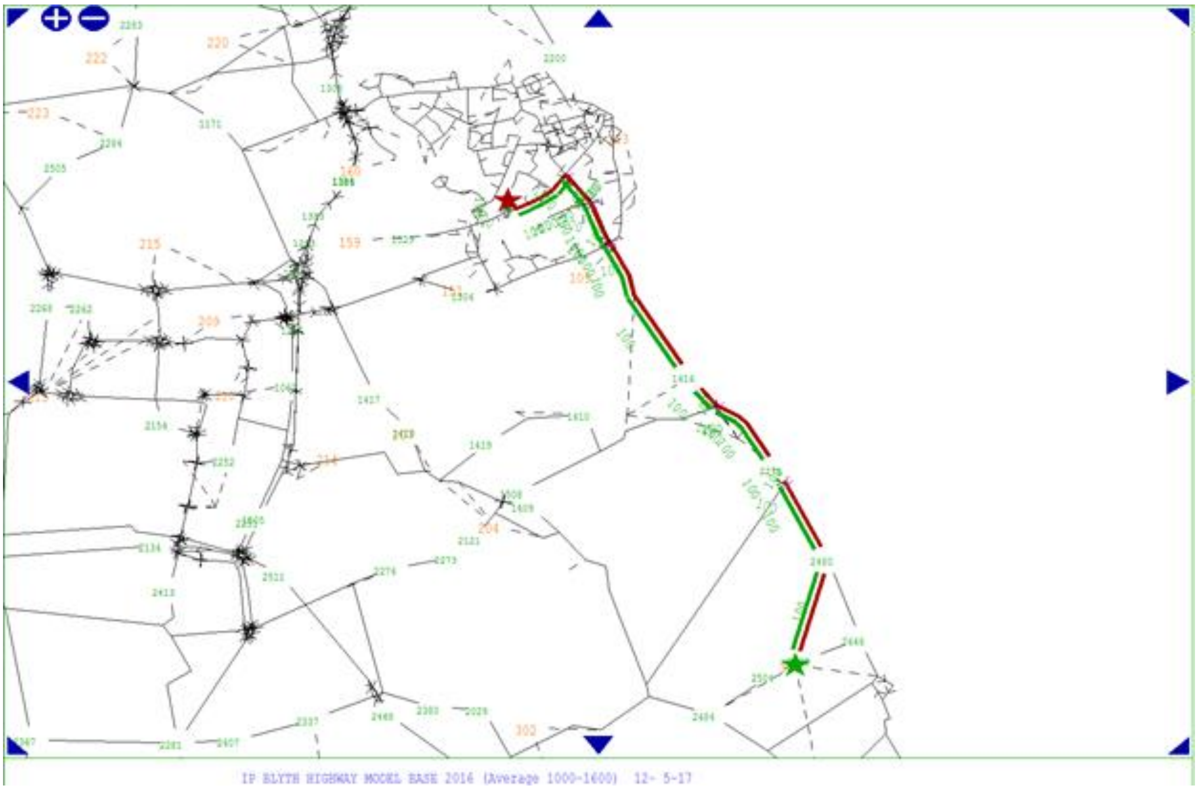


Figure 10-9. IP Routing from Zone 204 to 168 (Seaton Delaval)

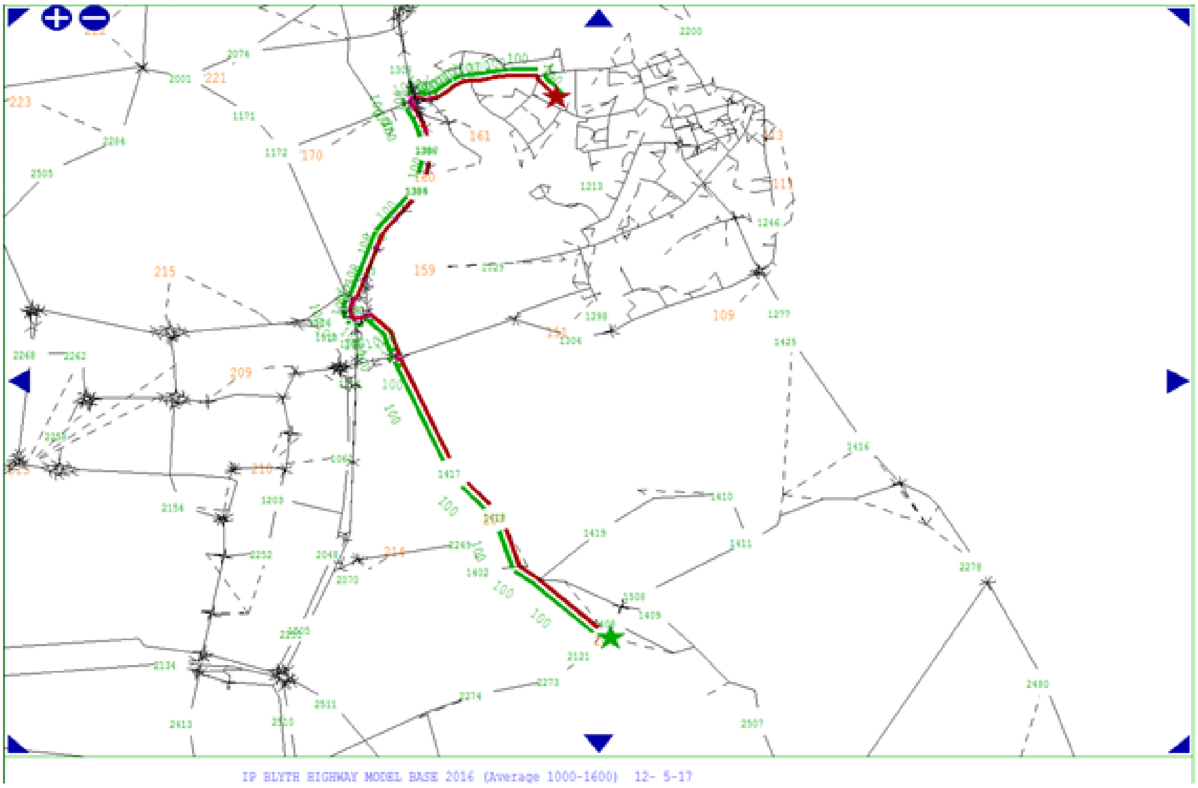


Figure 10-10. IP Routing from Zone 222 to 105 (Bedlington)

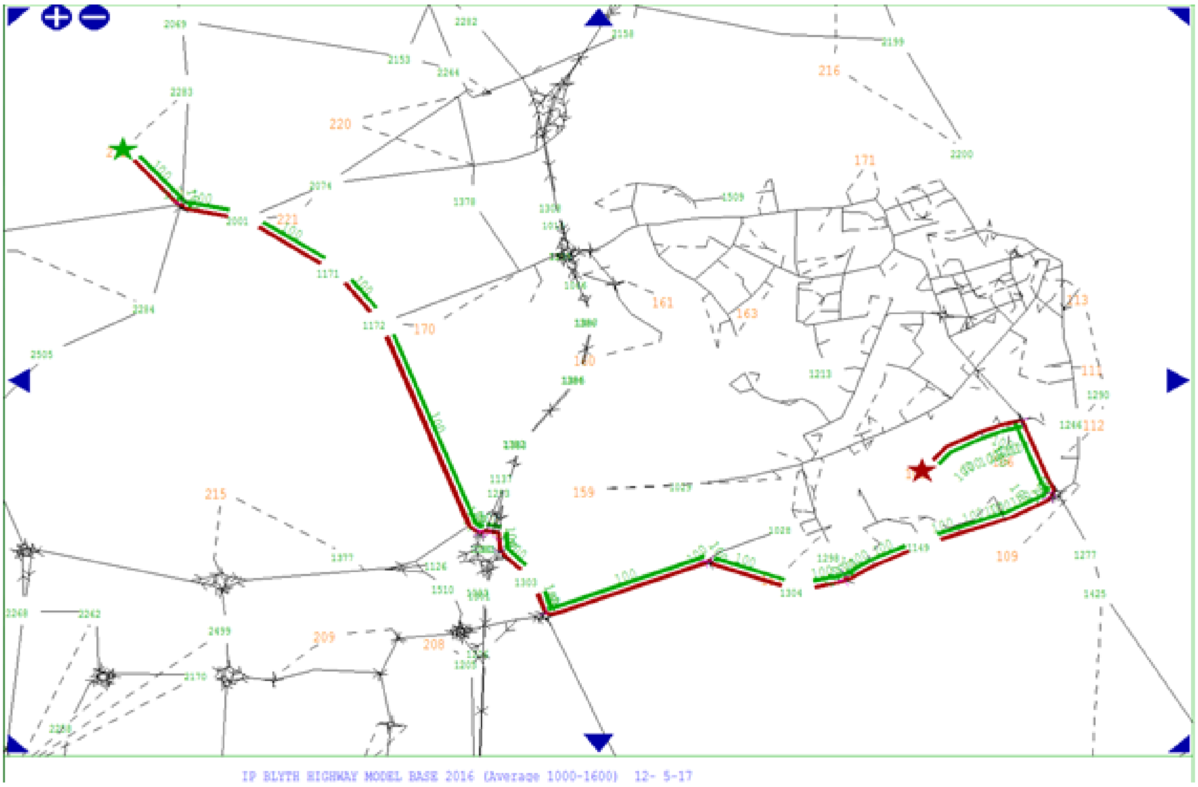


Figure 10-11. IP Routing from Zone 309 to 102 (Ashington)

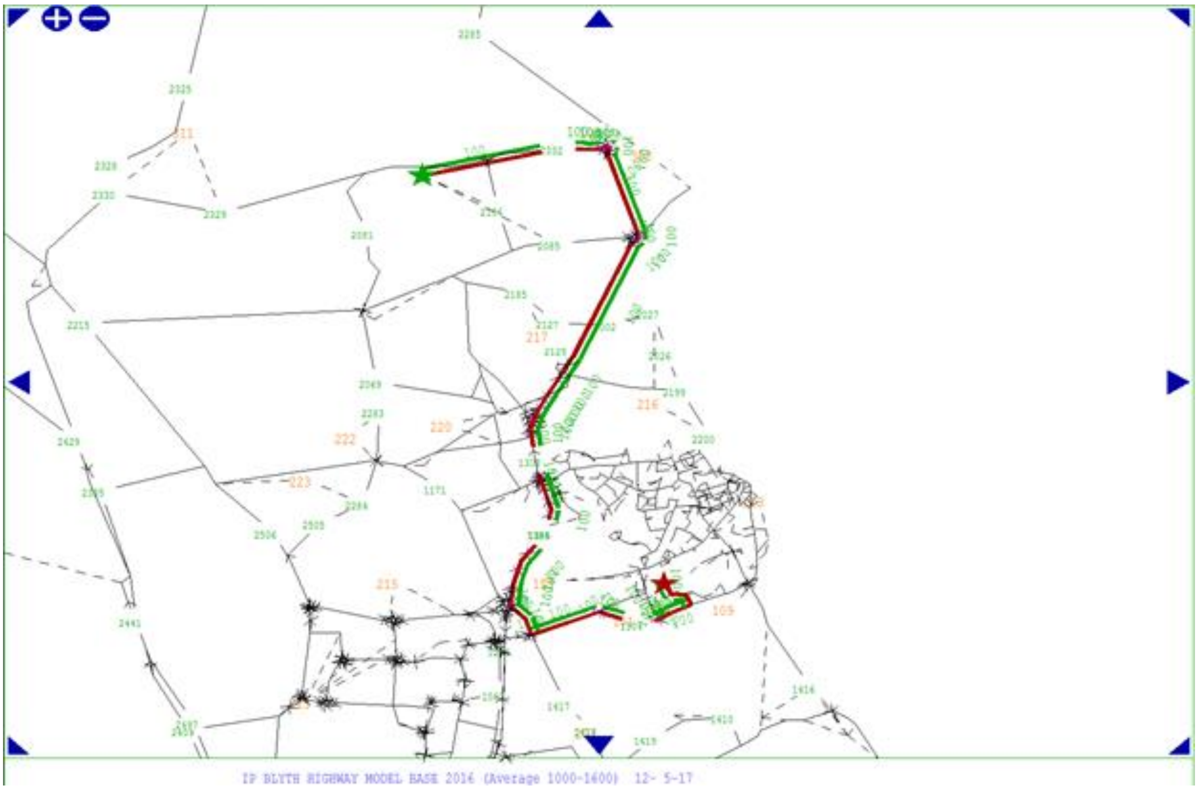
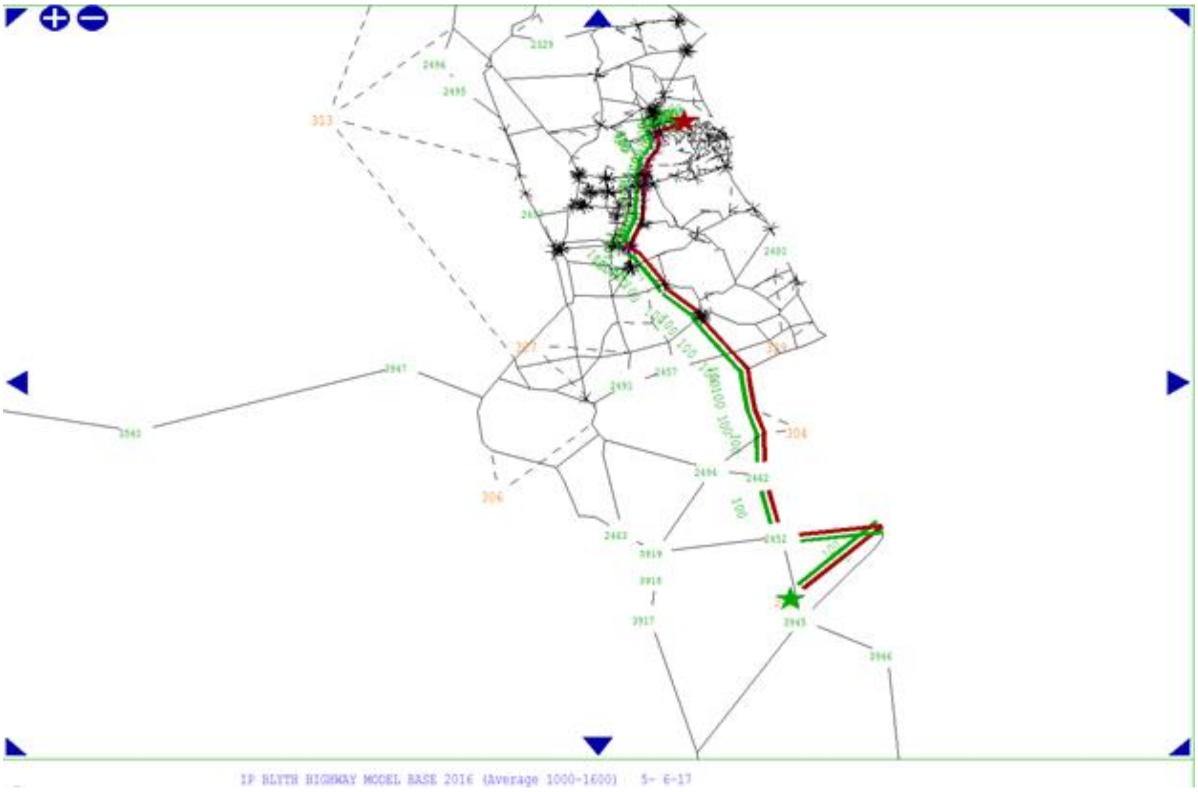


Figure 10-12. IP Routing from Zone 305 to 127 (Sunderland)



In all cases for the IP model, inbound and outbound movements were considered sensible. Traffic was seen to be using the primary routes between origin and destination. Where there was route choice, traffic continued to use sensible routes and was split sensibly based upon the apparent generalised cost of the alternative routes.

Similarly to the above, Figure 10-13 to Figure 10-18 below show model screendumps which present a snapshot of OD pairs where modelled routing was checked in the PM peak. The outbound routing has been presented in the PM scenario for the same surrounding major conurbations.

Figure 10-13. PM Routing from Zone 131 to 213 (Cramlington)

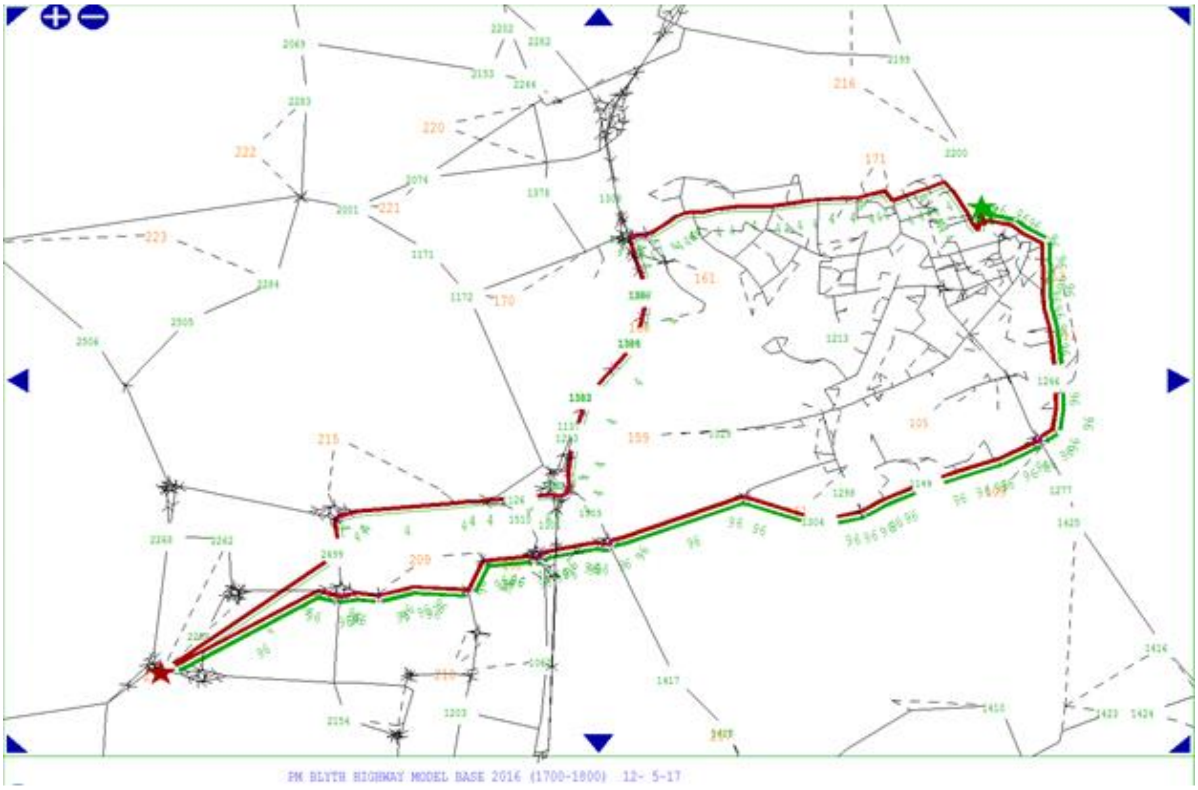


Figure 10-14. PM Routing from Zone 147 to 301 (Whitley Bay)

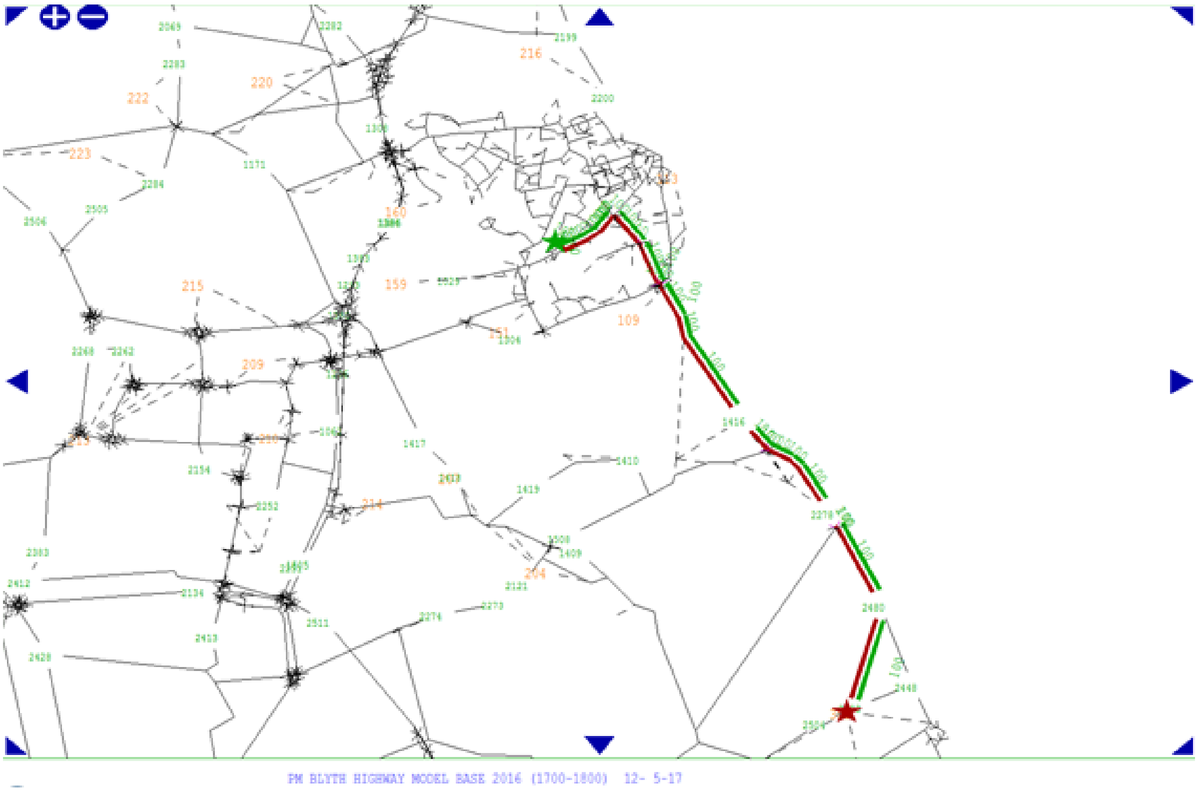


Figure 10-15. PM Routing from Zone 168 to 204 (Seaton Delaval)

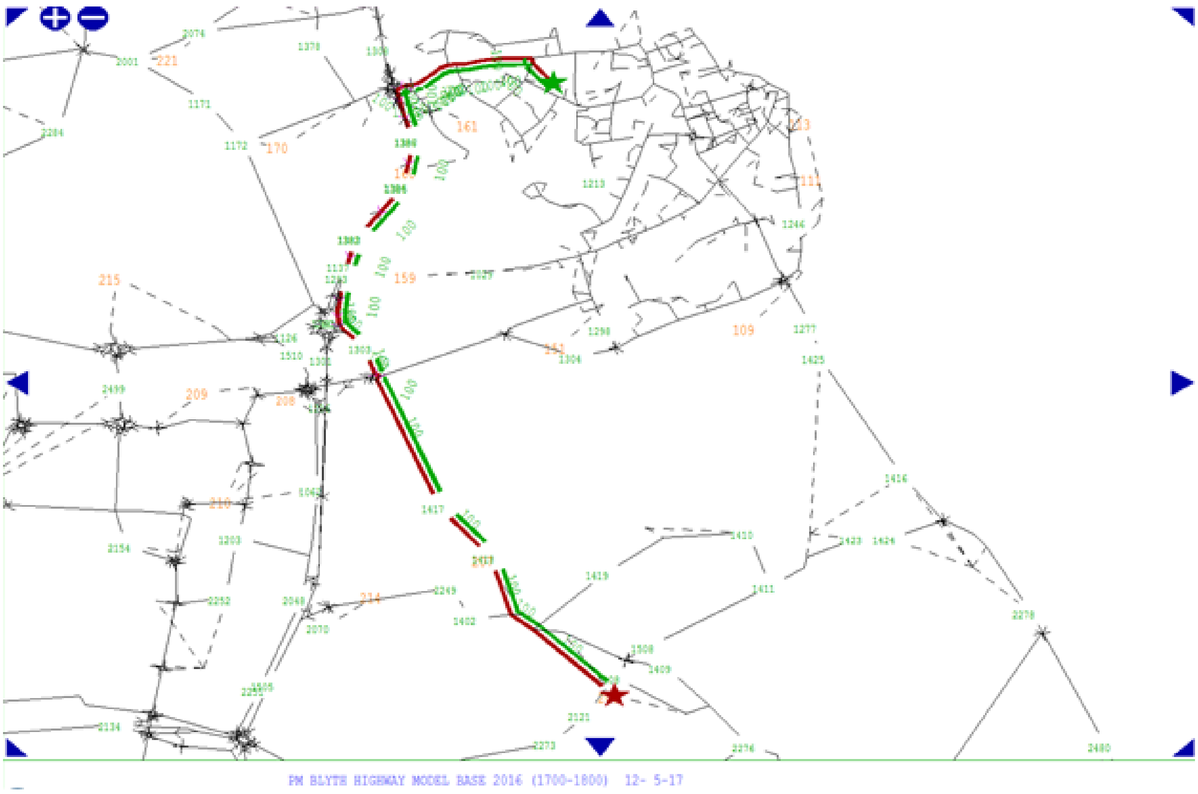


Figure 10-16. PM Routing from Zone 105 to 222 (Bedlington)

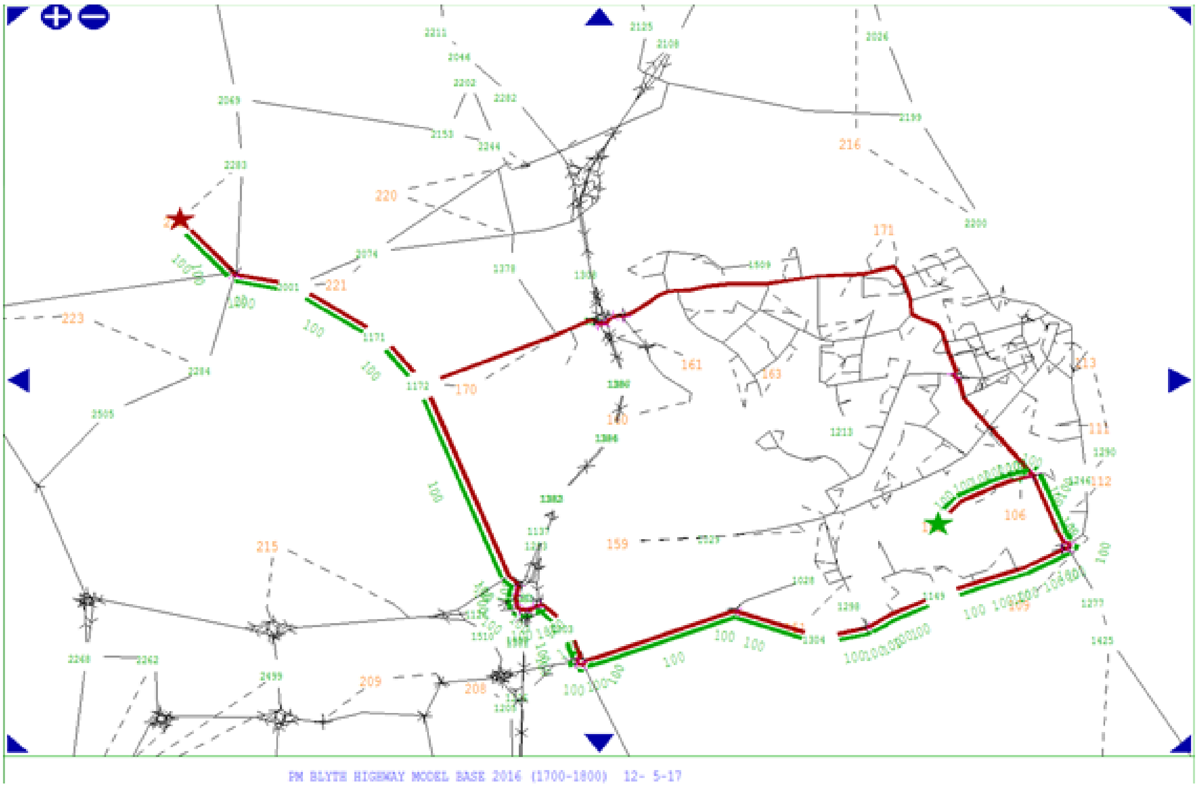


Figure 10-17. PM Routing from Zone 102 to 309 (Ashington)

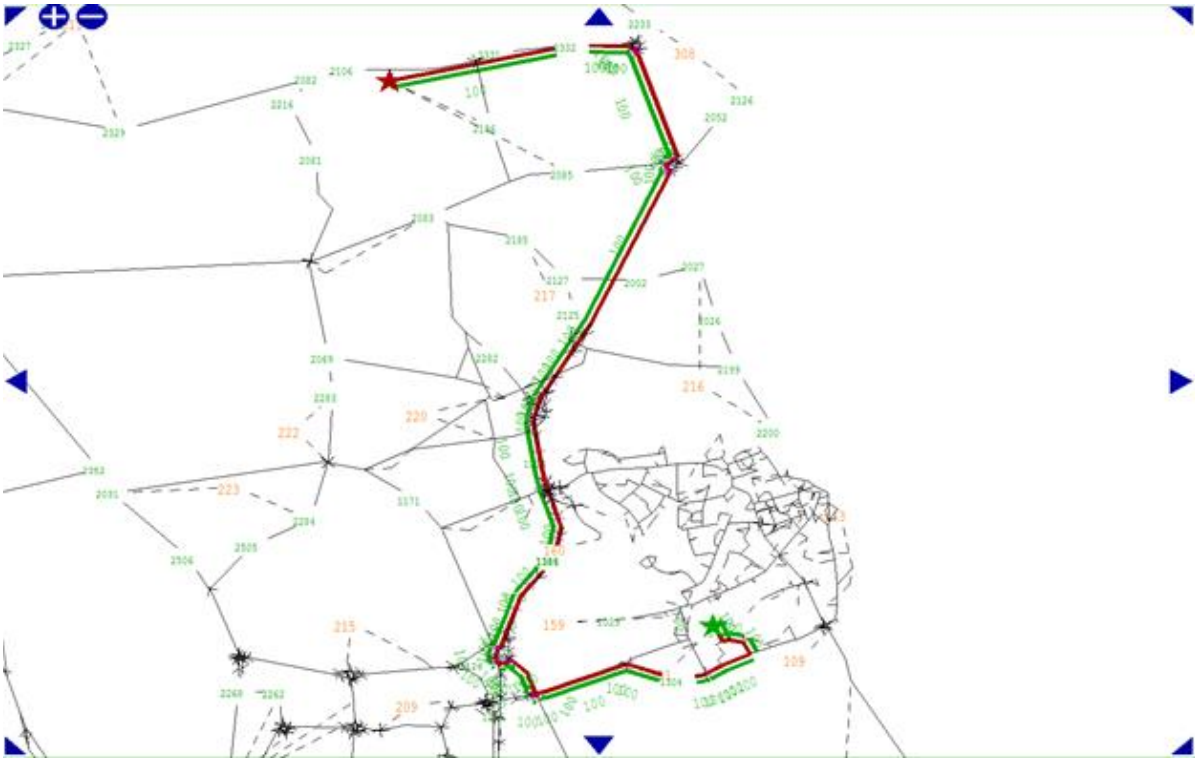
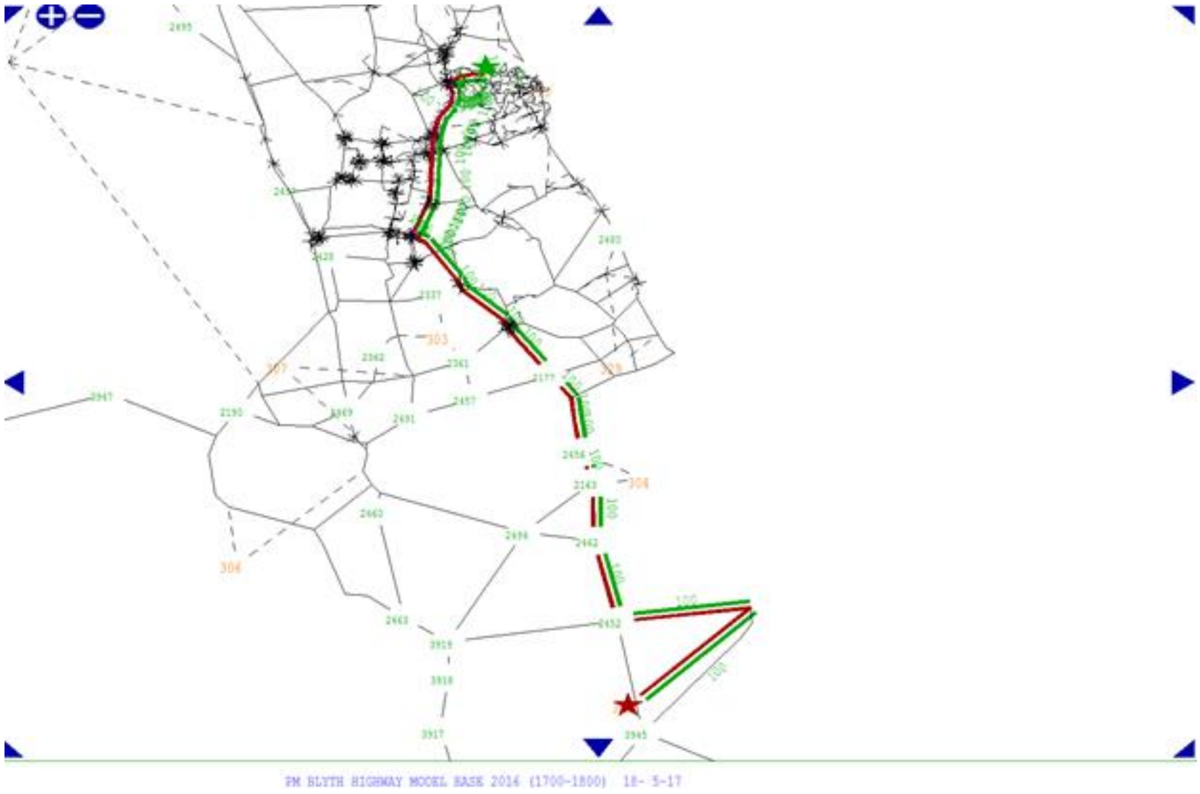


Figure 10-18. PM Routing from Zone 127 to 305 (Sunderland)



In all cases for the PM model, inbound and outbound movements were considered sensible. Traffic was seen to be using the primary routes between origin and destination. Where there was route choice, traffic continued to use sensible routes and was split sensibly based upon the apparent generalised cost of the alternative routes.

11. Assignment Calibration and Validation

11.1 Journey Time Validation

This section of the report looks at modelled route journey times and the validation of these against observed. The observed journey time information taken from Trafficmaster data, as outlined in Chapter 5 of this report, was used to validate modelled vehicle journey times in each of the modelled peaks. The DMRB acceptability guideline for this test is that 85% of routes are within 15% or 1 minute of the observed time, whichever is highest.

Table 11-1. AM Journey Time Routes

Route	Observed Time (mins)	Modelled Time (mins)	Difference (mins)	Percentage Difference
01CW	14.47	15.90	1.44	9.9%
01AC	13.68	14.82	1.13	8.3%
02NB	4.30	4.64	0.34	7.9%
02SB	4.87	4.89	0.02	0.4%
03CW	11.65	12.17	0.52	4.4%
03AC	11.23	12.65	1.42	12.6%
05NB	4.77	4.86	0.09	1.9%
05SB	4.12	4.47	0.36	8.7%
06NB	6.75	7.58	0.83	12.3%
06SB	6.33	7.26	0.96	15.1%

Table 11-2. IP Journey Time Routes

Route	Observed Time (mins)	Modelled Time (mins)	Difference (mins)	Percentage Difference
01CW	13.47	14.48	1.01	7.5%
01AC	13.53	14.33	0.79	5.9%
02NB	4.18	4.48	0.30	7.1%
02SB	4.52	4.51	0.01	0.3%
03CW	11.25	11.74	0.49	4.4%
03AC	11.52	12.46	0.94	8.1%
05NB	4.73	4.76	0.03	0.5%
05SB	4.33	4.46	0.13	2.9%
06NB	6.50	7.27	0.77	11.8%
06SB	6.47	7.09	0.62	9.6%

Table 11-3. PM Journey Time Routes

Route	Observed Time (mins)	Modelled Time (mins)	Difference (mins)	Percentage Difference
01CW	14.50	16.38	1.88	13.0%
01AC	14.35	15.83	1.48	10.3%
02NB	4.17	4.91	0.74	17.8%
02SB	4.72	4.71	0.01	0.1%
03CW	11.35	11.69	0.34	3.0%
03AC	12.35	13.38	1.03	8.3%
05NB	4.73	4.79	0.05	1.1%
05SB	4.20	4.64	0.44	10.4%
06NB	6.68	7.68	1.00	14.9%
06SB	8.22	7.44	0.78	9.5%

In total 10 journey times were recorded and all 10 were shown in the model to pass the DMRB guideline in all three peaks.

The journey times in the above tables were recorded as end-to-end journey times. Graphs were output using a series of intermediate timing points along the recorded routes in order to define a time profile graph of each route in each peak. These graphs can be seen in Appendix C. All journey time profile graphs show a similar profile between timing points within the overall routes to observed, with the exception of the A192 SB route in the PM peak (Figure 12-48). This route shows delay in the observed routing via the roundabout from the A192 North to A1061 Laverock Hall Road. The model has been calibrated to experience delay here but it has been unable to experience the similar extent of delay. This will therefore underestimate the benefits in the PM peak.

12. Summary

AECOM has been commissioned by Northumberland County Council to build a SATURN model to test future options for a relief road serving Blyth. The model has been built in accordance with WebTAG standards.

The demand matrices underpinning the traffic model have been derived from RSI information following a large scale data collection exercise in September 2017. Data was also collected to assist in the calibration and validation of the model.

As with any model, it has been necessary to apply matrix estimation to the prior matrix to improve the goodness of fit of observed data to modelled data. A series of tests on the information before and after this process has shown that the matrix estimation has not had a material impact on the information contained in the prior matrix.

The model calibrates and validates well against WebTAG criteria. All 10 journey times validate across each of the peak periods. The base model is therefore considered a suitable and robust too for building future year scenarios and testing the impact of a Blyth Relief Road.

Appendix A Speed-Flow Curves

Table 12-1. Variable Speed-Flow Curves

Free Flow Speed (KPH)	Congested Speed (KPH)	Link Capacity	Power	Reference	Suitable Road Type
112	60	10833	2.00	1	D5M Rural
110	89	8700	4.00	2	D4M Rural
119	85	6875	3.20	3	D3M Rural
112	90	4580	3.85	4	D2M Rural
104.5	45	4360	3.68	5	On/Off Slip Roads Rural (D2AP)
108.5	45	6780	3.66	6	D3 All Purpose
104.5	45	4360	3.68	7	D2 All Purpose
91	45	1860	2.24	8	Single Carriageway 10m “Good”
84	45	1660	2.13	9	Single Carriageway 10m “Typical”
87	45	1640	2.16	10	Single Carriageway 7.3m “Good”
78	45	1380	2.07	11	Single Carriageway 7m “Typical”
67	45	1010	1.79	12	Single Carriageway 6.5m “Poor”
80	45	4360	3.68	13	D2 All Purpose 50

Table 12-2. ‘Fixed Speed’ Speed-Flow Curves

Free Flow Speed (KPH)	Congested Speed (KPH)	Link Capacity	Power	Reference	Suitable Road Type
39	38	1730	1.02	201	Urban Central (Slight Dev)
37	36	1270	1.02	203	Urban Central (Typical Dev)
31	30	1270	1.02	205	Urban Central (Heavy Dev)
48	47	1730	1.26	207	Urban Non-Cent S (Slight Dev) 30
51	50	1730	1.25	208	Urban Non-Cent S (Slight Dev) 40
60	59	1730	1.25	209	Urban Non-Cent S (Slight Dev) 50
86	85	1730	1.25	210	Urban Non-Cent S (Slight Dev) 60
27	26	1270	2.03	211	Urban Non-Cent S (Typical Dev) 20
36	35	1270	2.00	212	Urban Non-Cent S (Typical Dev) 30
45	44	1270	2.00	213	Urban Non-Cent S (Typical Dev) 40
15	14	1270	1.03	216	Urban Non-Cent S (Heavy Dev) 20
18	17	1270	1.02	217	Urban Non-Cent S (Heavy Dev) 30
25	24	1270	1.01	218	Urban Non-Cent S (Heavy Dev) 40
45	44	3460	1.26	221	Urban Non-Cent D (Slight Dev) 30
49	48	3460	1.26	222	Urban Non-Cent D (Slight Dev) 40
67	66	3460	1.25	223	Urban Non-Cent D (Slight Dev) 50
80	79	3460	1.25	224	Urban Non-Cent D (Slight Dev) 60
85	84	3460	1.25	225	Urban Non-Cent D (Slight Dev) 70
40	39	2540	2.01	226	Urban Non-Cent D (Typical Dev) 30
44	43	2540	2.00	227	Urban Non-Cent D (Typical Dev) 40

Free Flow Speed (KPH)	Congested Speed (KPH)	Link Capacity	Power	Reference	Suitable Road Type
35	34	1000	1.02	231	Urban Non-Cent D (Heavy Dev) 30
40	39	1150	1.01	232	Urban Non-Cent D (Heavy Dev) 40
48	47	1640	1.09	236	Rural Single Carriageway (Good) 30
32	31	810	1.74	237	Rural Single Carriageway (Poor) 30
56	55	1640	1.09	238	Rural Single Carriageway (Good) 40
36	35	1010	1.73	239	Rural Single Carriageway (Poor) 40
62	61	1640	1.09	240	Rural Single Carriageway (Good) 50
62	61	1010	1.73	241	Rural Single Carriageway (Poor) 50
68	67	1640	1.09	242	Rural Single Carriageway (Good) 60
68	67	1010	1.73	243	Rural Single Carriageway (Poor) 60
64	63	4400	1.11	244	2 Lane Motorway 40Mph Speed Limit
78	77	4400	1.11	245	2 Lane Motorway 50Mph Speed Limit
85	84	4400	1.10	246	2 Lane Motorway 70Mph Speed Limit
53	52	6600	0.82	247	3 Lane Motorway 40Mph Speed Limit
67	66	6600	0.82	248	3 Lane Motorway 50Mph Speed Limit
85	84	6600	0.81	249	3 Lane Motorway 70Mph Speed Limit
53	52	2000	1.06	250	On/Off Slip Road 40Mph
67	66	2000	1.06	251	On/Off Slip Road 50Mph
80	79	2000	1.06	252	On/Off Slip Road 60Mph
85	84	2000	1.06	253	On/Off Slip Road 70Mph
48	47	3460	1.26	254	2 Lane Circulatory Carriageway 30
48	47	5190	1.26	255	3 Lane Circulatory Carriageway 30
56	55	3460	1.25	256	2 Lane Circulatory Carriageway 40
56	55	5190	1.25	257	3 Lane Circulatory Carriageway 40
48	47	6920	1.26	258	4 Lane Circulatory Carriageway 30
56	55	6920	1.25	259	4 Lane Circulatory Carriageway 40
48	47	2000	1.07	261	On/Off Slip Road 30Mph
62	61	3460	1.25	262	2 Lane Circulatory Carriageway 50
53	52	8800	0.82	263	4 Lane Motorway 40Mph Speed Limit
48	47	450	1.73	264	Rural Single Carriageway (V. Poor)
48	47	3000	1.26	265	2 Lane Circulatory Carriageway 30

Appendix B Gravity Model Calibrated Journey Purpose Graphs

Figure 12-1. HB Work Observed Journey Length

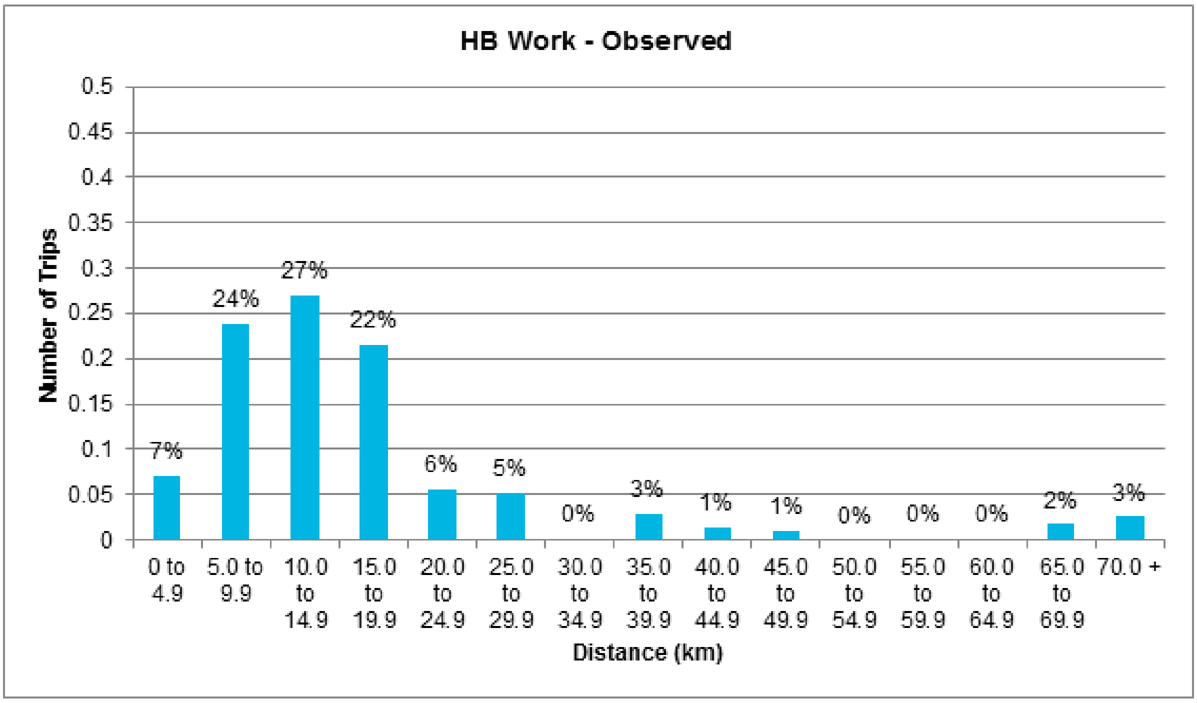


Figure 12-2. HB Work Calibrated Gravity Model Journey Length

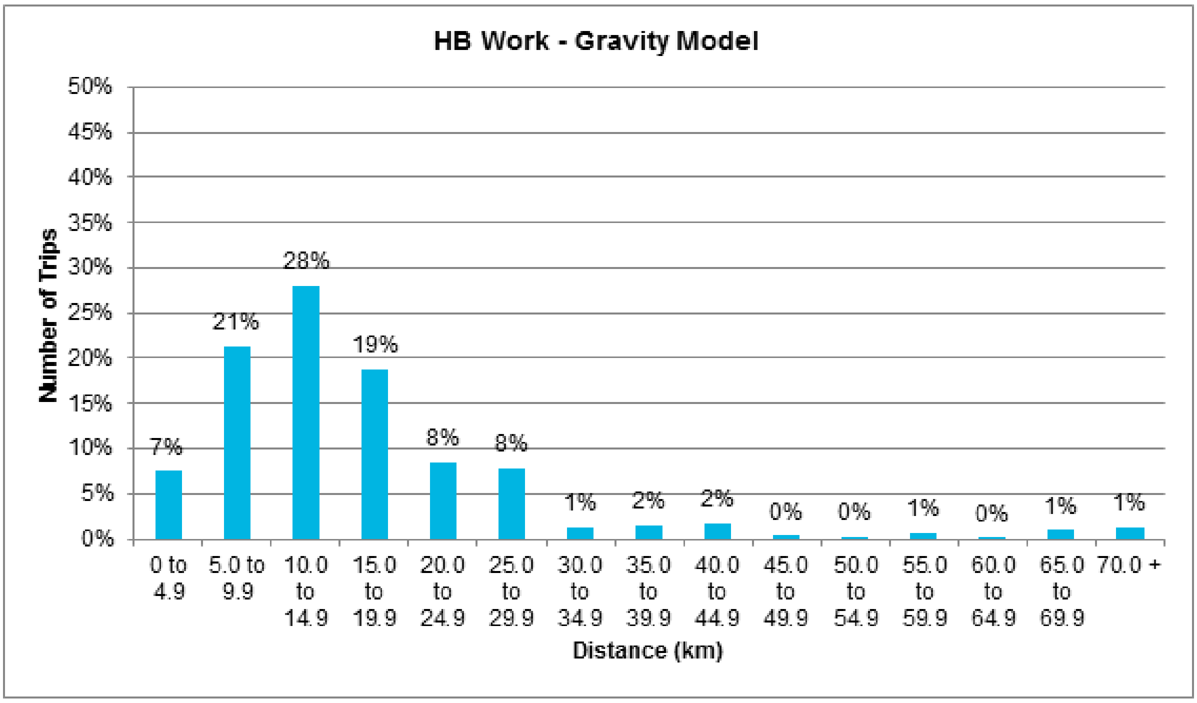


Figure 12-3. HB Education Observed Journey Length

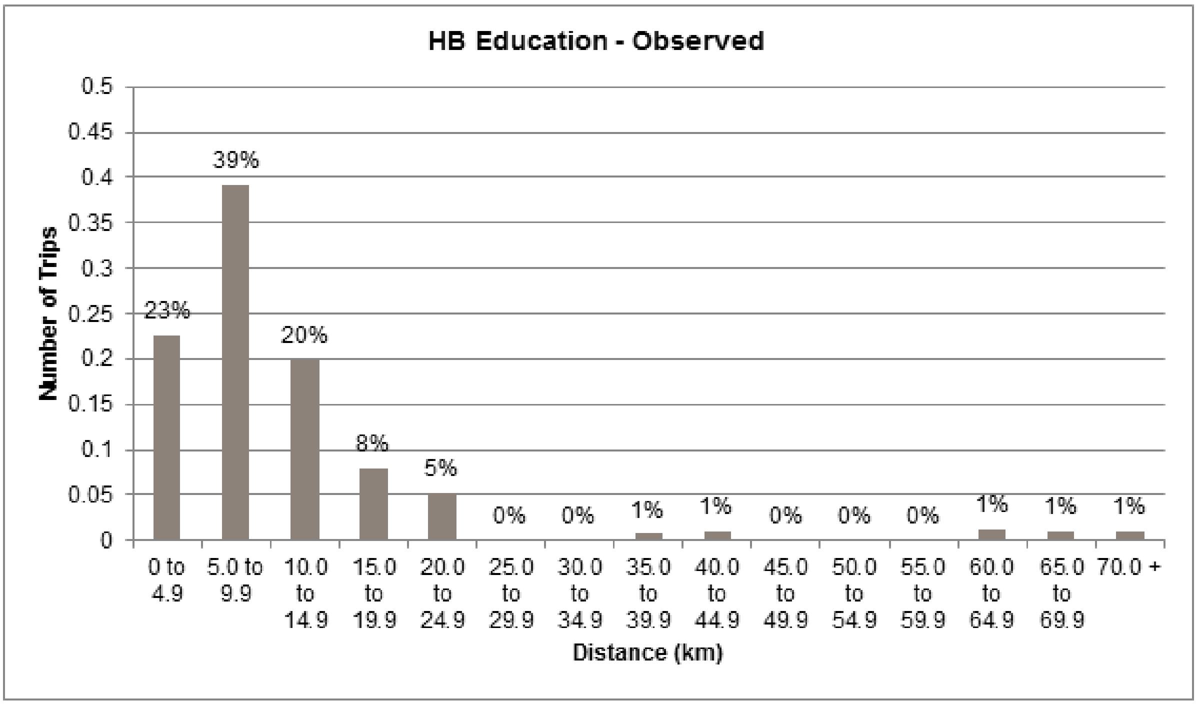


Figure 12-4. HB Education Calibrated Gravity Model Journey Length

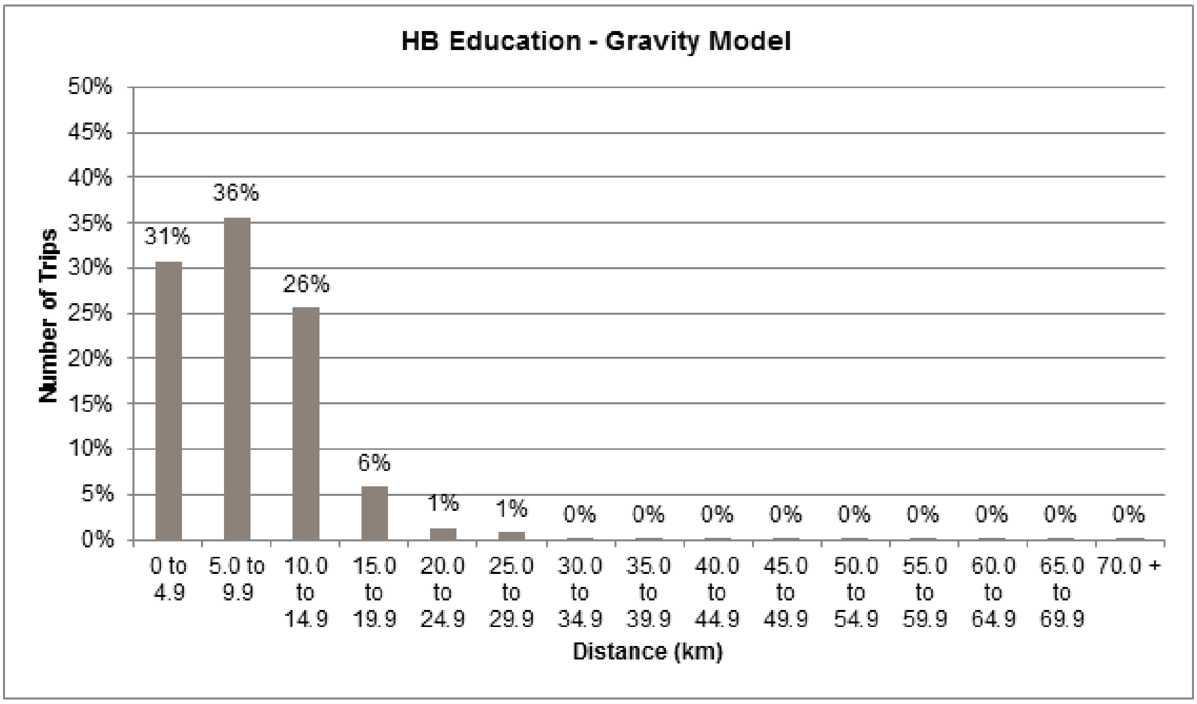


Figure 12-5. HB Shopping Observed Journey Length

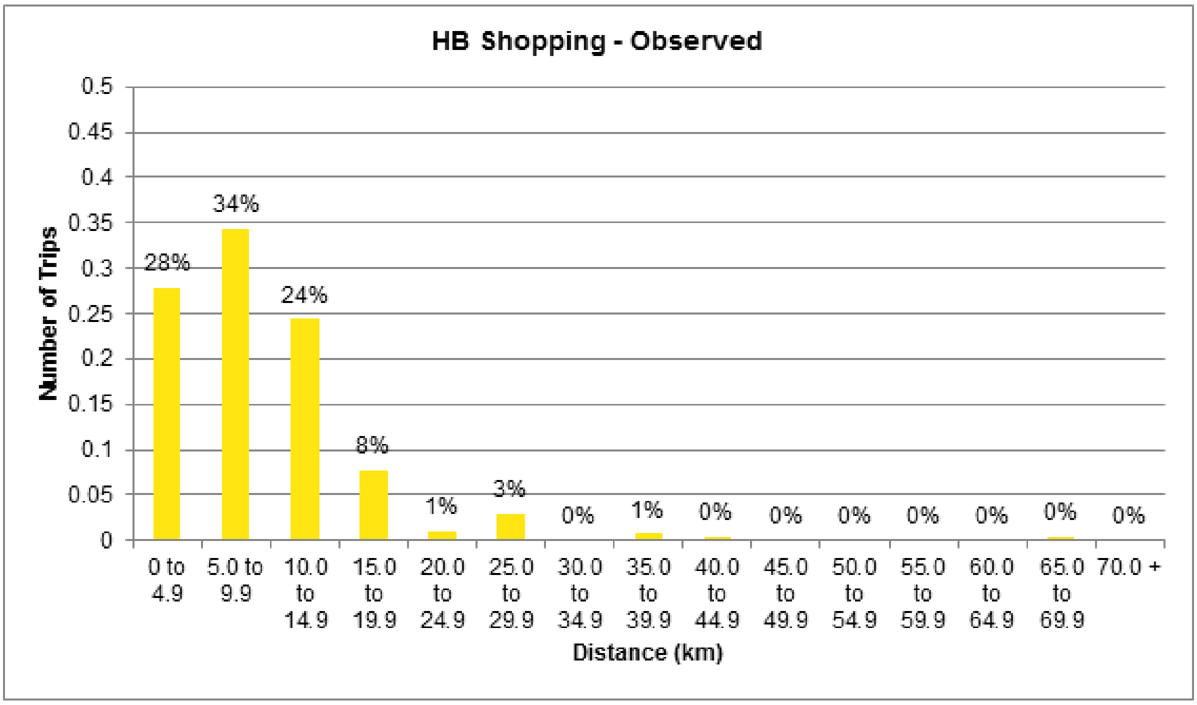


Figure 12-6. HB Shopping Calibrated Gravity Model Journey Length

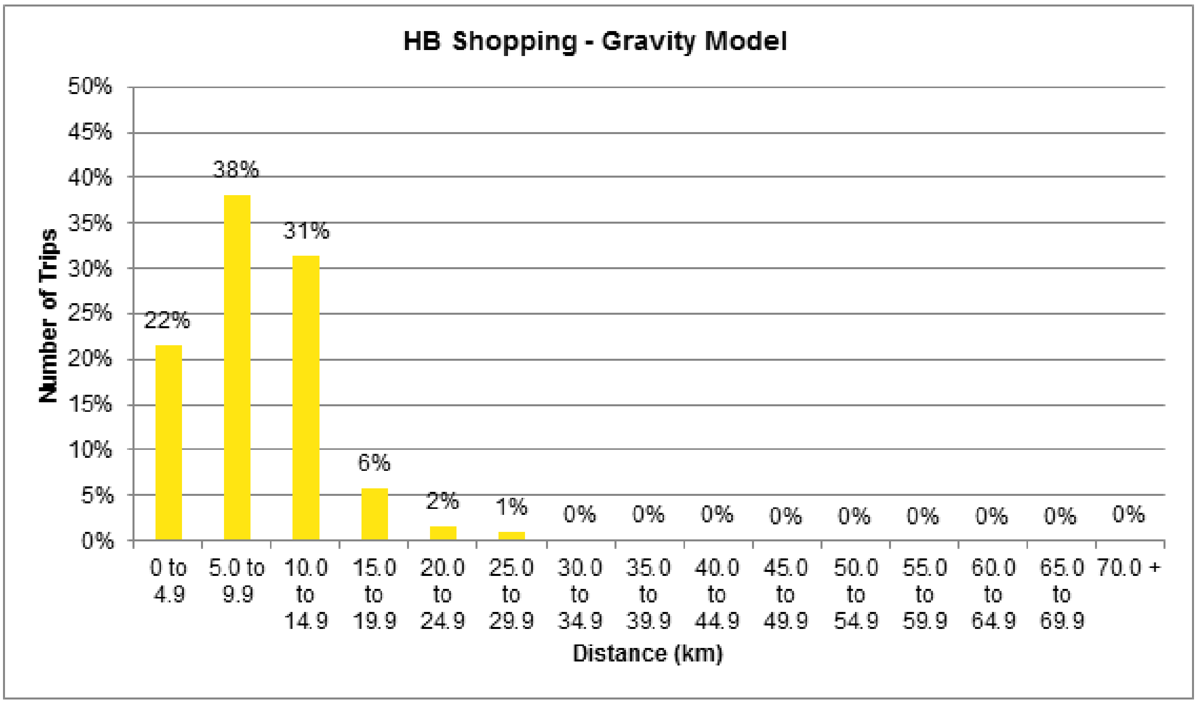


Figure 12-7. HB Other Observed Journey Length

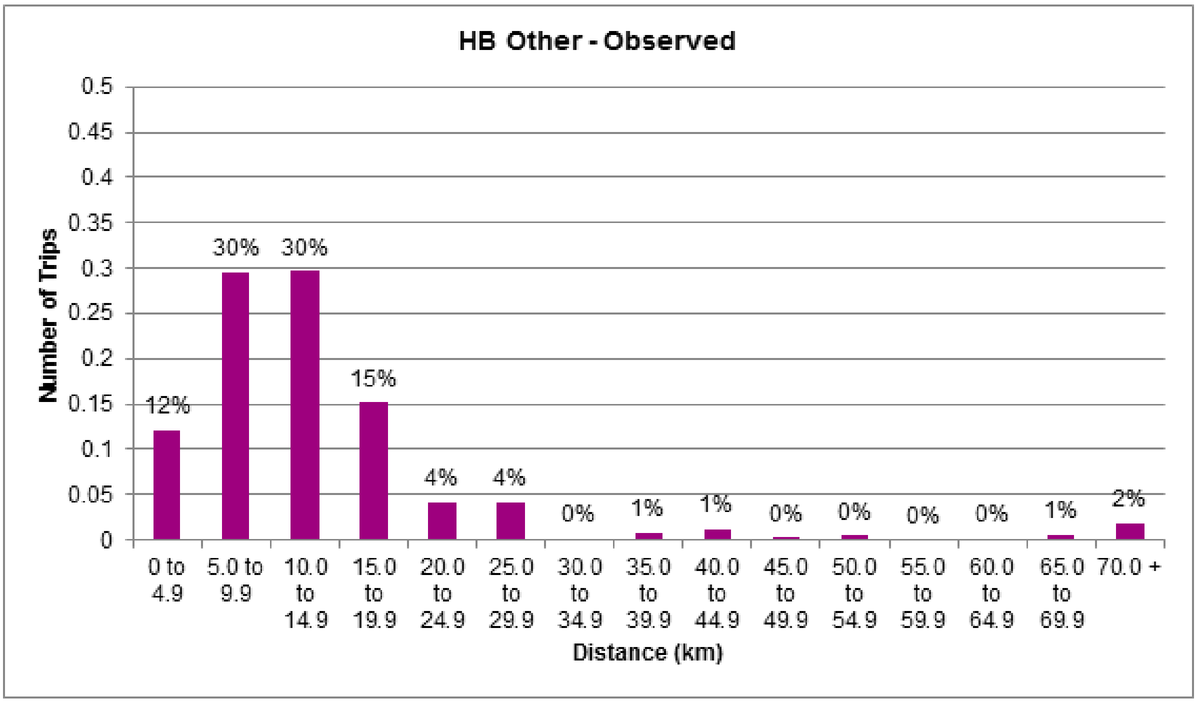


Figure 12-8. HB Other Calibrated Gravity Model Journey Length

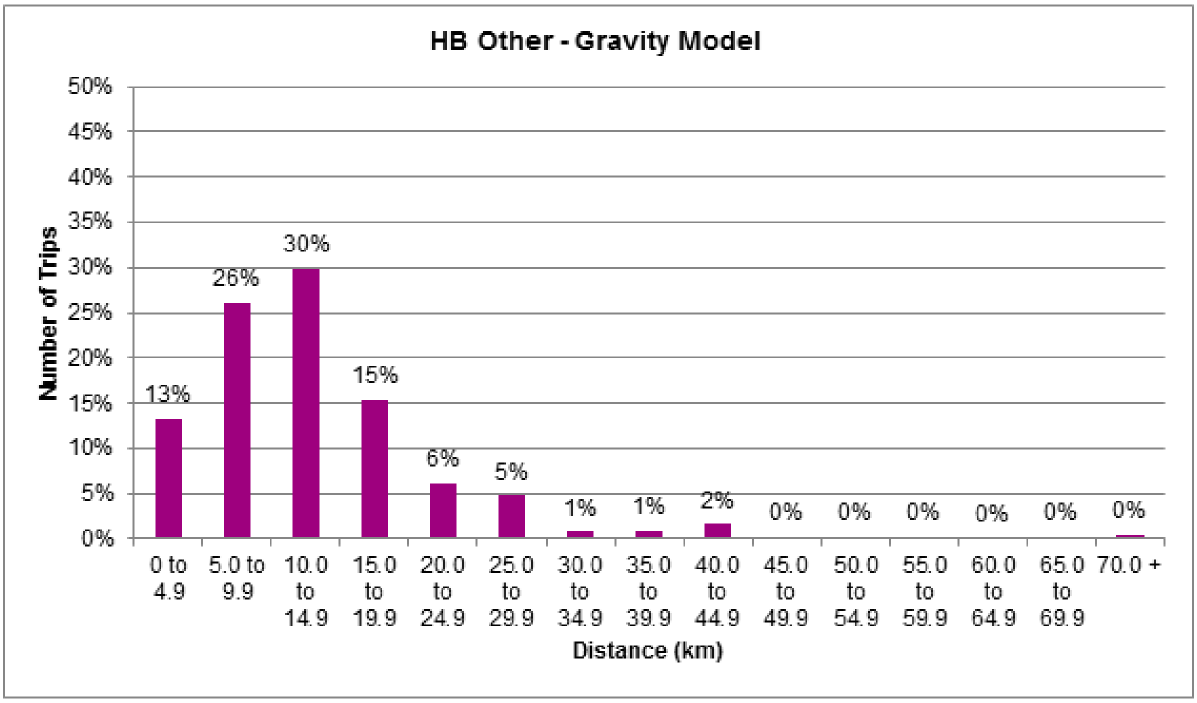


Figure 12-9. HB Business Observed Journey Length

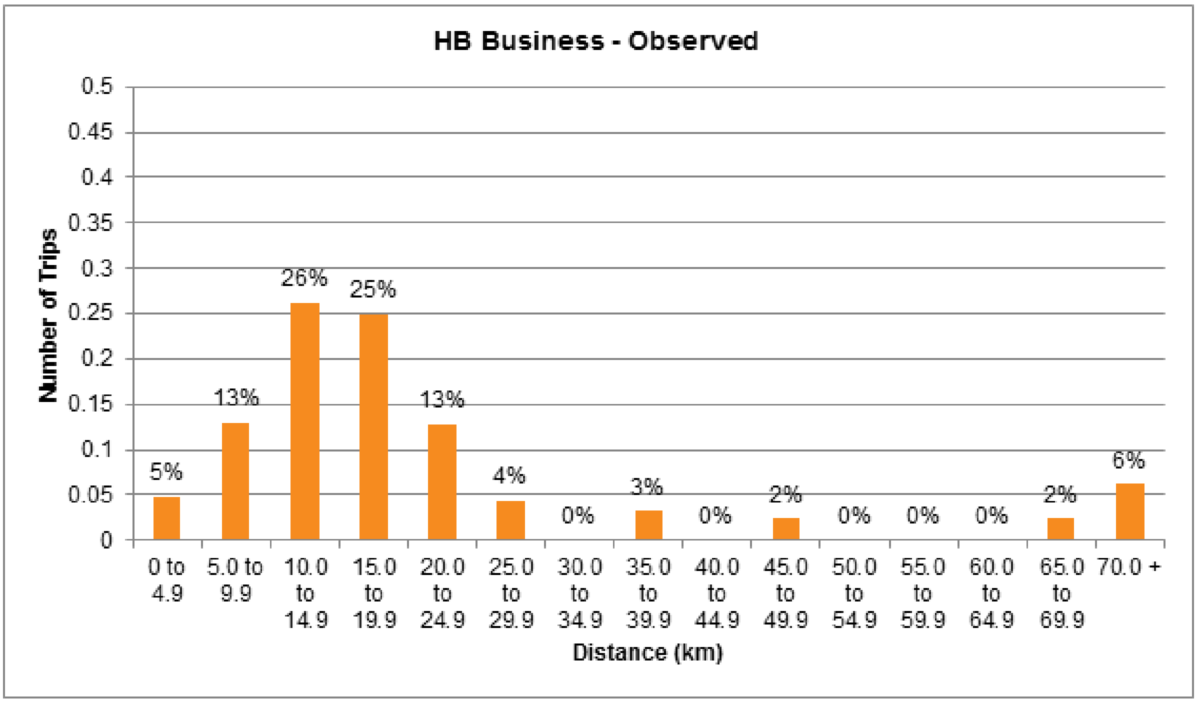


Figure 12-10. HB Business Calibrated Gravity Model Journey Length

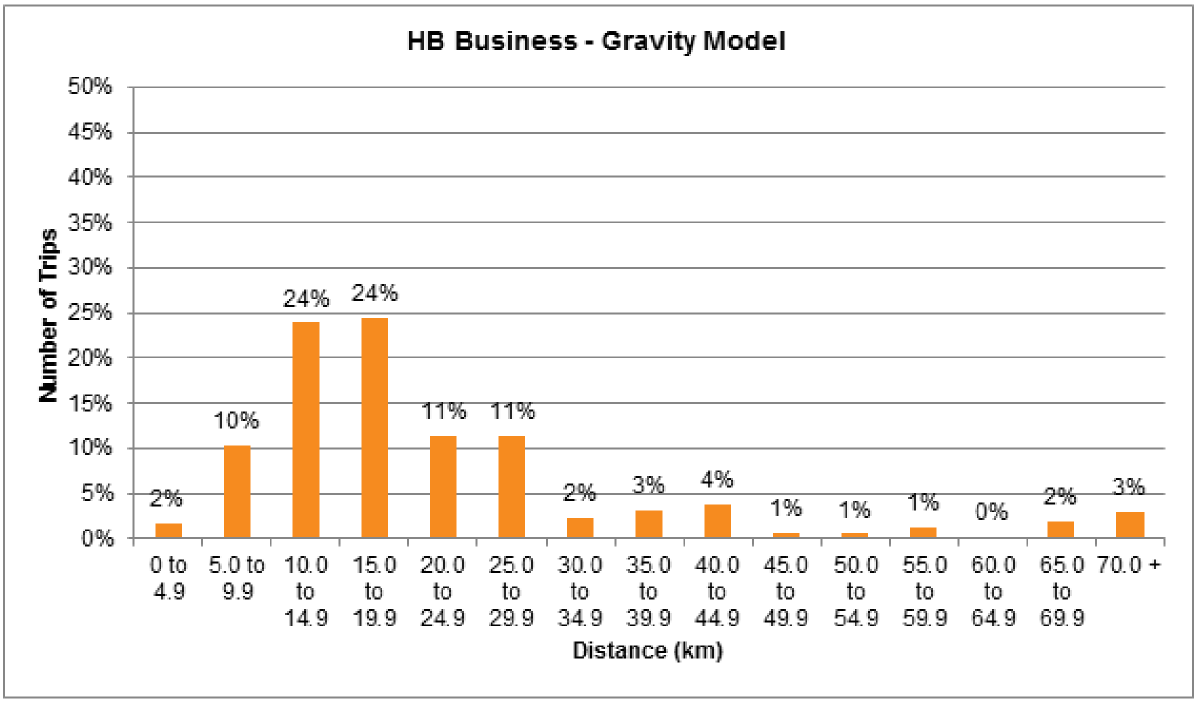


Figure 12-11. NHB Business Observed Journey Length

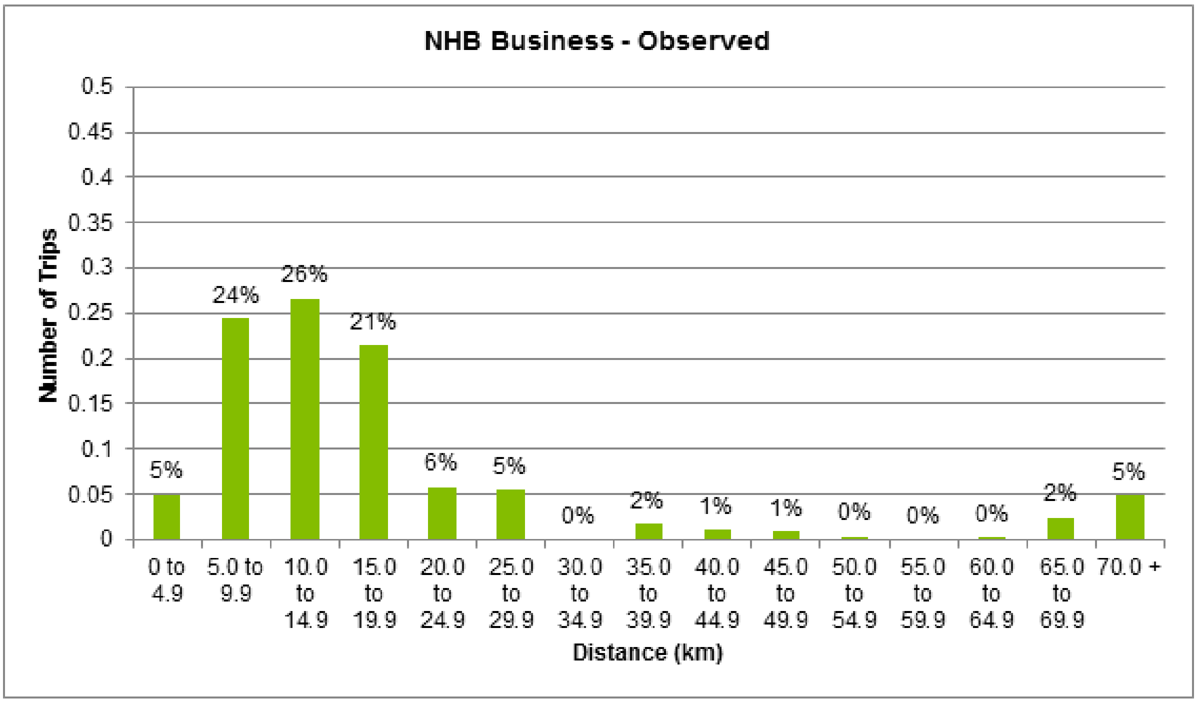


Figure 12-12. NHB Business Calibrated Gravity Model Journey Length

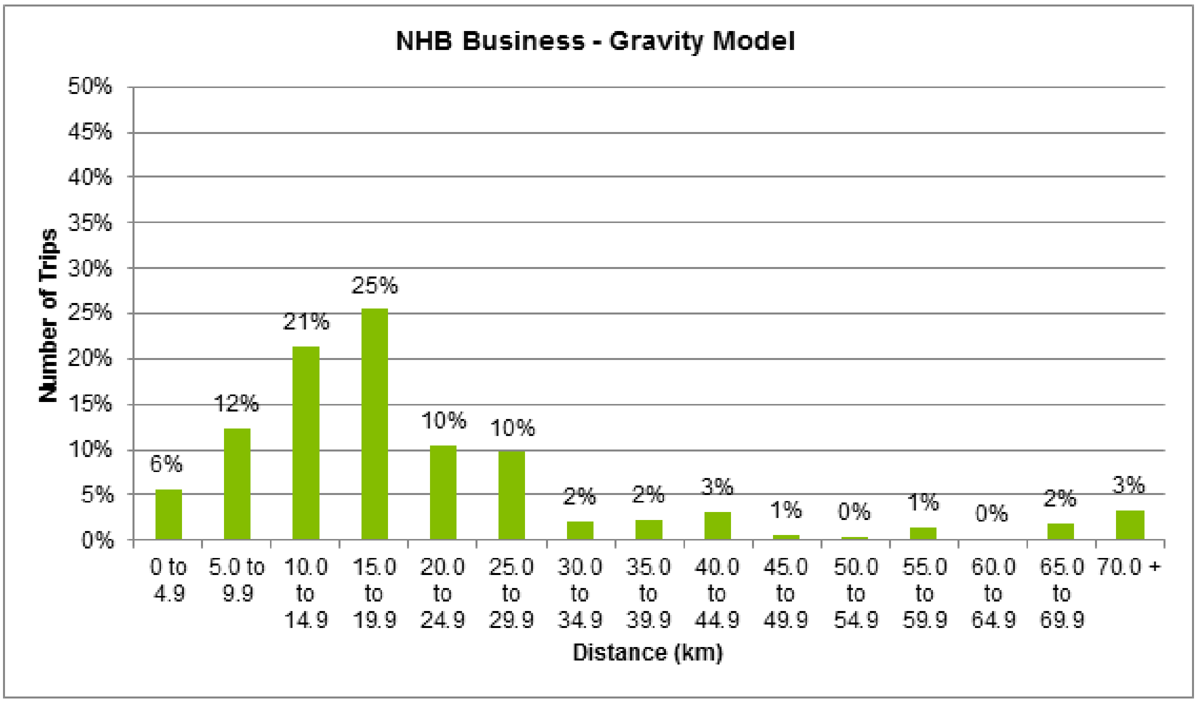


Figure 12-13. NHB Other Observed Journey Length

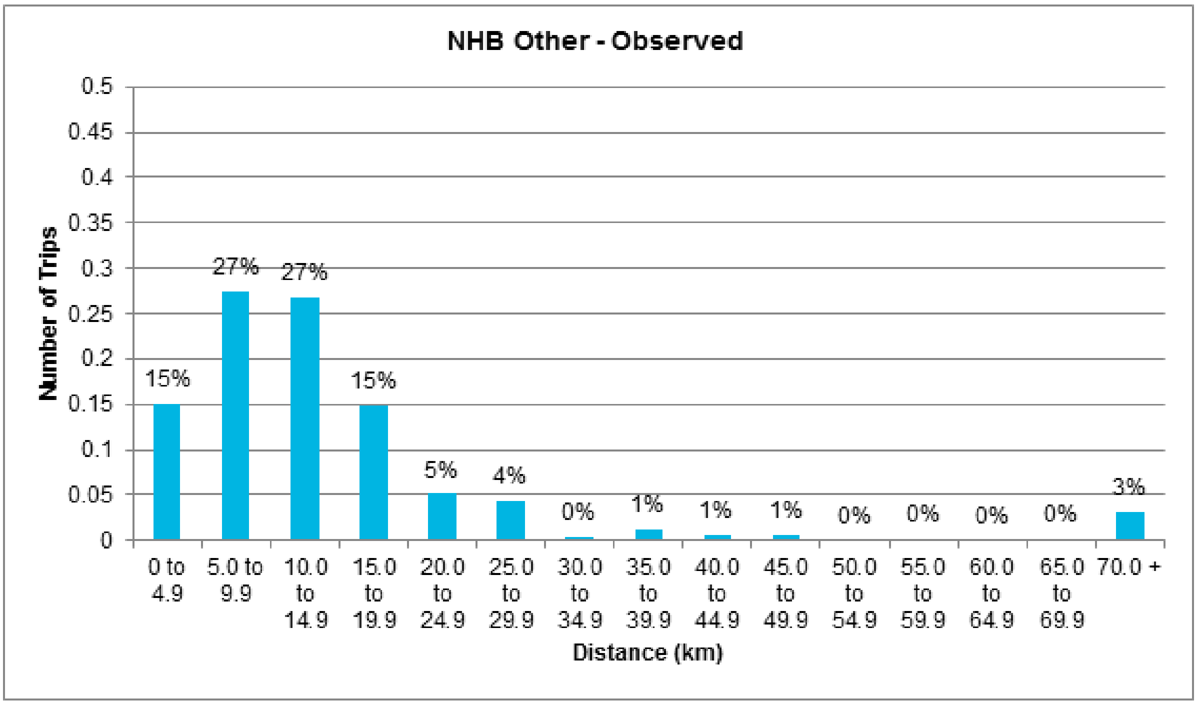


Figure 12-14. NHB Other Calibrated Gravity Model Journey Length

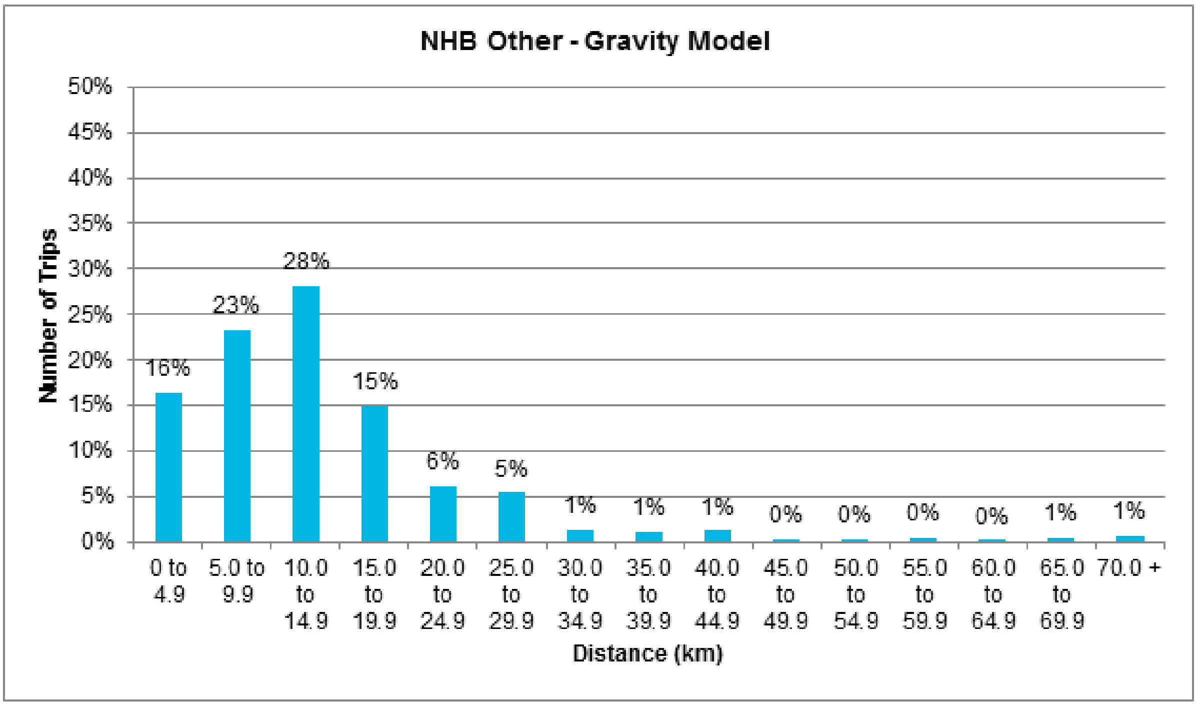


Figure 12-15. LGV Observed Journey Length

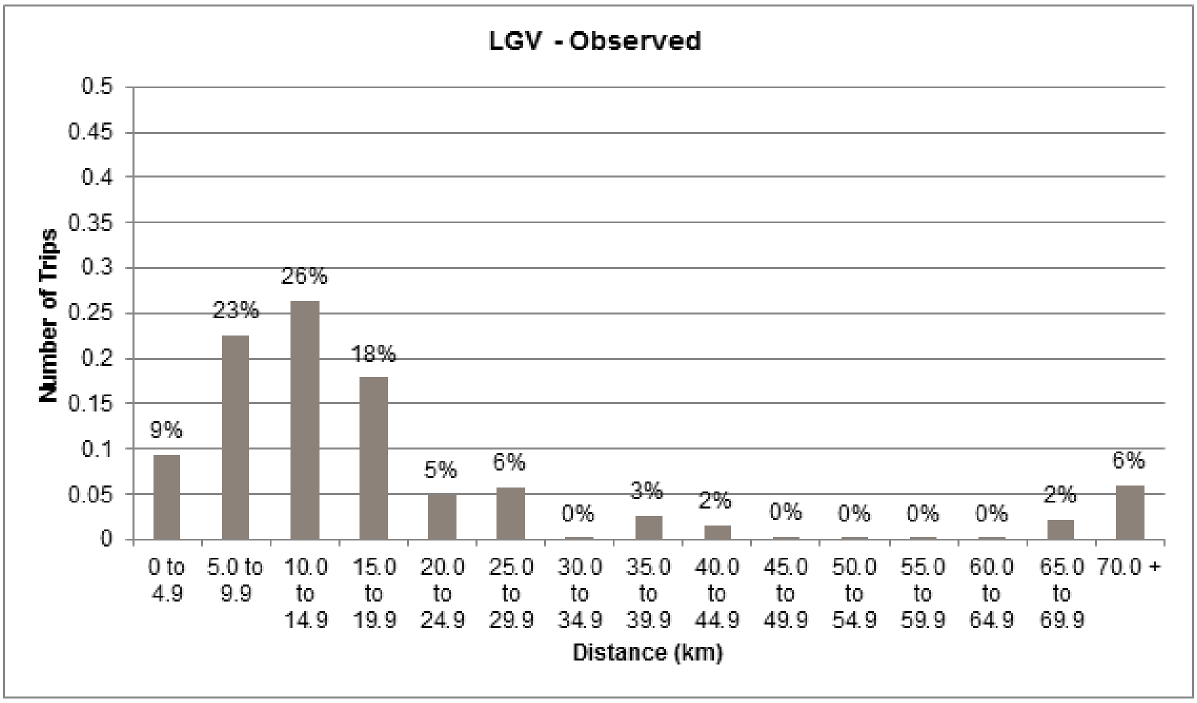


Figure 12-16. LGV Calibrated Gravity Model Journey Length

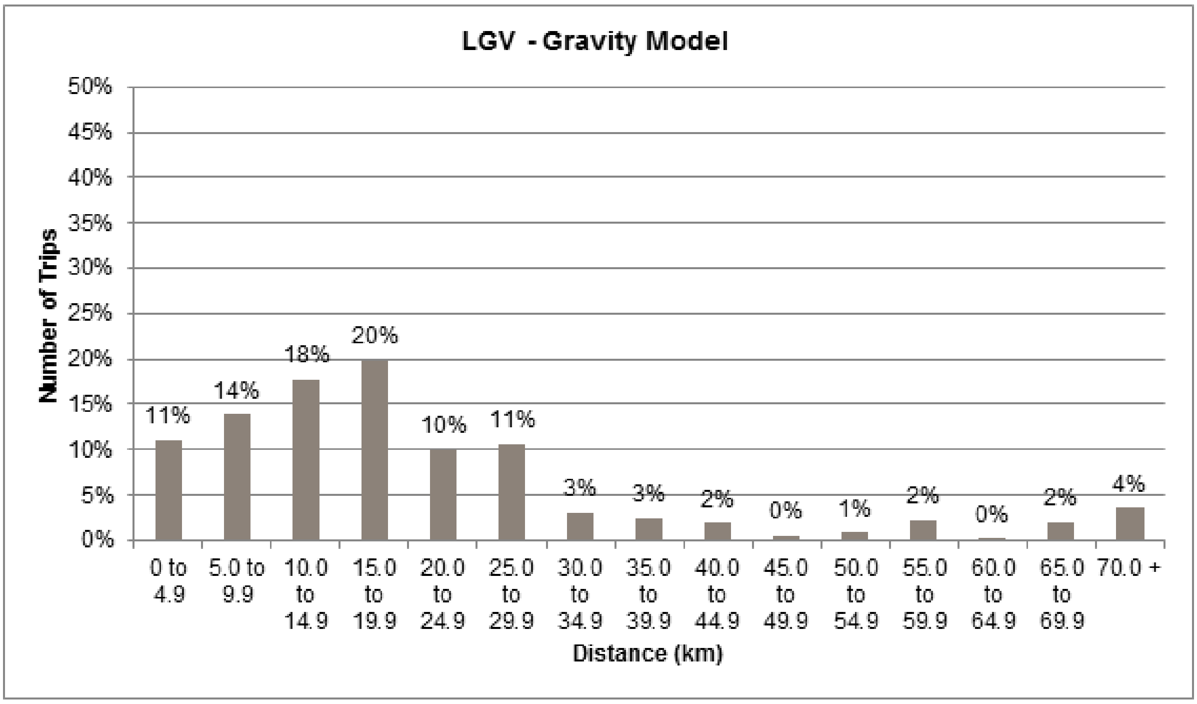


Figure 12-17. HGV Observed Journey Length

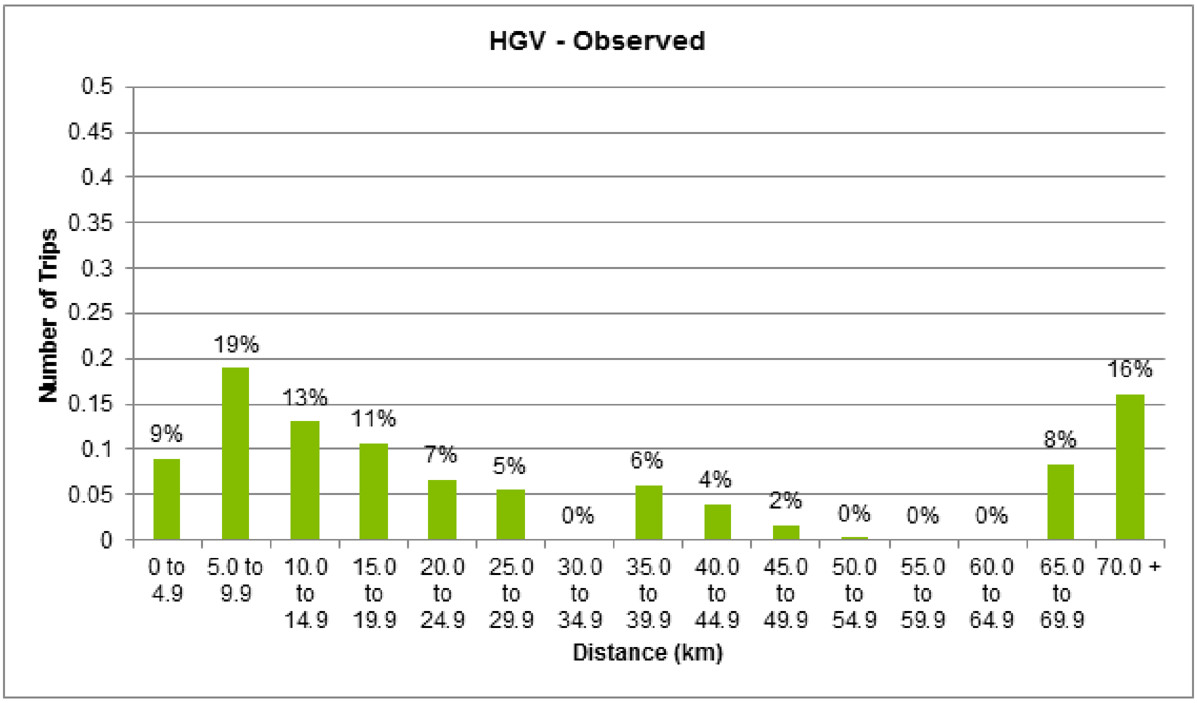
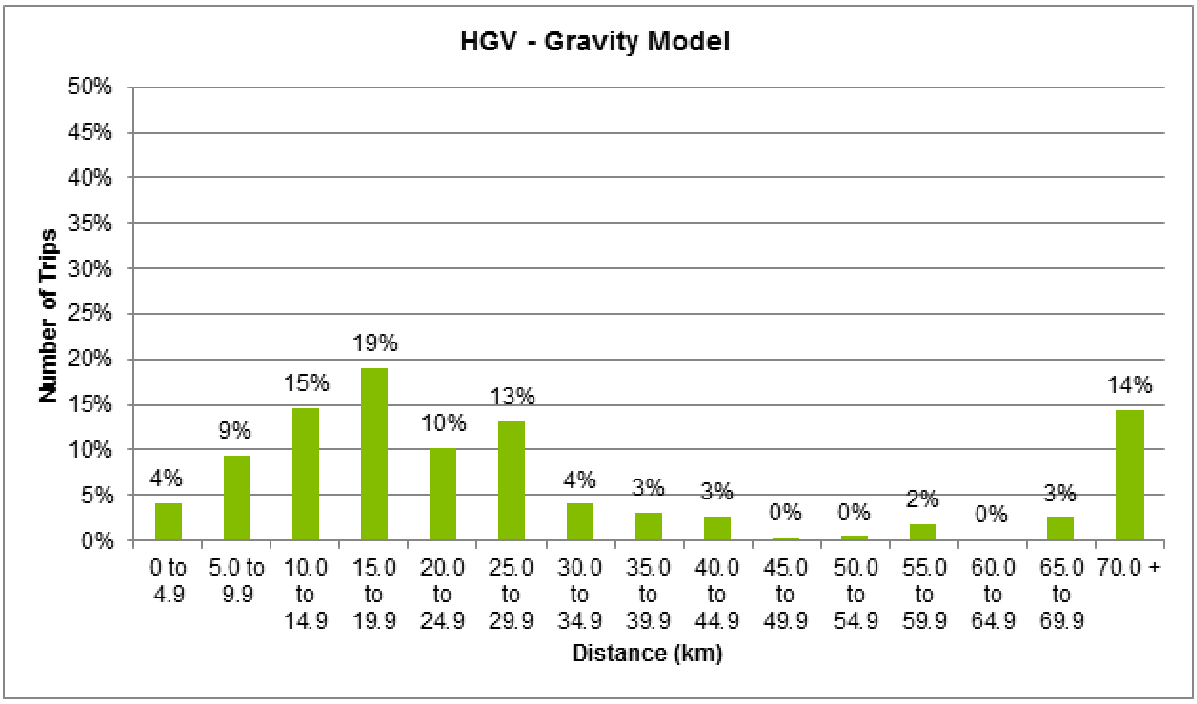


Figure 12-18. HGV Calibrated Gravity Model Journey Length



Appendix C Journey Time Profile Graphs

Figure 12-19. AM Journey Time Profile Graph: A193 NB

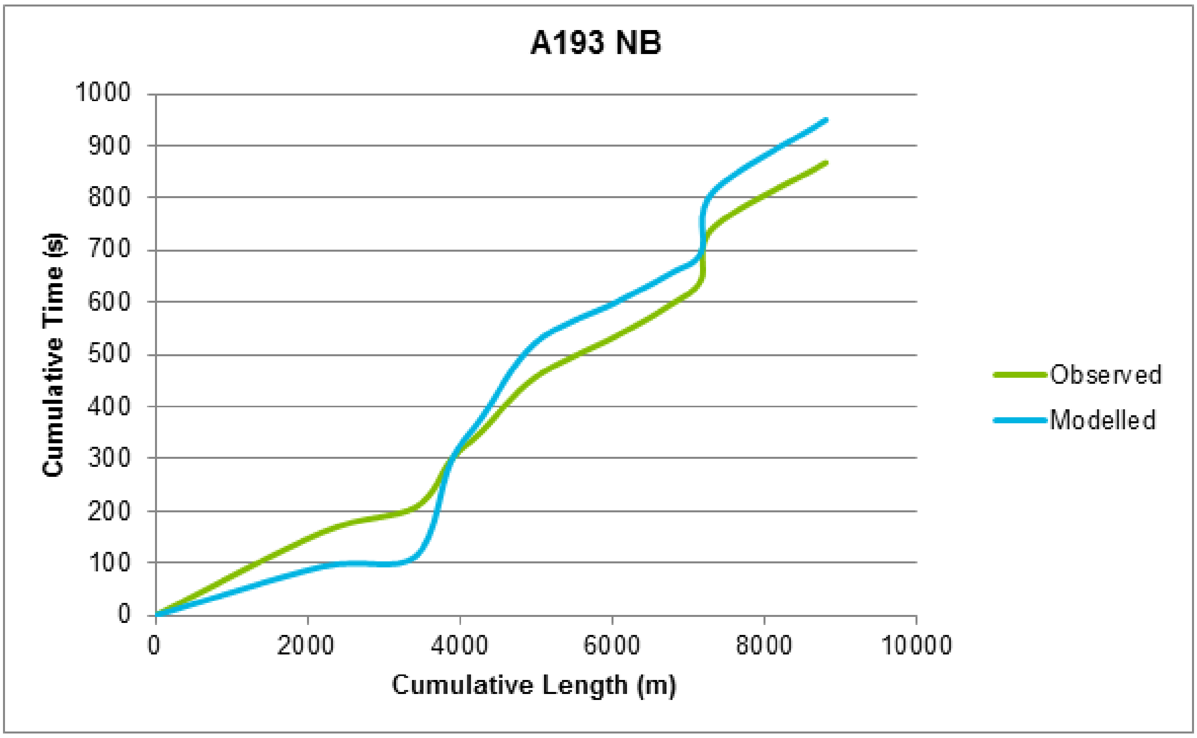


Figure 12-20. AM Journey Time Profile Graph: A193 SB

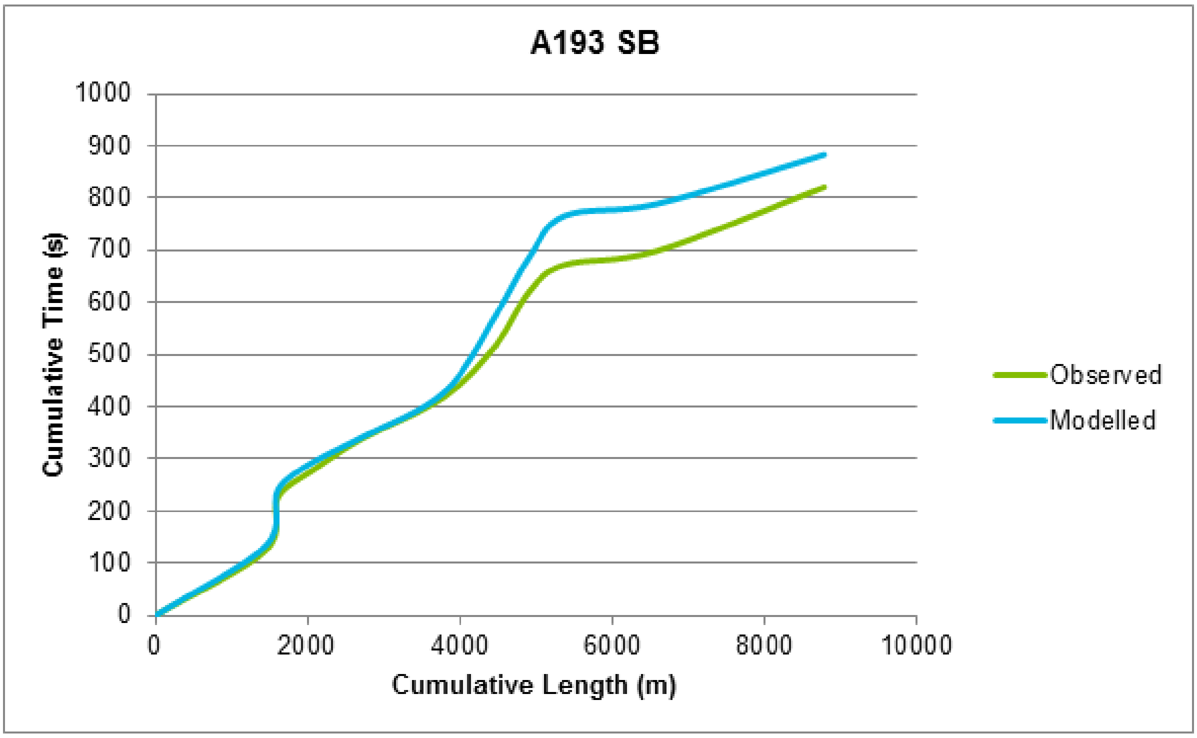


Figure 12-21. AM Journey Time Profile Graph: A189 NB

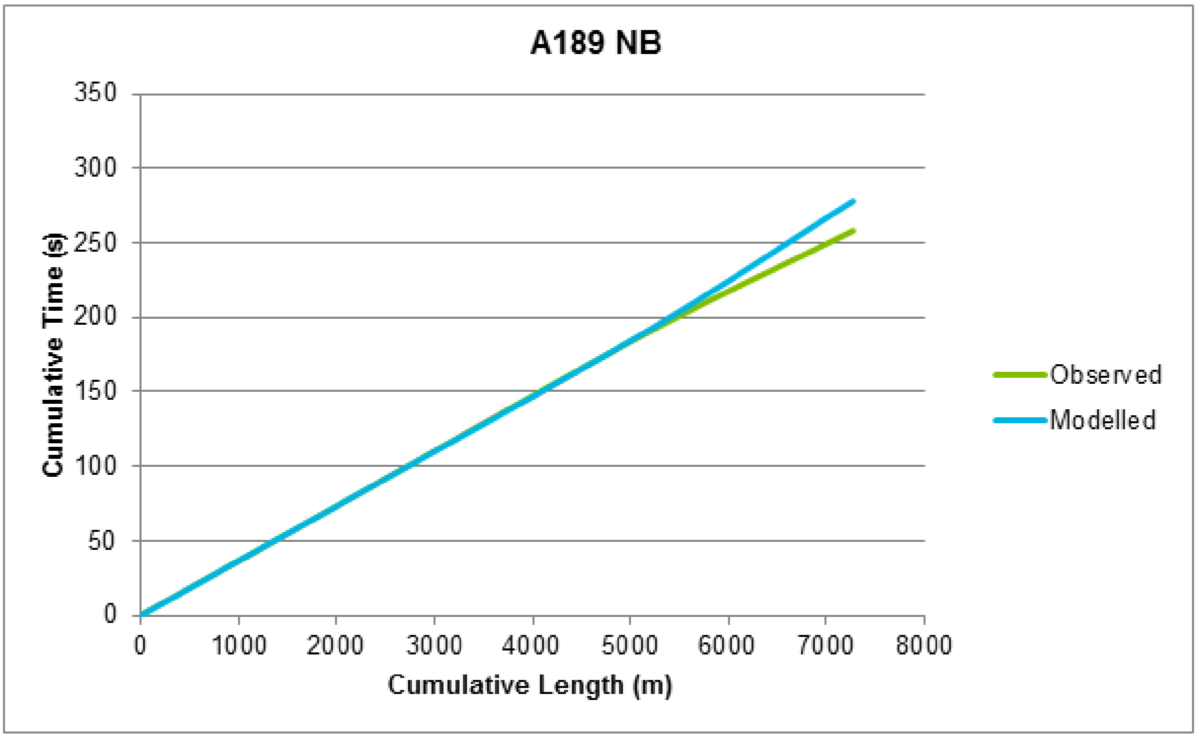


Figure 12-22. AM Journey Time Profile Graph: A189 SB

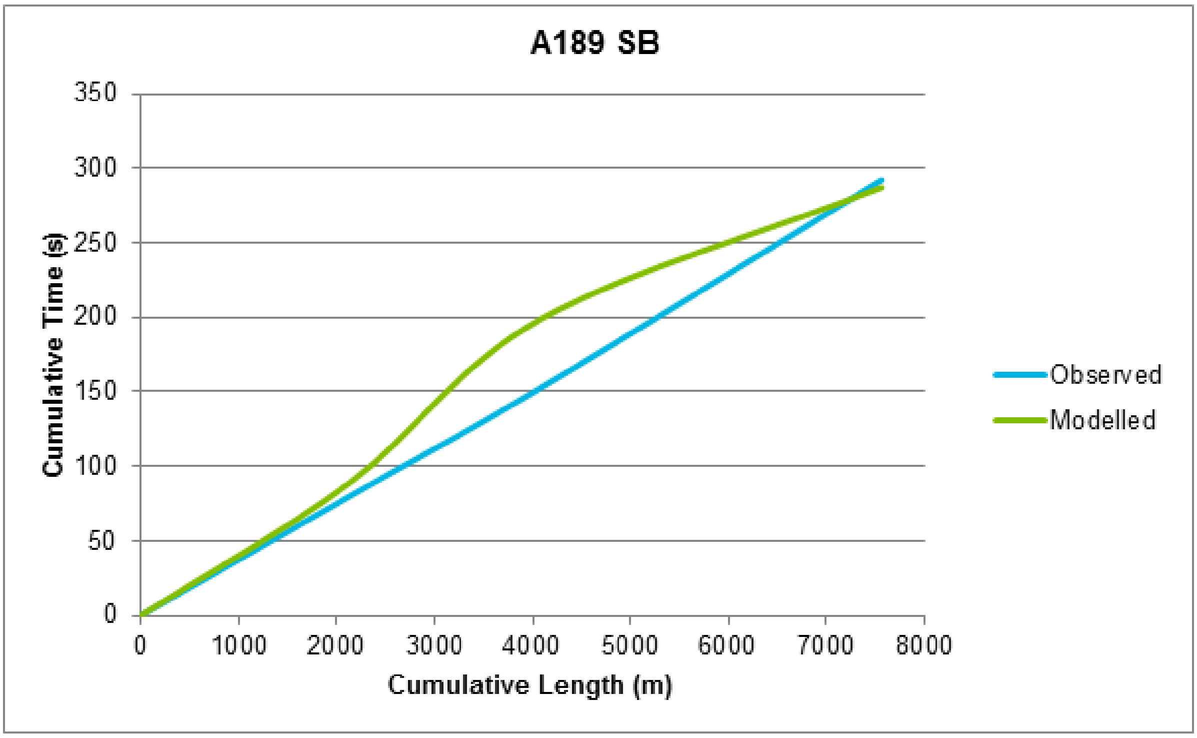


Figure 12-23. AM Journey Time Profile Graph: Laverock Hall Road SB

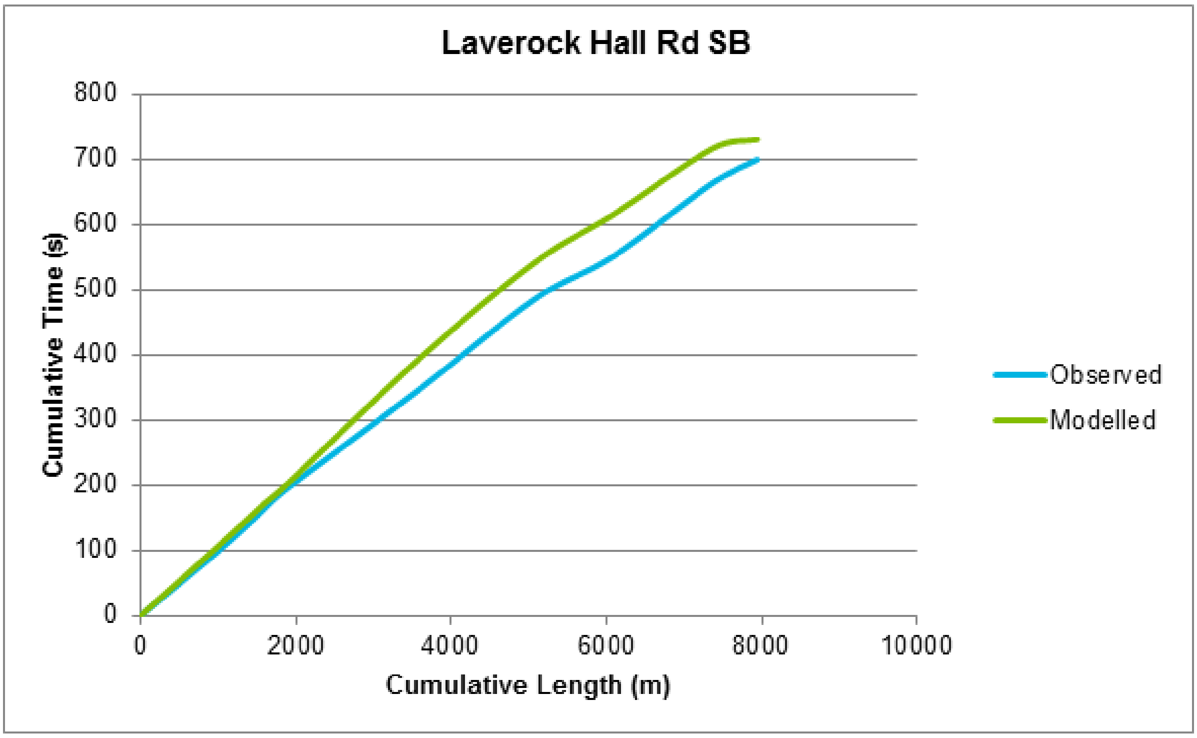


Figure 12-24. AM Journey Time Profile Graph: Laverock Hall Road NB

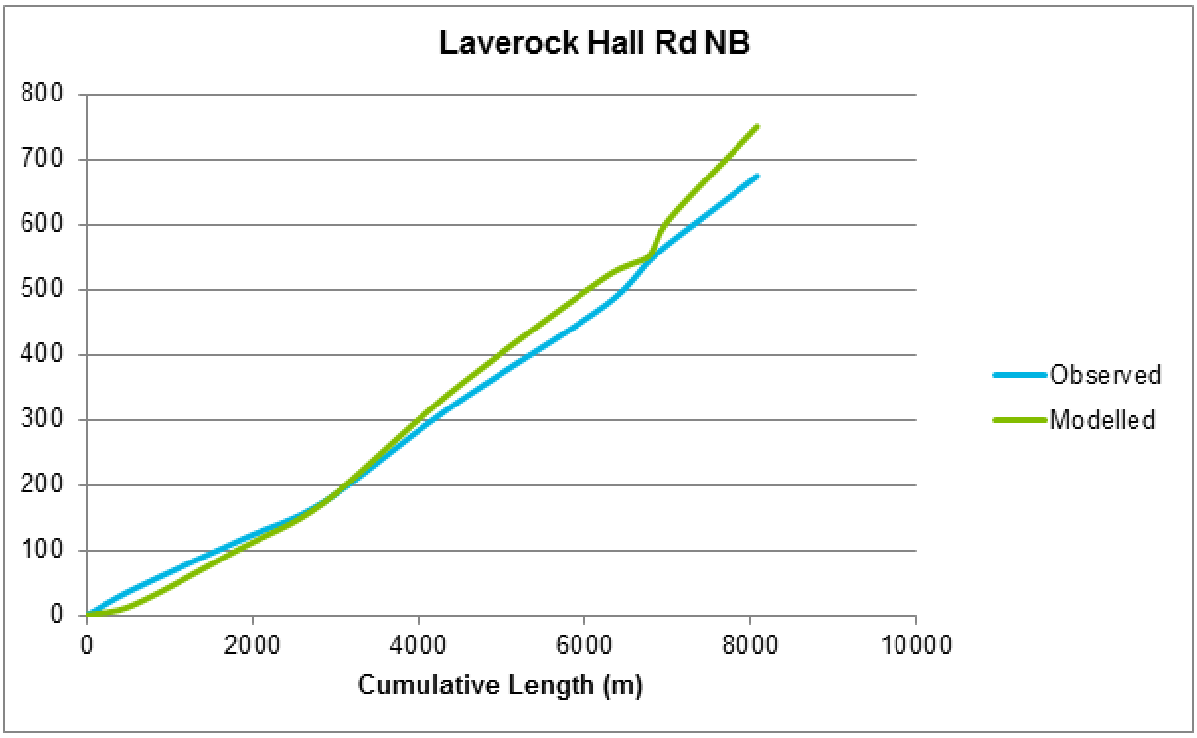


Figure 12-25. AM Journey Time Profile Graph: Plessey Road NB

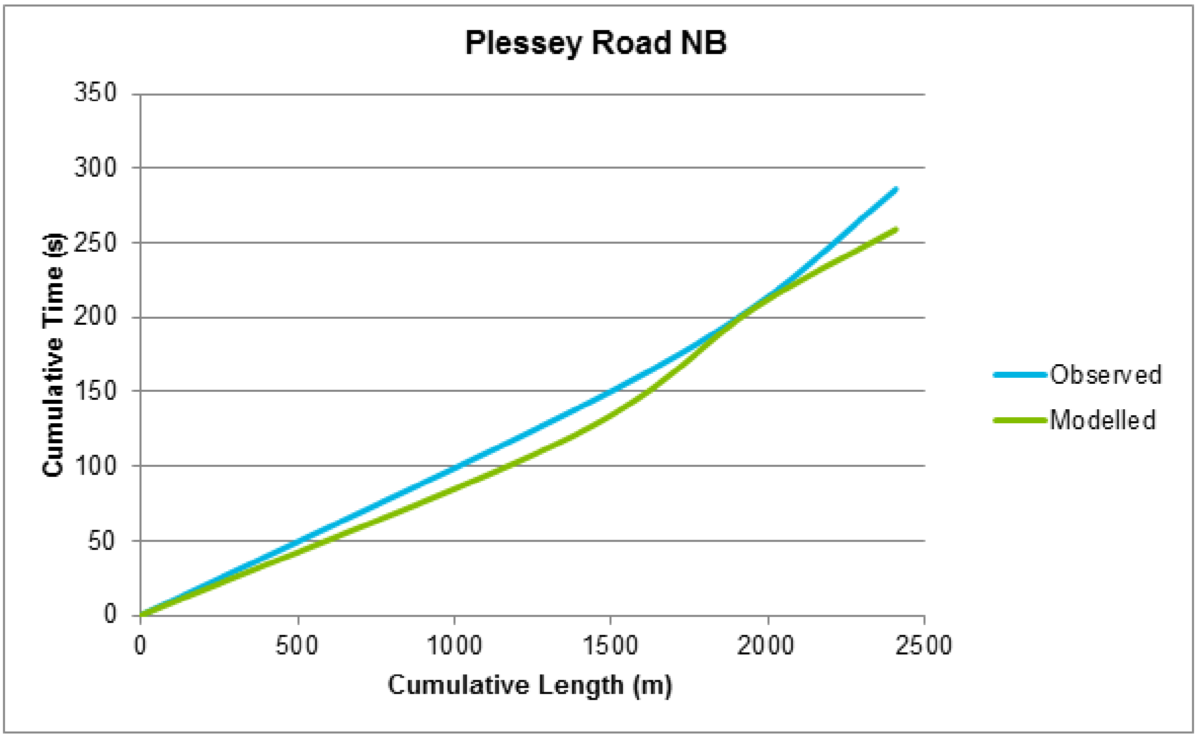


Figure 12-26. AM Journey Time Profile Graph: Plessey Road SB

Figure 12-27. AM Journey Time Profile Graph: A192 NB

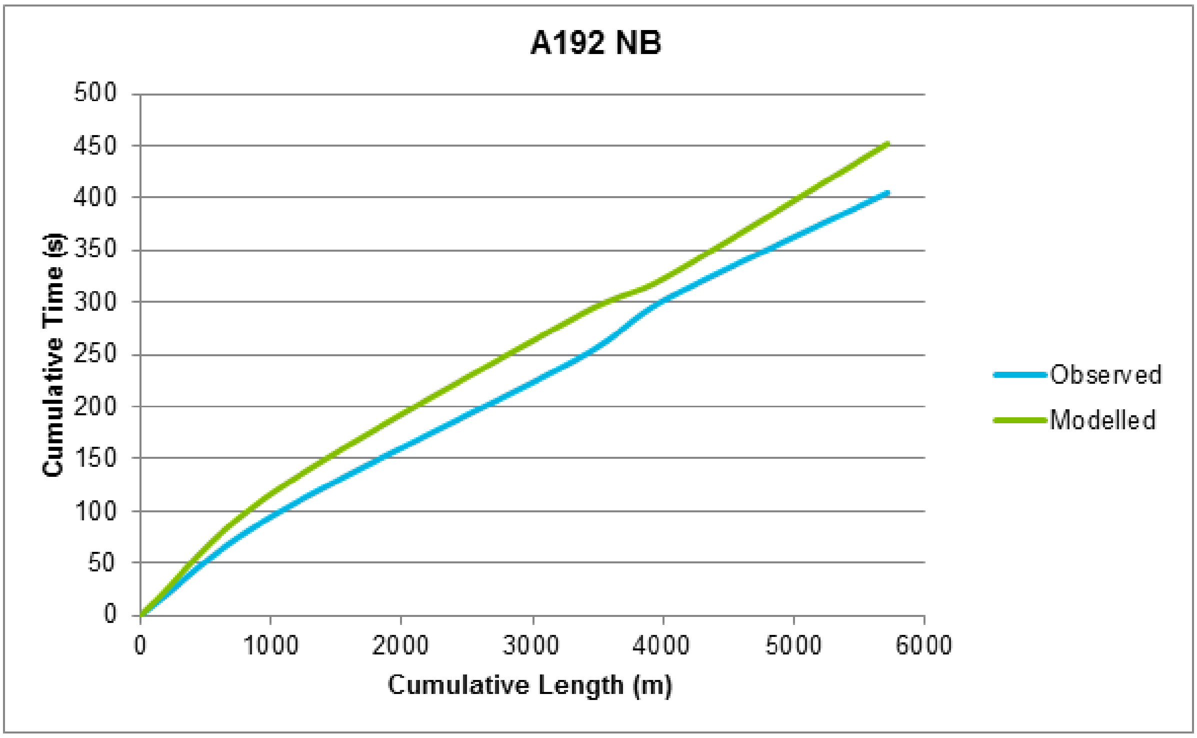


Figure 12-28. AM Journey Time Profile Graph: A192 SB

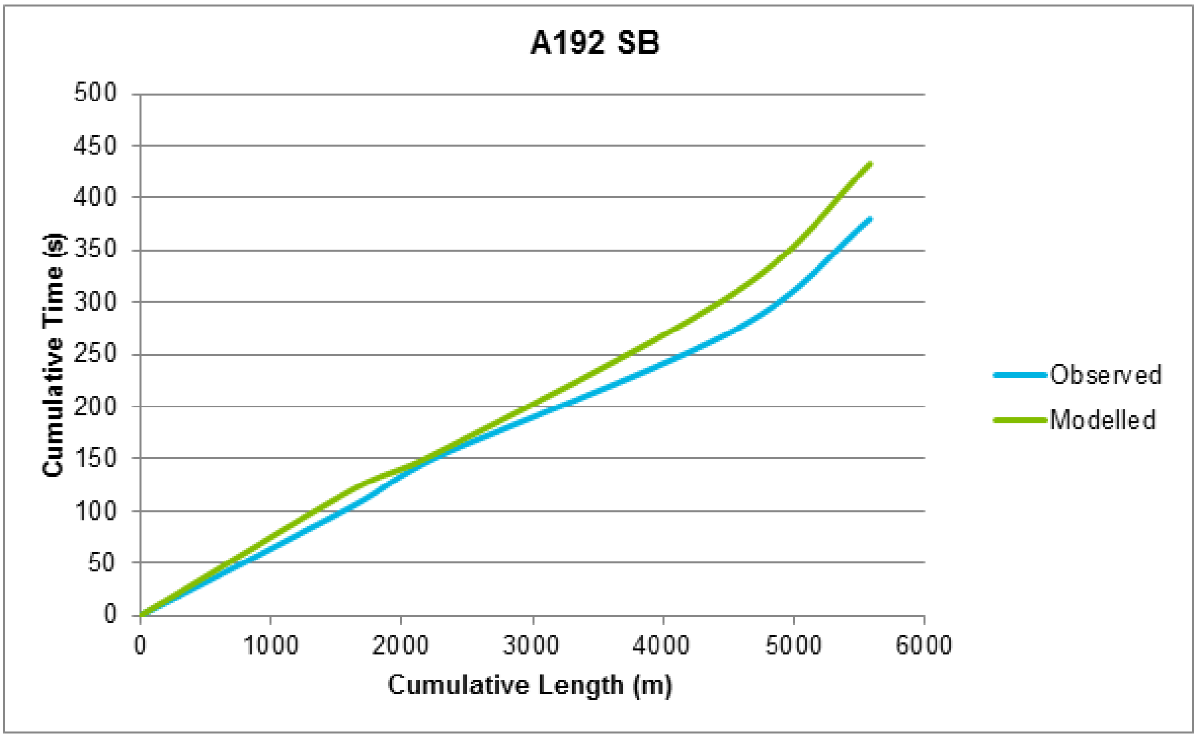


Figure 12-29. IP Journey Time Profile Graph: A193 NB

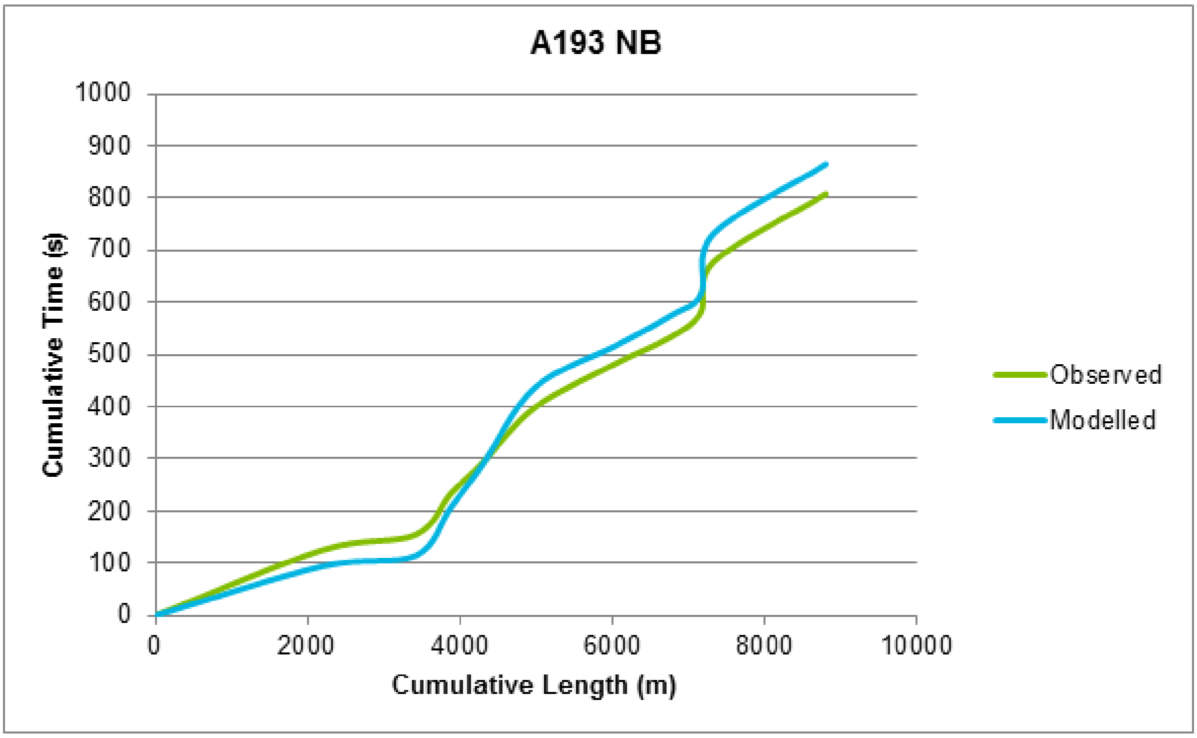


Figure 12-30. IP Journey Time Profile Graph: A193 SB

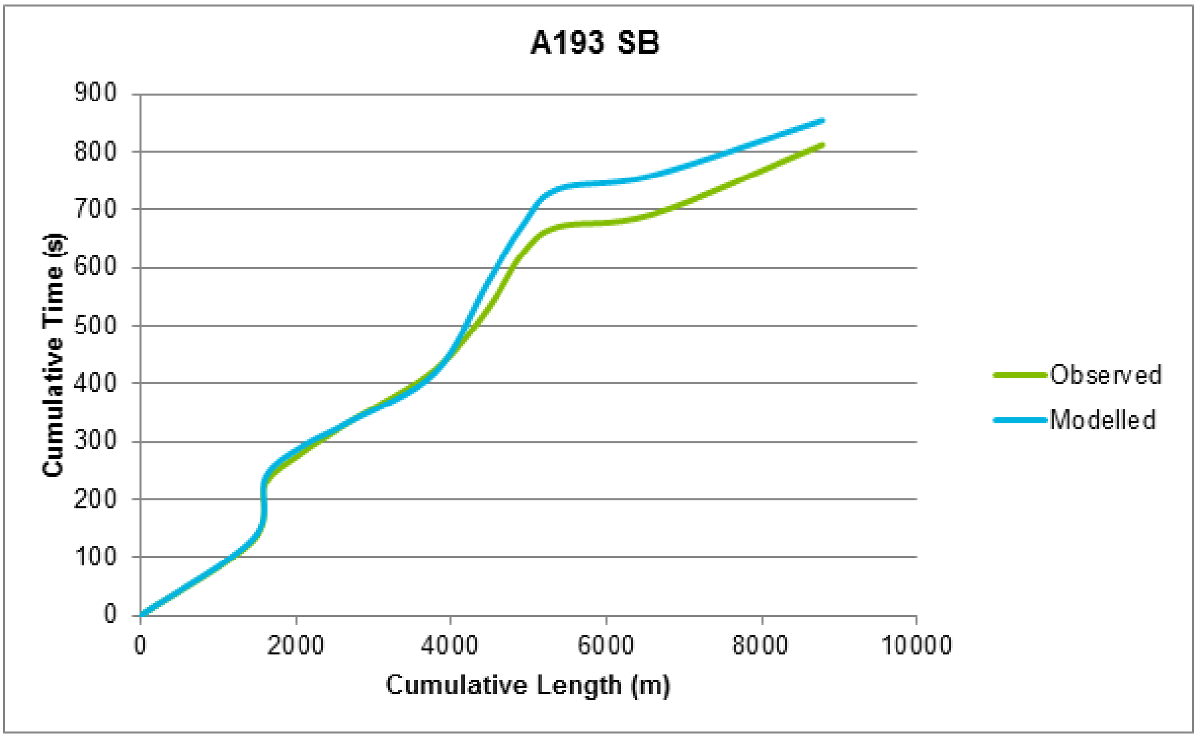


Figure 12-31. IP Journey Time Profile Graph: A189 NB

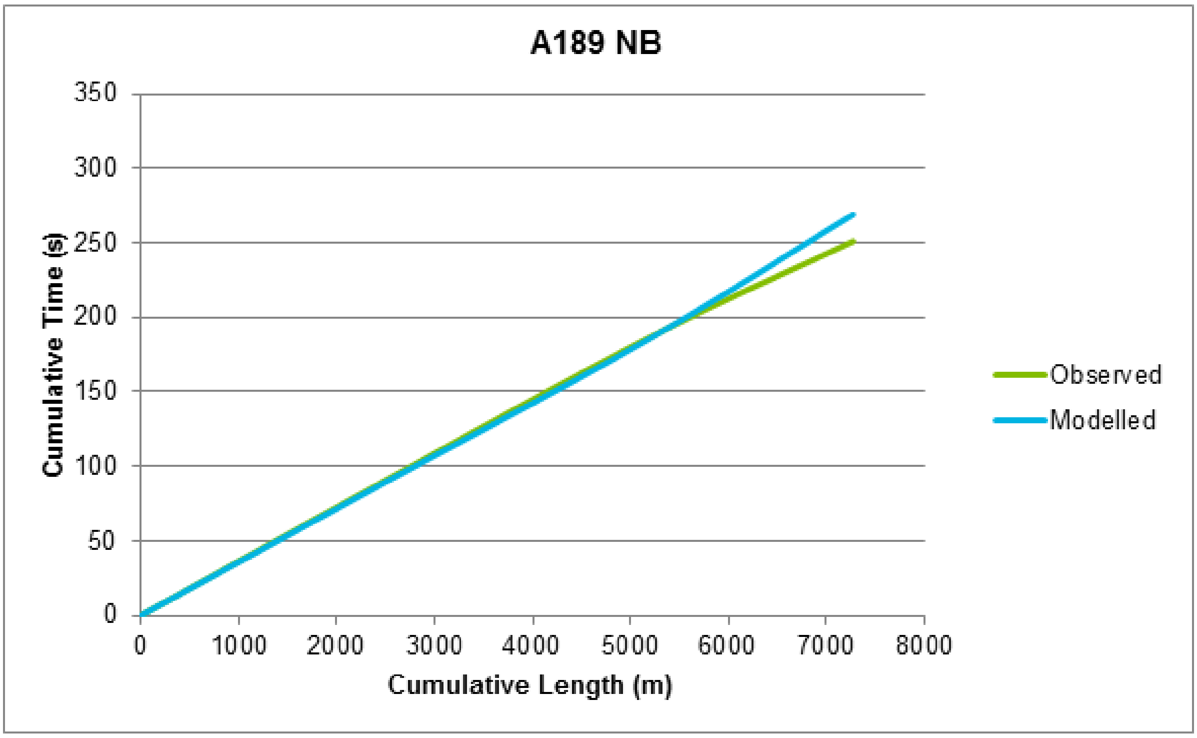


Figure 12-32. IP Journey Time Profile Graph: A189 SB

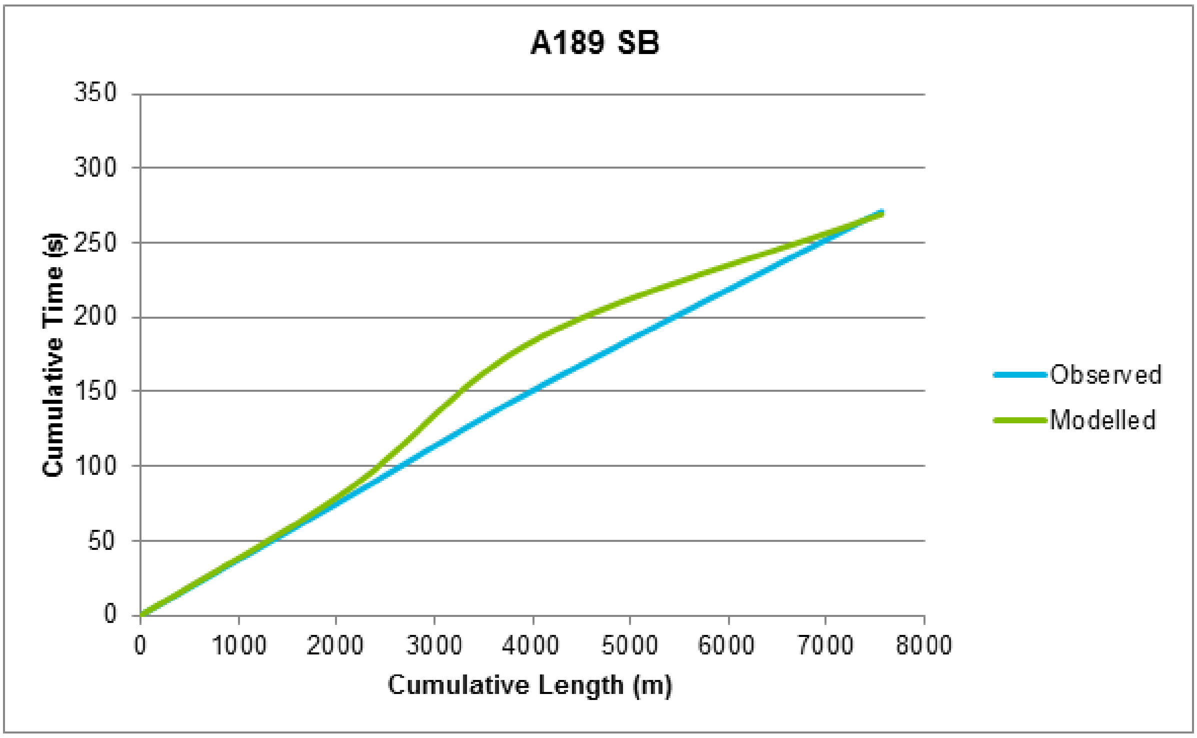


Figure 12-33. IP Journey Time Profile Graph: Laverock Hall Road SB

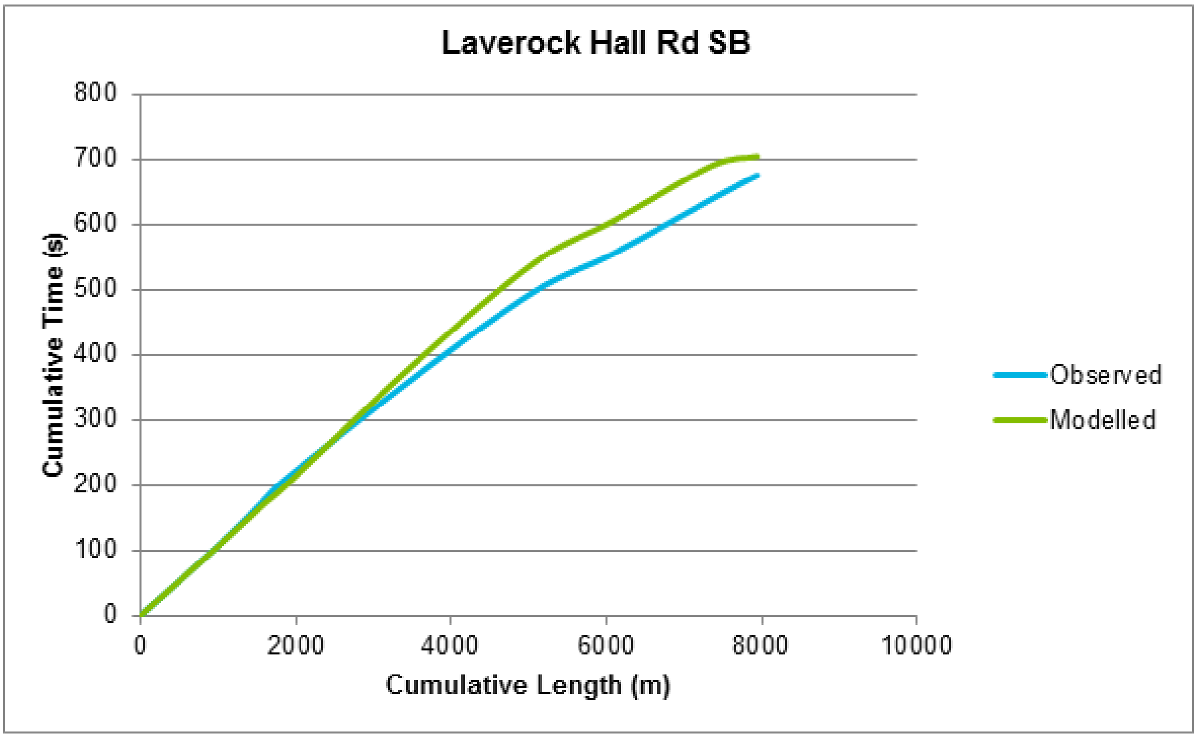


Figure 12-34. IP Journey Time Profile Graph: Laverock Hall Road NB

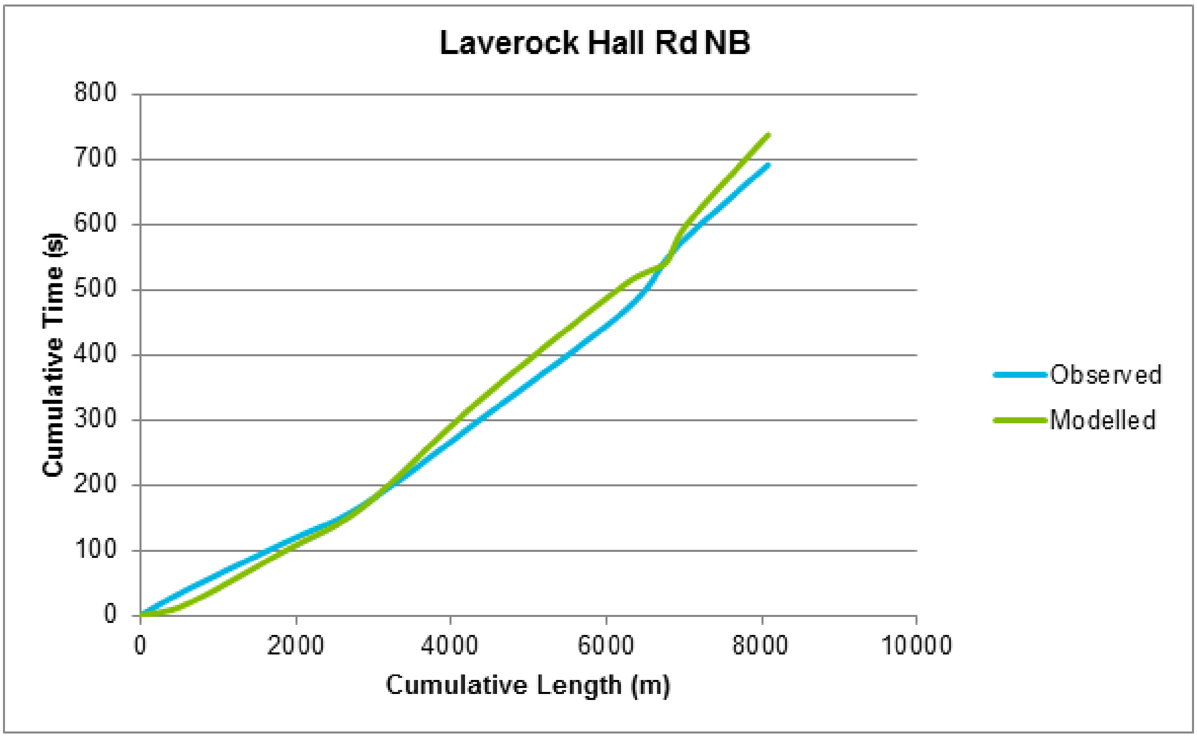


Figure 12-35. IP Journey Time Profile Graphs: Plessey Road NB

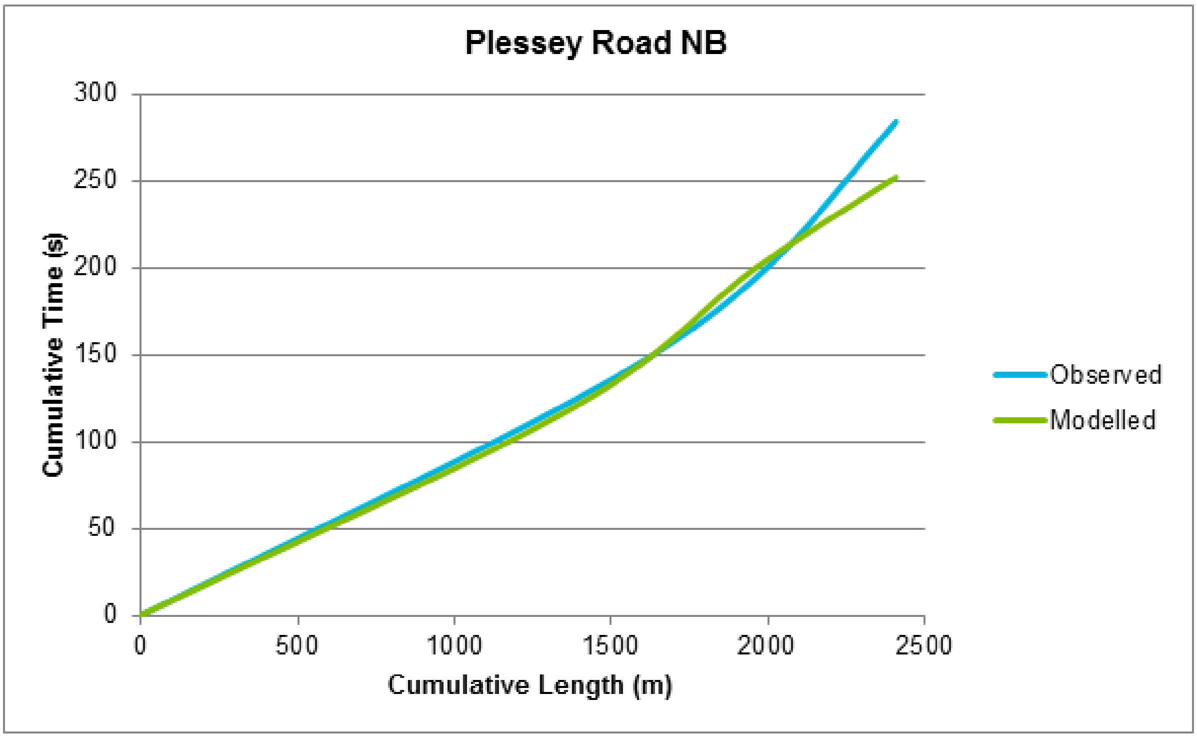


Figure 12-36. IP Journey Time Profile Graph: Plessey Road SB

Figure 12-37. IP Journey Time Profile Graphs: A192 NB

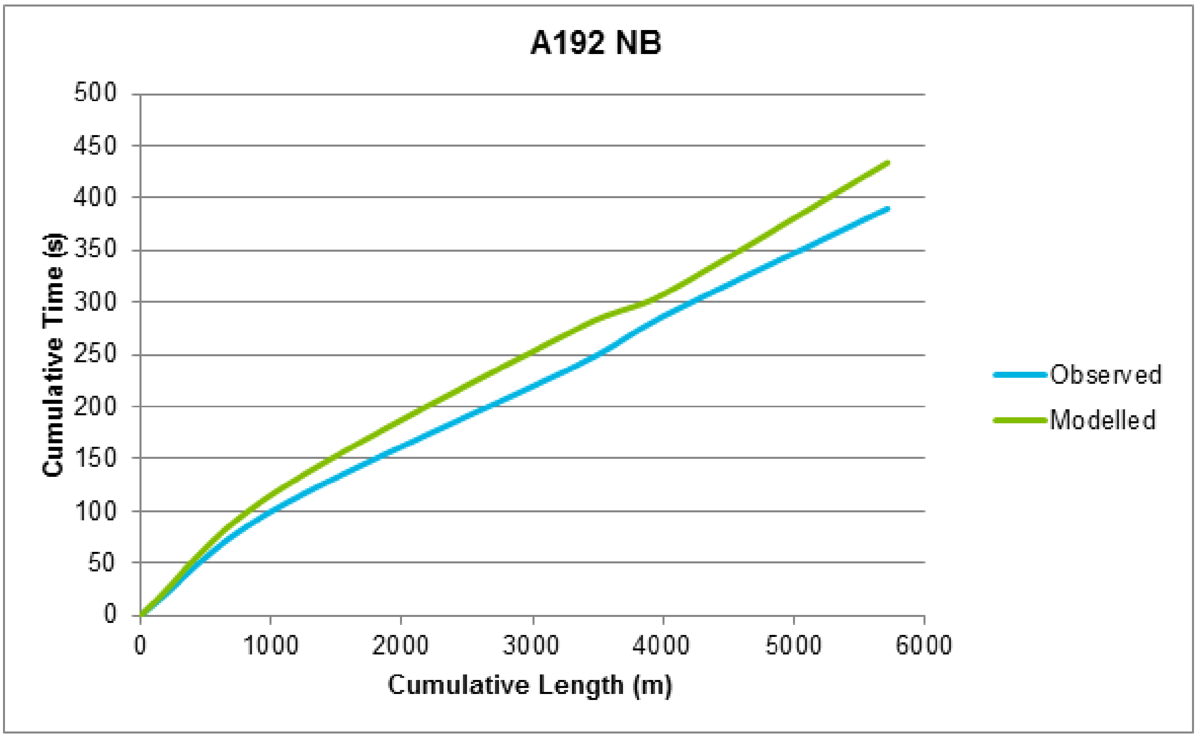


Figure 12-38. IP Journey Time Profile Graphs: A192 SB

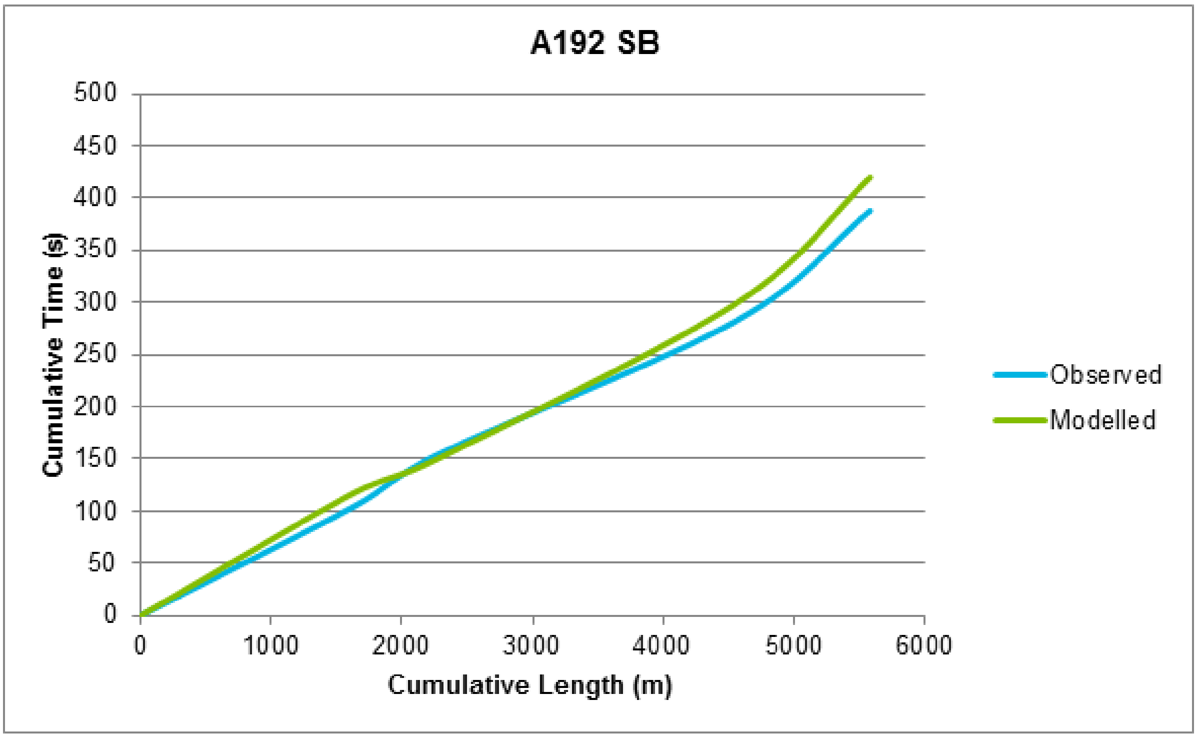


Figure 12-39. PM Journey Time Profile Graph: A193 NB

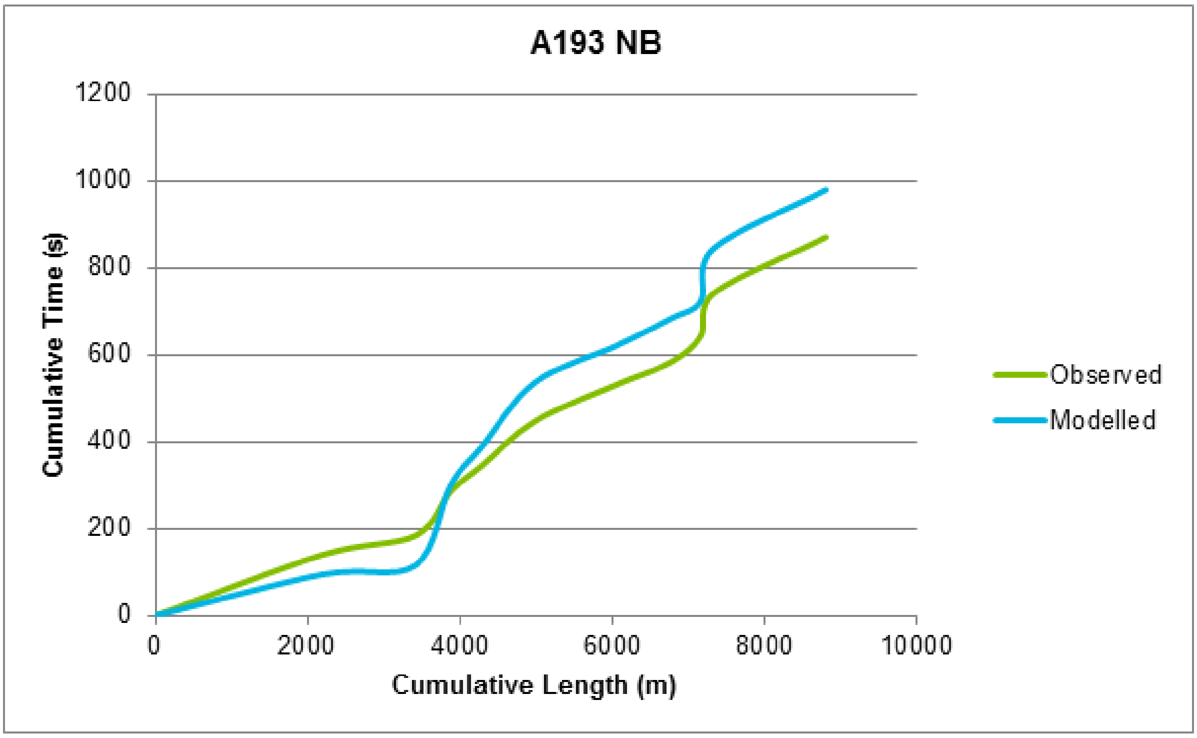


Figure 12-40. PM Journey Time Profile Graph: A193 SB

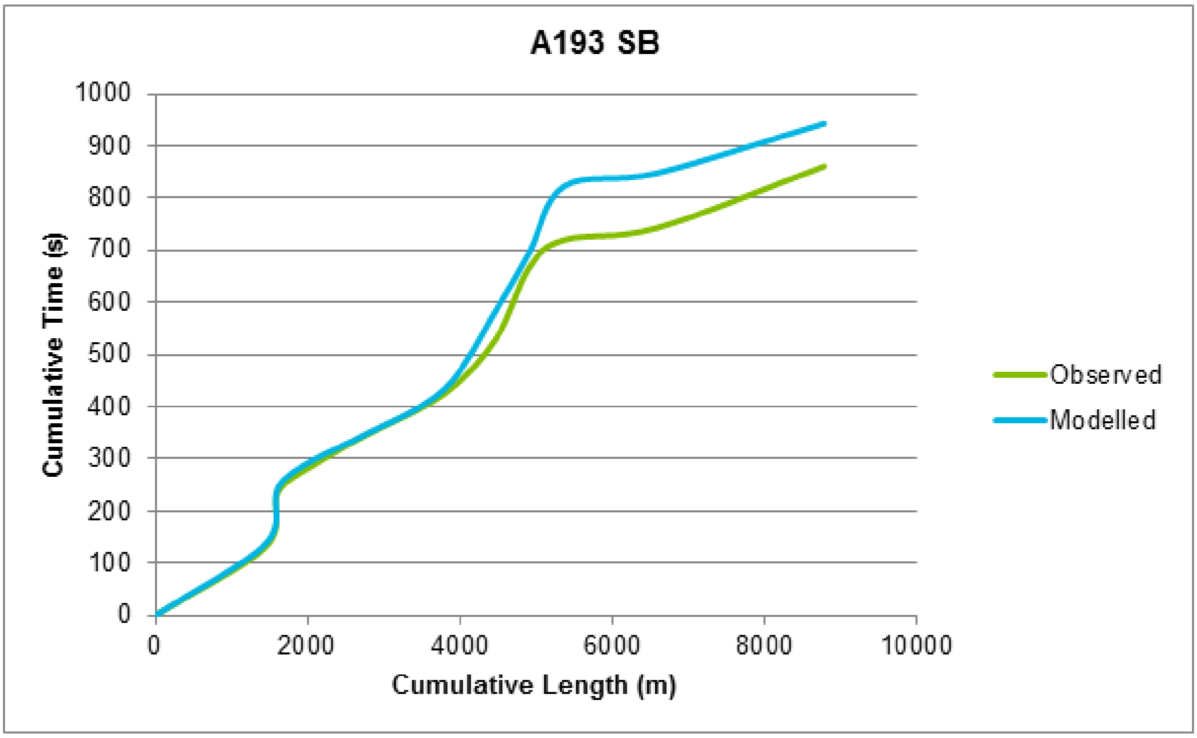


Figure 12-41. PM Journey Time Profile Graph: A189 NB

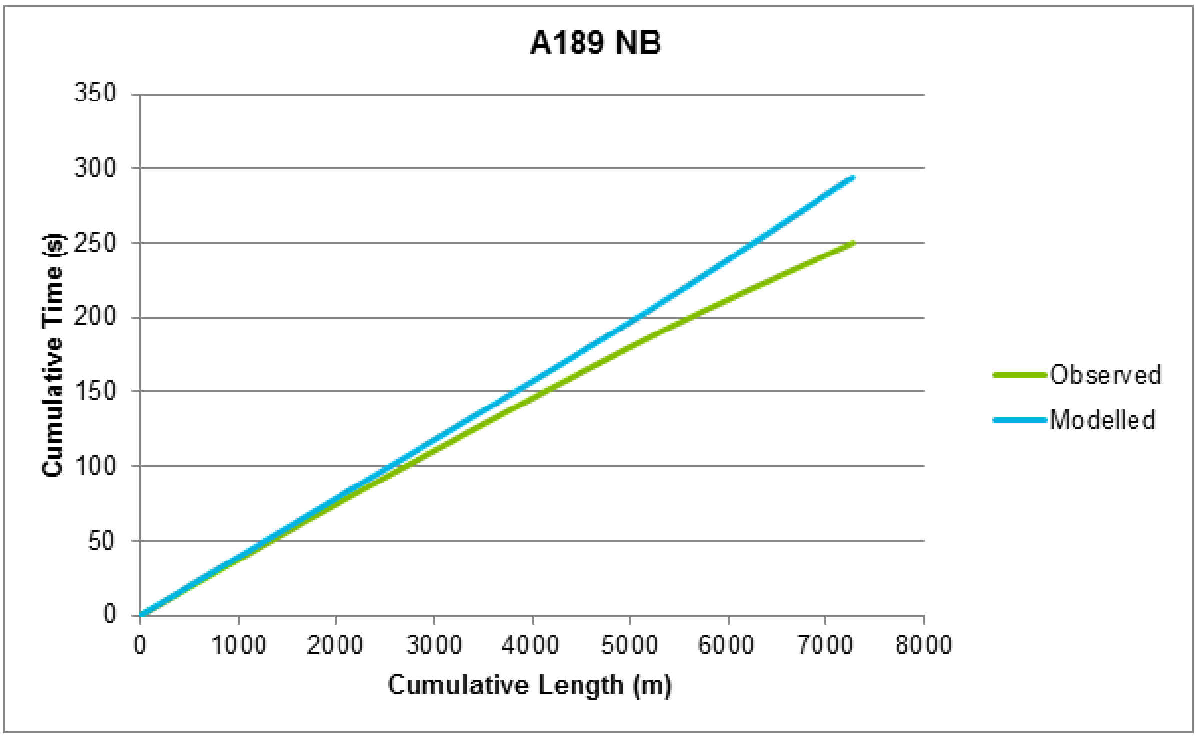


Figure 12-42. PM Journey Time Profile Graph: A189 SB

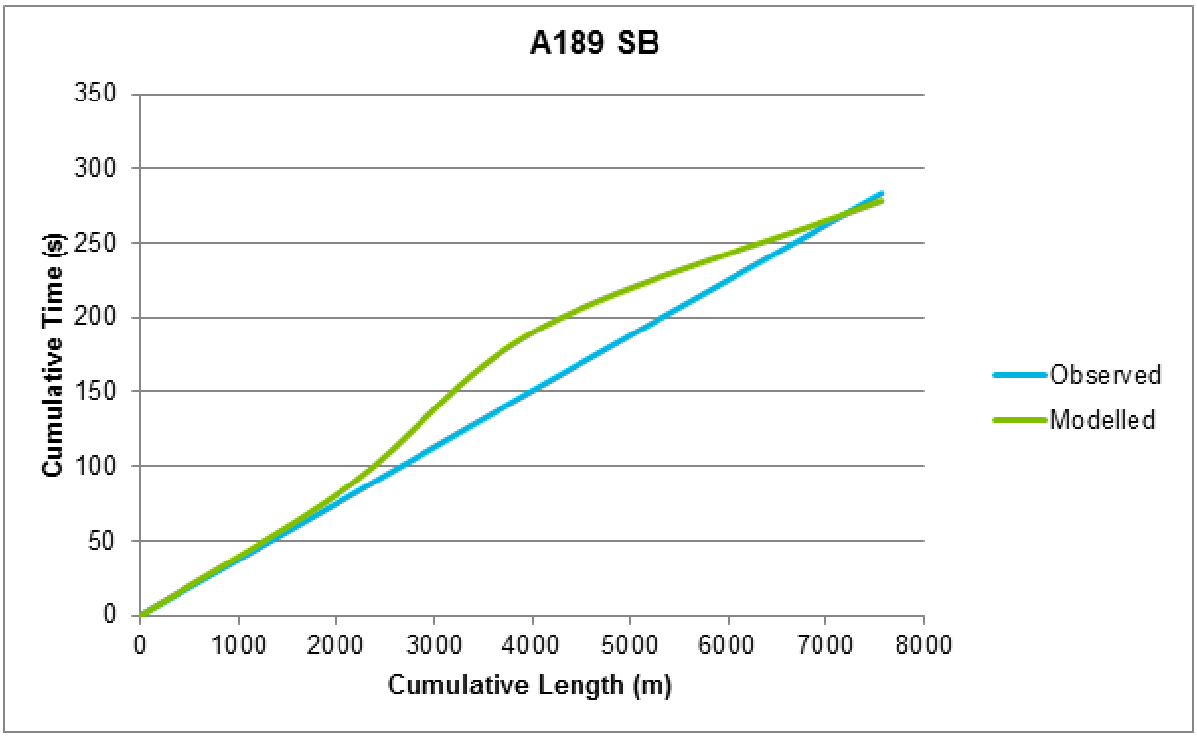


Figure 12-43. PM Journey Time Profile Graph: Laverock Hall Road SB

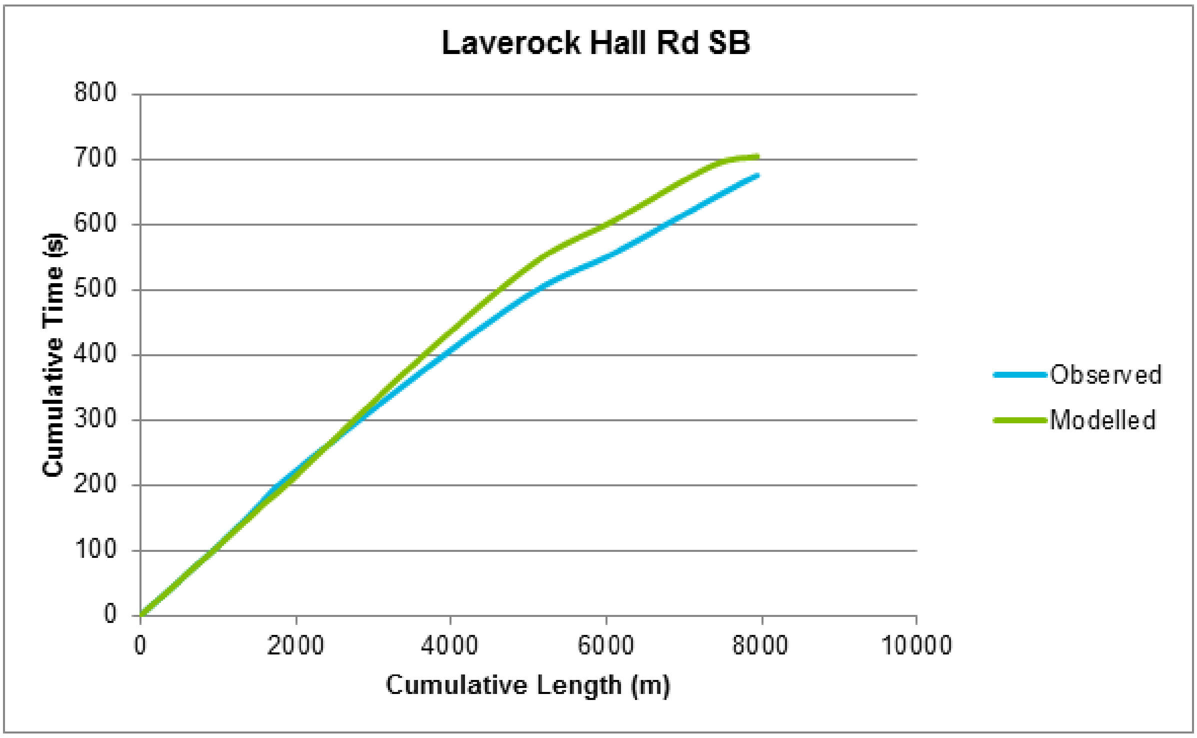


Figure 12-44. PM Journey Time Profile Graph: Laverock Hall Road NB

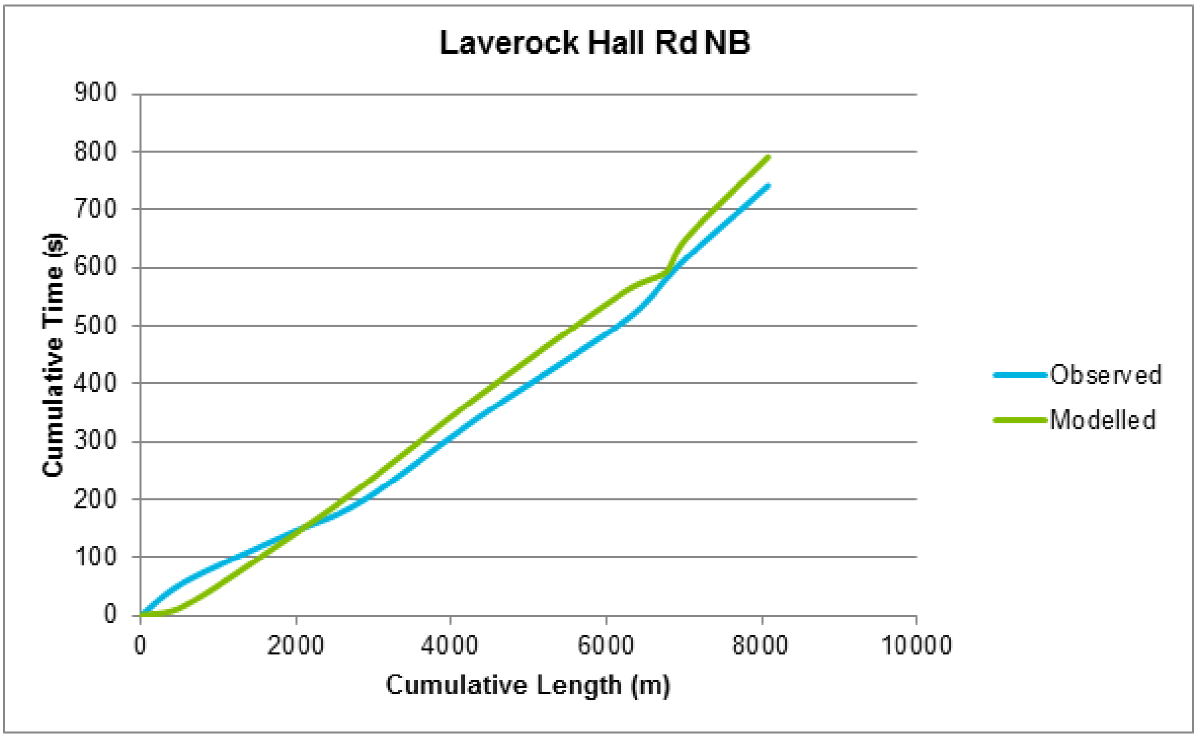


Figure 12-45. PM Journey Time Profile Graph: Plessey Road NB

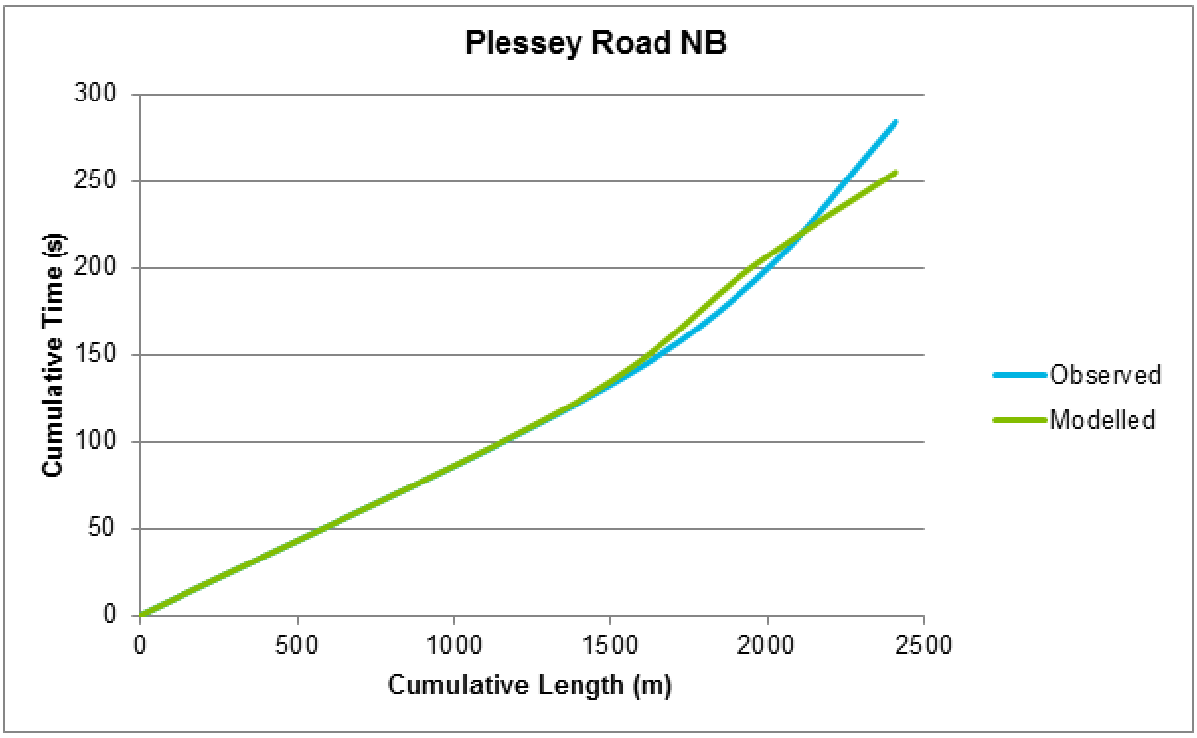


Figure 12-46. PM Journey Time Profile Graph: Plessey Road SB

Figure 12-47. PM Journey Time Profile Graph: A192 NB

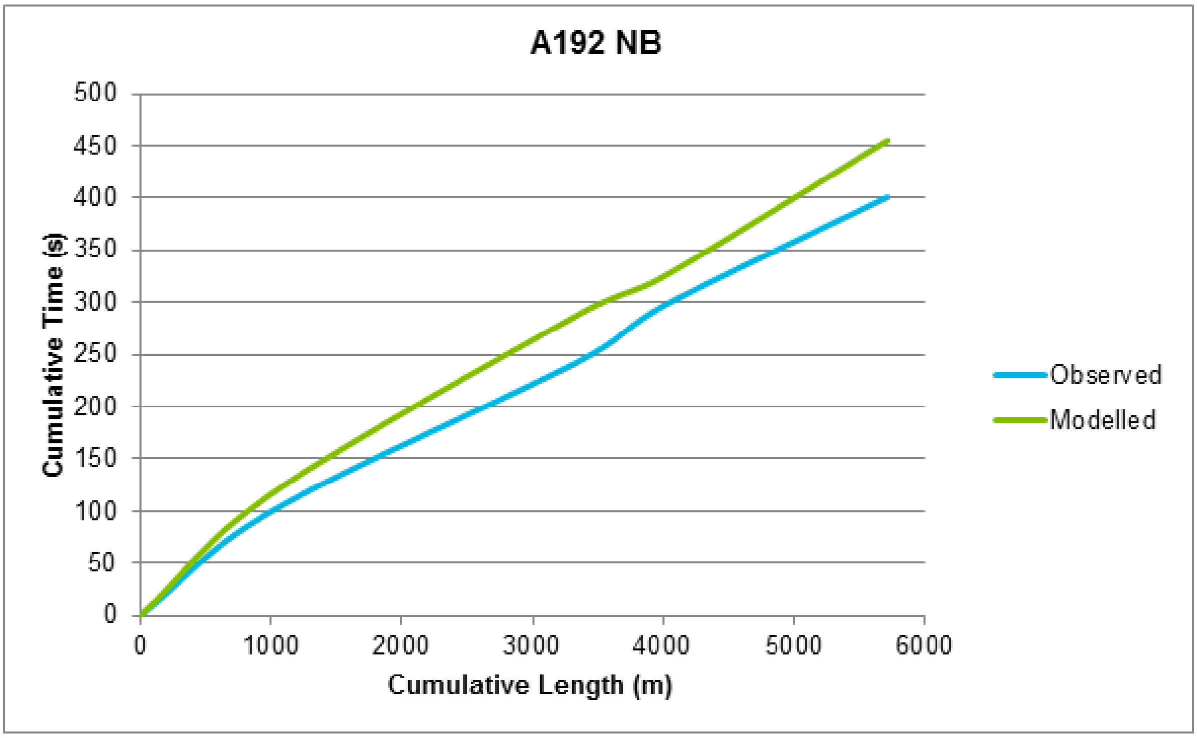
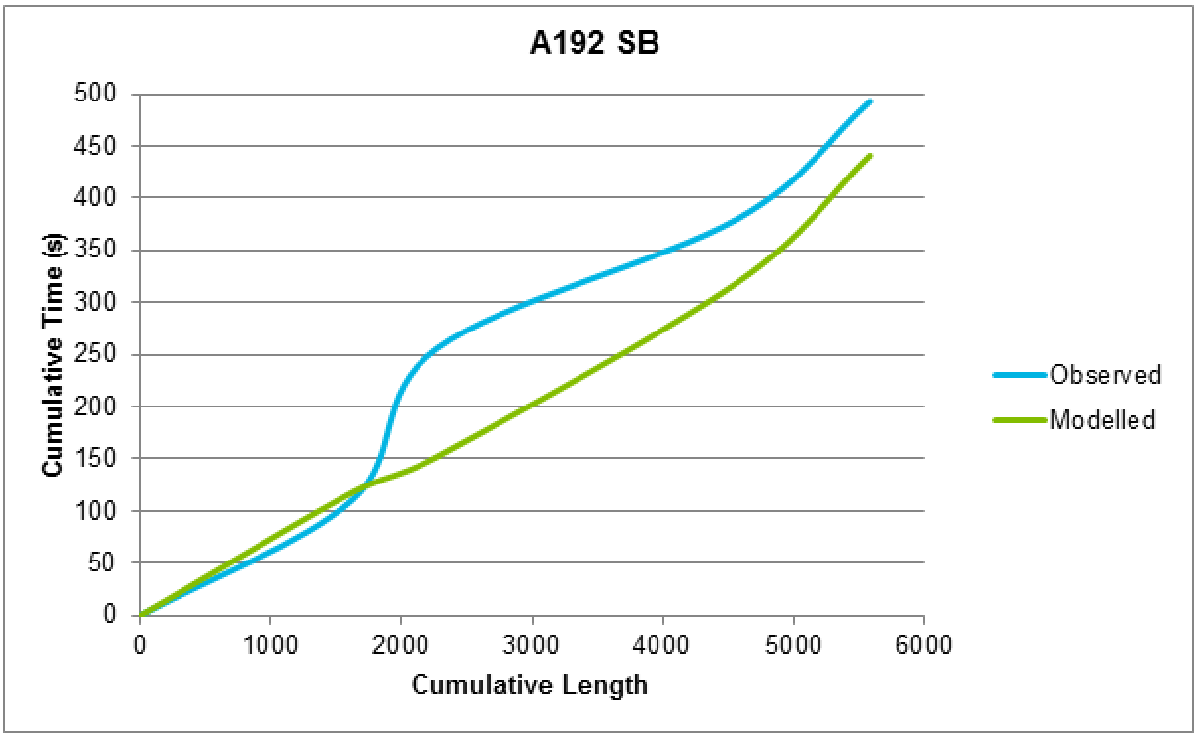


Figure 12-48. PM Journey Time Profile Graph: A192 SB



AECOM Limited
One Trinity Gardens
First Floor
Quayside
Newcastle-upon-Tyne
NE1 2HF
UK

T: +44 (191) 224 6500
aecom.com