Broughton Bypass Model

Local Model Validation Report

August 2015

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<tr><td colspan="2">Document Control Sheet</td><td colspan="2">BPP 04 F8
Version 17; July 2014</td></tr>
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Project: Broughton Bypass
Client: Lancashire County Council   Project No: B2237509
Document title: Local Model Validation Report
Ref. No: LMVR_03

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DATE	06/02/15	Document status Draft for client review

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DATE	13/03/15	Document status Final

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DATE	18/08/15	Document status Final following independent assurance

Contents

1 Introduction

1.1 Scheme Overview

The proposed scheme is a bypass around the village of Broughton which lies on the busy A6, three miles north of Preston.

This section of the north-south running A6 (known as Garstang Road), experiences severe peak hour traffic congestion between Station Lane, Newsham; Broughton Crossroads and Junction 1 of the M55 motorway, a total distance of approximately 2.6km or 1.7 miles. Journey times along the west-east running Whittingham Lane to Broughton Crossroads also suffer from significant peak hour delay over a distance of 1.4km or 0.9 miles. The environmental and social impacts of this congestion on the residential area of Broughton are compounded by the narrow width of the A6 road as it runs through the village which limits the scope for online improvements.

The high annual mean levels of nitrogen dioxide (NO_2) attributed to vehicle emissions in the village led to Broughton's designation as an Air Quality Management Area (AQMA). As a result of the impact of A6 traffic on the village and surrounding areas which use Broughton as a community centre, Lancashire County Council (LCC) has been promoting a bypass solution to remove through traffic since 1986.

Planning permission for the construction of a Broughton Bypass was first granted in July 2001. Due to the five year time limit under the Town and Country Planning Act and a lack of funding to materially construct the scheme at that time, the local authority had to reapply for renewals every five years. LCC last successfully resubmitted the planning application in July 2013.

The 2013 planning application was largely informed by an Environmental Statement which used outputs from the Broughton Transport Model, a strategic traffic model which was constructed in early 2013. The agreed methodology for construction of this model was that it should be proportionate to the timescale of the project and the purpose of planning permission scrutiny.

As part of the planning application, a non-technical summary was produced, which detailed alternative options to mitigate the problem. These were:

- *On-line improvements to the A6 Garstang Road*
- *Park and Ride facility in the Broughton Area*
- *New junction on the M6 in the Garstang/Brock area*
- *Bypass of Broughton to the west of the village*
- *A bypass to the east of the village close to the primary school and Marriott hotel*

The alternative options were discarded in favour of the proposed scheme comprising a bypass to the east of the village. More information on the alternative options is provided in the 2013 planning application and an April 2012 Options Study Report, available on the Lancashire County Council website.

In March 2014, LCC advised that a Business Case for Broughton Bypass was to be submitted to Transport for Lancashire (TfL) and / or Department for Transport in

2015 in order to access devolved local major transport scheme funding (now Local Growth Fund) which had been indicatively allocated subject to a DfT compliant business case demonstrating the scheme offers value for money. In order to support the business case, the Broughton Transport Model (used to inform the planning application re-submission and subsequent approval) needed updating to ensure it was in line with current best practice contained within the DfT's web based Transport Appraisal Guidance known as WebTAG.

The process proposed to update the model was detailed in an Appraisal Specification Report (ASR), issued to LCC in June 2014.

This report outlines the work undertaken in producing a WebTAG compliant Broughton Transport Model, required to ensure a robust appraisal of the scheme.

1.2   Report Structure

The remainder of this report is set out as follows:

Chapter 2- *Details the uses of the model and key design considerations*
Chapter 3- *Identifies the standards to which the model was built*
Chapter 4- *Describes the key features of the model*
Chapter 5- *Details the data used for model calibration and validation*
Chapter 6- *Describes the processes used in developing the modelled network*
Chapter 7- *Describes the processes used in developing the modelled demand (i.e. trip matrices)*
Chapter 8 – *Details the network calibration and validation*
Chapter 9 – *Describes the route choice calibration and validation*
Chapter 10 – *Provides information on the calibration and validation of the trip matrices*
Chapter 11 – *Details the calibration and validation of the assignment*
Chapter 12 – *Provides a summary of the model and its development*

2 Proposed Uses of the Model and Key Model Design Considerations

2.1 The bypass scheme

A preferred route for a bypass scheme around Broughton has been in place since 1992 and the planning application was resubmitted and reapproved in 2013. The proposed scheme is intended to address a number of issues in the local Broughton area, as illustrated below:
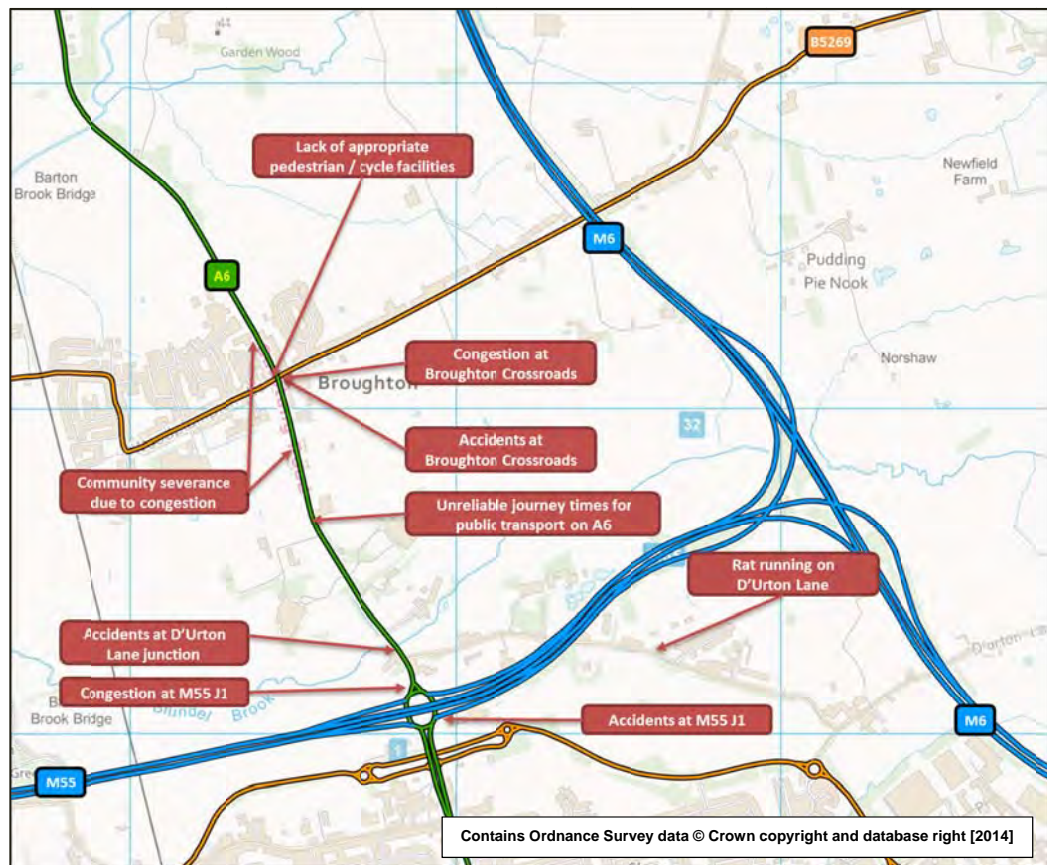
Figure 2-A   Local Traffic Issues

These issues are described in a number of other documents including:

- *Central Lancashire Highway and Transport Masterplan*
- *Preston, South Ribble and Lancashire City Deal*
- *North West Preston Strategic Masterplan*

In addition to the bypass, two other schemes were proposed which have recently been completed: M55 junction 1 improvements; and M6 J32 (Broughton Interchange) northbound widening. The alignment of the proposed bypass and the location of other recent improvements of relevance to the scheme are illustrated overleaf:
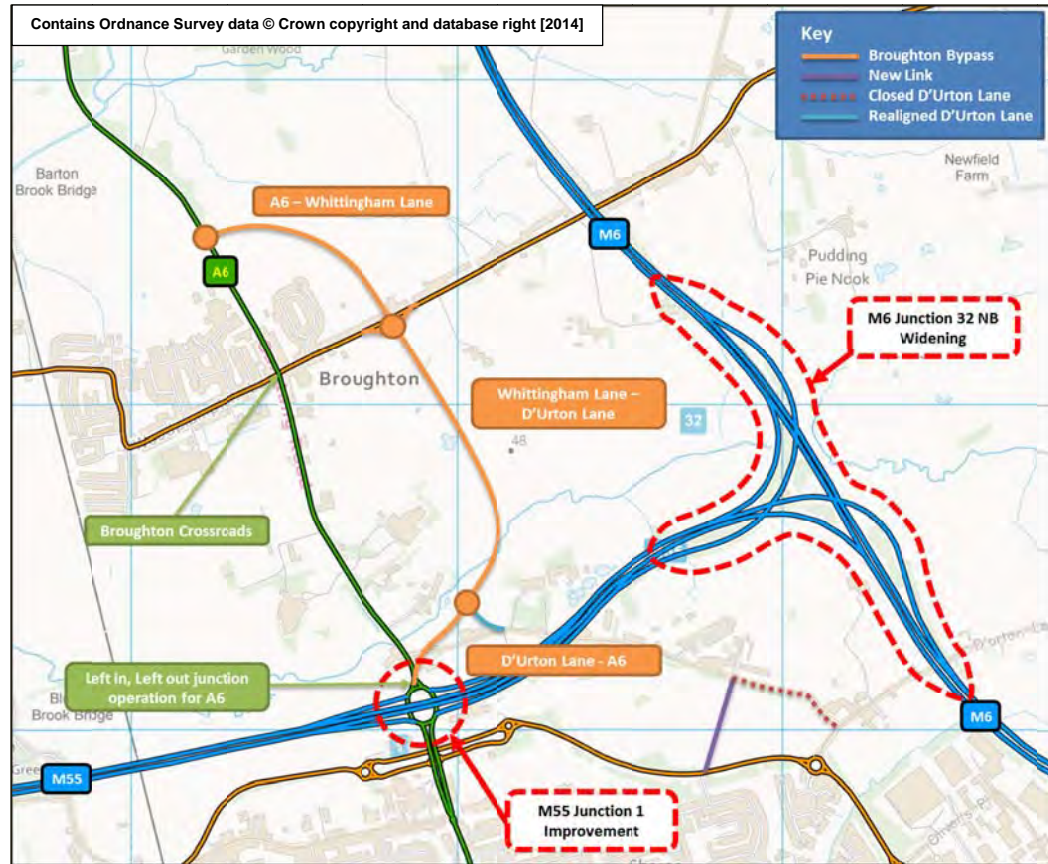
Figure 2-B   Proposals for Broughton Bypass

The bypass is to be constructed on the east side of the village. From north to south it can be considered to have three sections:

- From A6 Garstang Road north of Broughton to Whittingham Lane;
- From Whittingham Lane to D'Urton Lane; and
- From D'Urton Lane to A6 Garstang Road just north of M55 Junction 1.

The bypass is scheduled to open in 2017 and will have a speed limit of 40mph. The sections between Whittingham Lane and D'Urton Lane, and D'Urton Lane and A6 Garstang Road are dual carriageway, and the remaining section to the north between Whittingham Lane and the A6 is single carriageway. Roundabout junctions are provided along the bypass with the exception of the southern tie in which is a left in left out priority junction.

D'Urton Lane has been realigned at its western end to tie in with the bypass. D'Urton Lane is also closed to vehicular traffic close to the junction with the section of D'Urton Lane that leads to Haighton Green Lane. A link is to be provided from D'Urton Lane to Eastway through the proposed development site, though this link will not open until after the opening year of the bypass.

The existing A6 through Broughton will be reduced in speed limit from 40mph to 30mph.

The M55 Junction 1 / A6 scheme aimed to improve the roundabout's performance by introducing full signal control to increase capacity and assist turning movements which previously added to delay at the junction. These improvements were completed in 2013.

The M6 J32 (Broughton Interchange) Northbound Widening scheme aimed to improve safety and reduce congestion on the northbound approach to Junction 32, which was particularly severe at weekends and bank holidays. The scheme involved widening the northbound M6 on the approach to the junction from 4 lanes to 5 lanes and within the junction from 2 lanes to 3 lanes. The junction format of the merge from the eastbound M55 would be altered from a lane gain to a standard slip road type merge layout. The M6 junction 32 improvements were completed in March 2015.

It is important to emphasise that these motorway schemes are not part of the scheme being assessed; only the Broughton Bypass scheme, indicated in orange in the above figure form the assessed scheme. They were included within the modelling as they are likely to have an influence on traffic using the bypass.

2.2   Land use developments

Several housing and employment land use developments are proposed for areas around Broughton and Preston as well as Garstang to the north. These developments are detailed under the relevant authorities' Local Plan, the Preston, South Ribble and Lancashire City Deal, and the Central Lancashire Masterplan. The locations of the proposed developments are illustrated below:
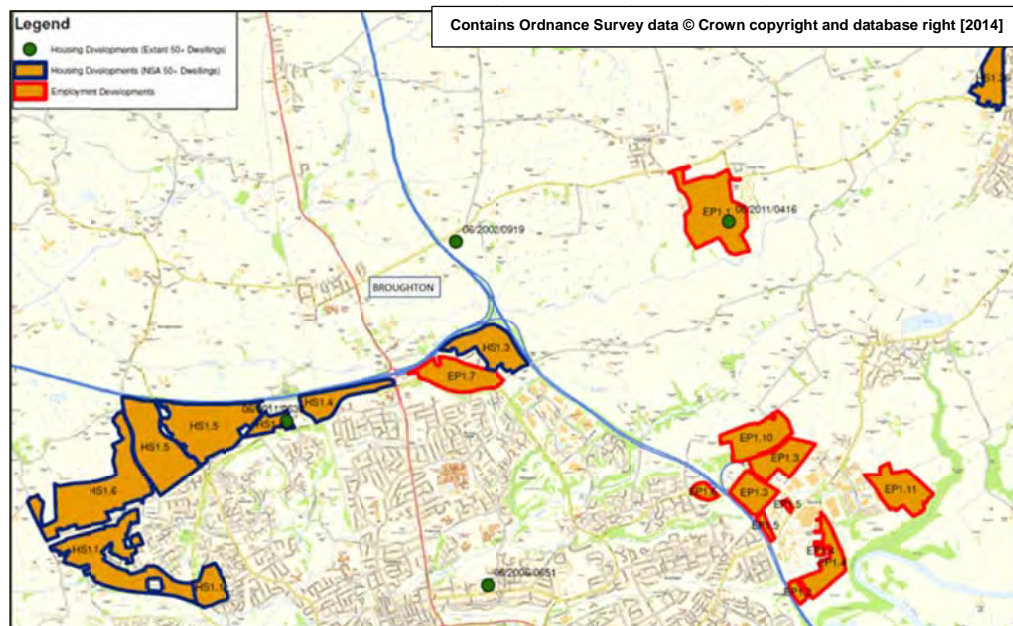
Figure 2-C   Developments around Broughton and Preston
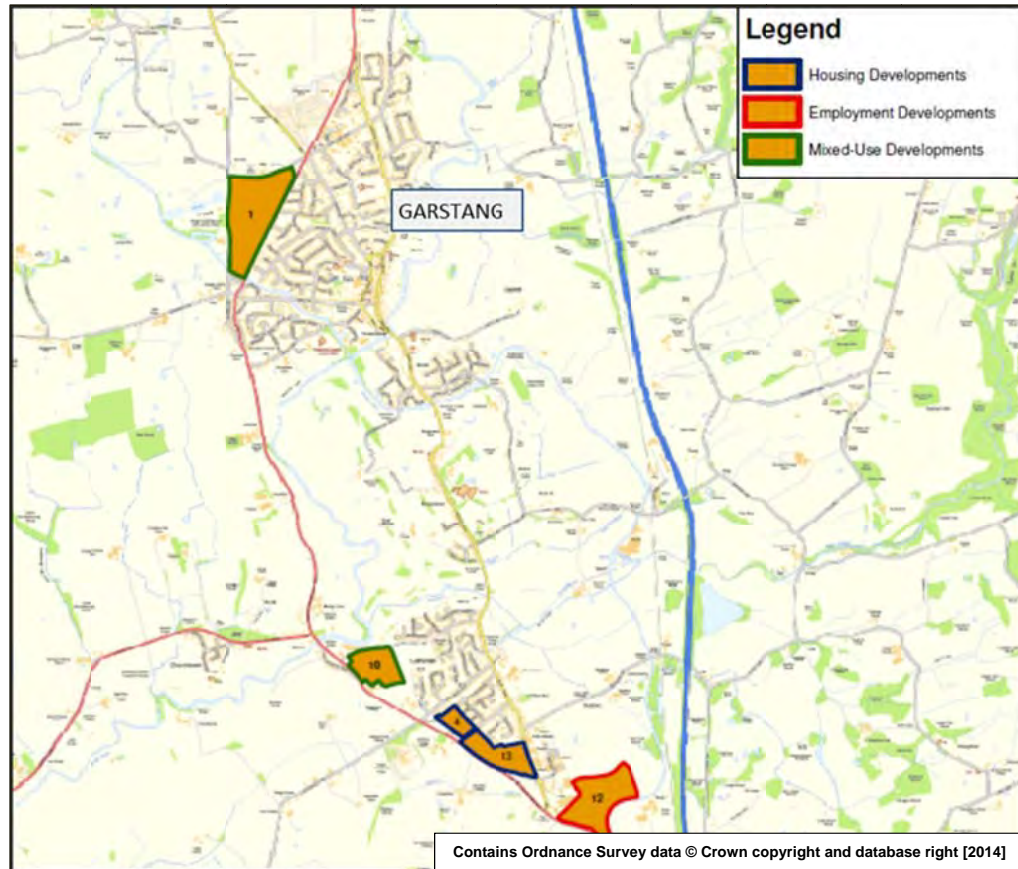
Figure 2-D   Developments around Garstang

Although it is not the intention that the model will be used for the sole purpose of testing development, it is important to ensure that the model is sufficiently well detailed to be able to model the impacts that these developments would have on the local road network. Baseline traffic conditions in the vicinity of these developments were required to be well represented in the model, as well as around the Broughton scheme itself.

It must be emphasised that none of the developments illustrated above are considered to be solely dependent on the bypass scheme. Within this context, the guidance on dependant development within TAG Unit A2.3 is noted, but not relevant.

2.3   Forecast Scenarios

Two forecast years will be modelled; the proposed bypass scheme opening year, which is 2017, and the scheme 'forecast year' set 15 years after that, i.e. at 2032.

Within each forecast year, two scenarios will be modelled, one with the scheme in place and one without the scheme.

For each forecast year, the specific inclusion of certain developments and infrastructure will be consistent with current expectations. For example, given that the M6 junction 32 proposals previously described are expected to be completed in 2015, the scheme will be present in both forecast years. The scheme does not form

part of the scheme being assessed, so it will therefore be included in both the 'with scheme' and 'without scheme' scenarios.

2.4   Key considerations

In order for the impacts of the bypass to be fully assessed it was considered important that the model accurately represented movements through Broughton and on north-south routes that would be affected by the bypass. More specifically it was necessary to ensure that movements on the A6 north of Preston, D'Urton Lane, Eastway, Lightfoot Lane and the interaction of these links with M55 J1, M6 J31a and the rest of the strategic road network were well represented.

Due to the changes at M55 J1, which were implemented in 2013, the modelled base year and data collection year was set as 2014. This ensured that any impacts during the construction phase of the scheme were excluded from the model, and the improvements to journey times brought about by the scheme were included in the model.

The model will be used to inform an economic assessment as part of the Outline Business Case for the scheme. To reflect the impact that the scheme has during the busiest parts of the day a morning peak and evening peak model was developed. The scheme is considered likely to also have an impact during less busy times of the day and therefore an average inter-peak hour was also required.

The key characteristics of the model can be described as in the table below:

Characteristic	Model approach
Model form	Highway Assignment Model
Software package	VISUM 13.0
Base year	2014
Time periods	AM peak (0800-0900), interpeak (average hour between 1000 and 1600) PM peak (1700-1800)
User classes	5 – Car Business, Car Commute, Car Other, LGV, HGV
Zone system	245 zones in model
Assignment methodology	"Assignment with ICA", including flow metering
Capacity restraint mechanism	Volume delay functions on links. Intersection Capacity Analysis (ICA) at junctions
Relevant guidance	WebTAG Unit M3.1

Table 2-A   Key model features

3 Model Standards

3.1 Validation Criteria and Acceptability Guidelines

The adequacy of the Broughton Transport Model to assess the bypass scheme was measured against the criteria set out in TAG Unit M3.1.

WebTAG guidance sets out measures to compare the base year model against observed independent data to quantify the level of fit. The validation of the highway assignment has been quantified using the following measures taken from WebTAG unit M3.1 paragraph 3.2.3:

- *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 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.*

Base matrix validation is defined as the differences between modelled and observed flows along screenlines within the model, the criteria to meet is set out in Table 3-A below.

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

Table 3-A Screenline Flow Validation Criterion

WebTAG specifies the following, within unit M3.1 paragraph 3.2.6:

- *Screenlines should normally consist of five or more links;*
- *The comparison of modelled and observed flows for screenlines containing high flow routes (such as motorways) should be presented both with and without such routes;*
- *The comparison should be presented separately for:*
    - *roadside interview screenlines;*
    - *other screenlines used as constraints in matrix estimation; and*
    - *screenlines used as independent validation.*
- *The comparison should be presented by vehicle type, i.e. for car, LGV and HGV traffic.*

It should be noted here that, as explained in section 11, given the relatively small study area, it was not possible to draw up screenlines consisting of more than five links, and that the screenlines actually used consisted of one to three links.

In addition to validation of total screenline flows, WebTAG Unit M3.1 also contains guidelines on the validation criteria for individual links or turning movements.

These criteria are detailed in Table 3-B presented below and include reference to the GEH statistic measuring the difference between modelled and observed flows. The GEH statistic is of the form:

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

where M is the modelled flow and C is the observed count.

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

Table 3-B   Link Flow and Turning Movement Validation Criteria

WebTAG guidance unit M3.1 paragraph 3.2.9 states that the above comparison of modelled and observed flows should be presented for total vehicle flows and for car flows, but not for LGV and HGV flows due to there being insufficient accuracy in the individual link counts for these vehicle types. In addition the above information should be presented by time period and applied to link flows.

Data collection sites used in the validation of the base year, as well as those sites used in the development of the base year model are presented within sections 11 and 5 respectively.

WebTAG also contains acceptability guidelines for the validation of journey times. The acceptability criterion for journey time validation is given below.

Criterion	Acceptability Guideline
Modelled times along routes should be within 15% of surveyed times, or 1 minute if higher	> 85% of routes

Table 3-C   Journey Time Validation Criterion

Independent validation as specified above quantifies the ability of the model to replicate base year travel conditions within the model area. To ensure these conditions have a sound basis WebTAG provides guidance as to the acceptable changes to the highway 'prior' matrices that should result from the application of matrix estimation. These have been reproduced below.

Measure	Significance Criteria
Matrix zonal cell values	Slope within 0.98and 1.02 Intercept near zero R^2 in excess of 0.95
Matrix zone 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%

Table 3-D   Significance of Matrix Estimation Changes

WebTAG Unit M3.1 paragraph 8.3.15 states that all exceedances of the above should be noted and assessed as to their importance to assess the scheme. In addition paragraph 8.3.15 further states that the independent validation of the model as set out in Table 3-A, Table 3-B, and Table 3-C, should not be achieved at the expense of matrix estimation as presented in Table 3-D. WebTAG states that a lower level of validation be reported.

3.2 Convergence Criteria and Standards

In order for the outcomes of the modelling to be reliable, the stability of the modelled flows needed to be confirmed. This ensures that when modelling the scheme, any flow changes which occur do so directly as a result of the scheme, rather than as a result random flow changes due to poor convergence. In addition the model should converge to a point in which routes obey Wardrop's First Principle of Traffic Equilibrium which unit M3.1 paragraph 2.3.7 defines as:

"Traffic arranges itself on networks such that the cost of travel on all routes used between each OD pair is equal to the minimum cost of travel and all unused routes have equal or greater cost."

This relates to how close the model is to a particular converged solution, which varies depending on the preferences of the user or software package being used. In VISUM this equates to how close the model is to Wardrop's Principle of Equilibrium and is measured using the Gap function. Gap (denoted δ) is calculated below:

$$\sigma = \frac{\sum T_{pij}(C_{pij} - C_{ij}^*)}{\sum T_{ij}C_{ij}^*}$$

where:

T_{pij}	is the flow on route p from origin i to destination j
T_{ij}	is the total travel from i to j
C_{pij}	is the (congested) cost of travel from i to j on path p
C_{ij}^*	is the minimum cost of travel from i to j

Source: WebTAG Unit M3.1 paragraph C.2.4

The gap value therefore represents the excess cost incurred by failing to travel on the route with the lowest generalised cost and is expressed relative to that minimum route cost. The excess cost is summed over each route between each O/D pair and multiplied by the number of trips between each O/D pair. This is divided by the minimum cost summed over each route between each O/D pair, also multiplied by the number of trips between each O/D pair.

For the model to be considered sufficiently well converged, the gap value must be less than 0.1%.

WebTAG describes other measures for assessing the model convergence, as detailed in the table below:

Measure of Convergence	Base Model Acceptable Values
Delta and %Gap	Less than 0.1% or at least with convergence fully documented and all other criteria met
Percentage of links with flow change < 1%	Four consecutive iterations greater than 98%
Percentage of links with cost change < 1%	Four consecutive iterations greater than 98%

Table 3-E   WebTag Convergence Measures

Within the model, the "Assignment with ICA" methodology will be used. This assignment methodology is described in more detail in section 4.7. As described in that section, VISUM does not generate outputs consistent with the WebTAG guidance. As a result, the amount of queuing in the models between each iteration has been used as an indicator of the model's stability.

4 Key Features of the Model

4.1 Fully Modelled Area and External Area

As outlined in Section 2, the primary purpose of the Broughton Transport Model will be the assessment of the impact on traffic of construction of a bypass on the eastern side of the village. Therefore, the key feature as outlined will be the accurate reflection of the current trip movements through the village, and modelling these trip lengths in full.

The following are longer distance strategic re-routing considered likely to occur due to Broughton Bypass, based on professional judgment:

- to the north traffic from north of Garstang a change from M6 J33 to travelling south to M55 J1;
- to the north traffic from Garstang and south changing from alternative parallel rat runs to using the A6 and the bypass to access Preston; and
- to the east traffic from Whittingham and Longridge changing from Haighton Green Lane and Longridge Road to access Preston and the motorway respectively now using the bypass to access M55 J1.

This is shown overleaf.

Contains Ordnance Survey data © Crown copyright and database right [2014]
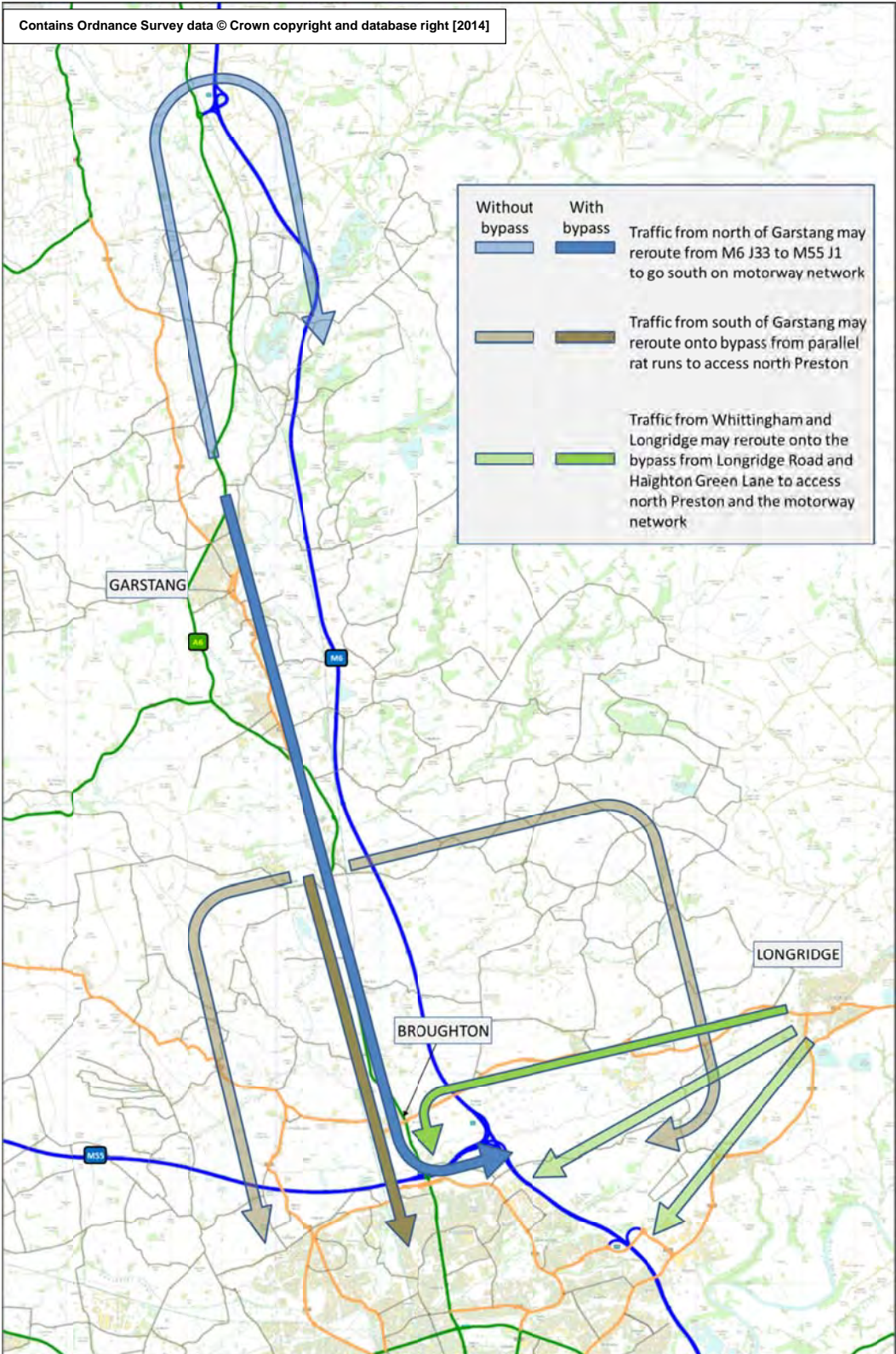
Table 4-A   Possible Longer Distance Re-routing due to bypass

In line with latest WebTAG Unit M3.1 guidance, the proposed network for the Broughton Transport Model will make use of a three stage structure with levels of detail reducing away from the centre of the study area. The breakdown of the proposed network structure is outlined below:

- Fully modelled area:
  - *Area of detailed modelling (Detailed); and*
  - *Rest of fully modelled area (ROFMA).*
- External Area.

The area of detailed modelling is characterised by where the level of impact from the scheme is certain and significant and, as such, the detail within the network and demand matrices is at its greatest. The rest of the fully modelled area is where the level of detail is not as great but capacity restraint is still modelled, and the external area is where the level of detail is at its lowest.

The external area of the model needs to include any commuter trips which may be impacted by any schemes being tested by the model. The area defined should be representative of any trips directly to and from the fully modelled area, but also be mindful of those trips which may pass through the fully modelled area and thus be impacted by the scheme.

The three tier structure is shown below.

Contains Ordnance Survey data © Crown copyright and database right [2014]
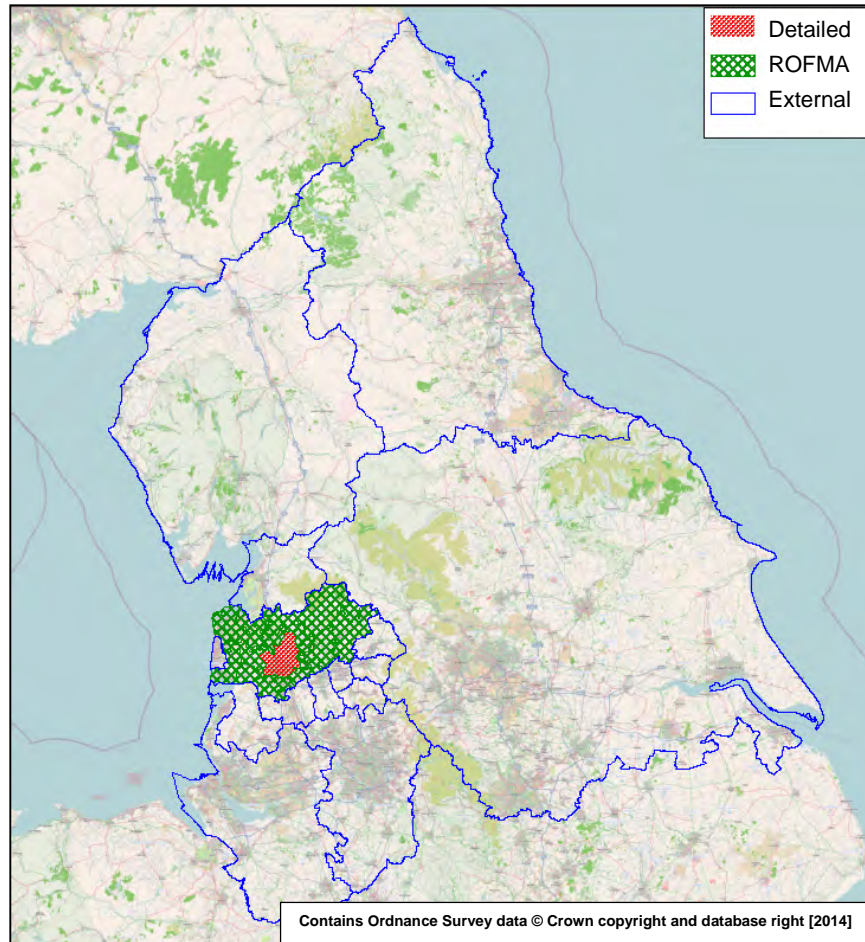
Figure 4-A   Three tier model structure

Note that in addition to the area shown above, the model was also extended to include all of the rest of Great Britain.

The level of detail required in the vicinity of the proposed scheme's location was informed by the previous modelling work, and designed to pick up the secondary re-routing impacts of the bypass, for the purposes of a robust economic appraisal. The area of greatest model detail is illustrated by the pink area below:
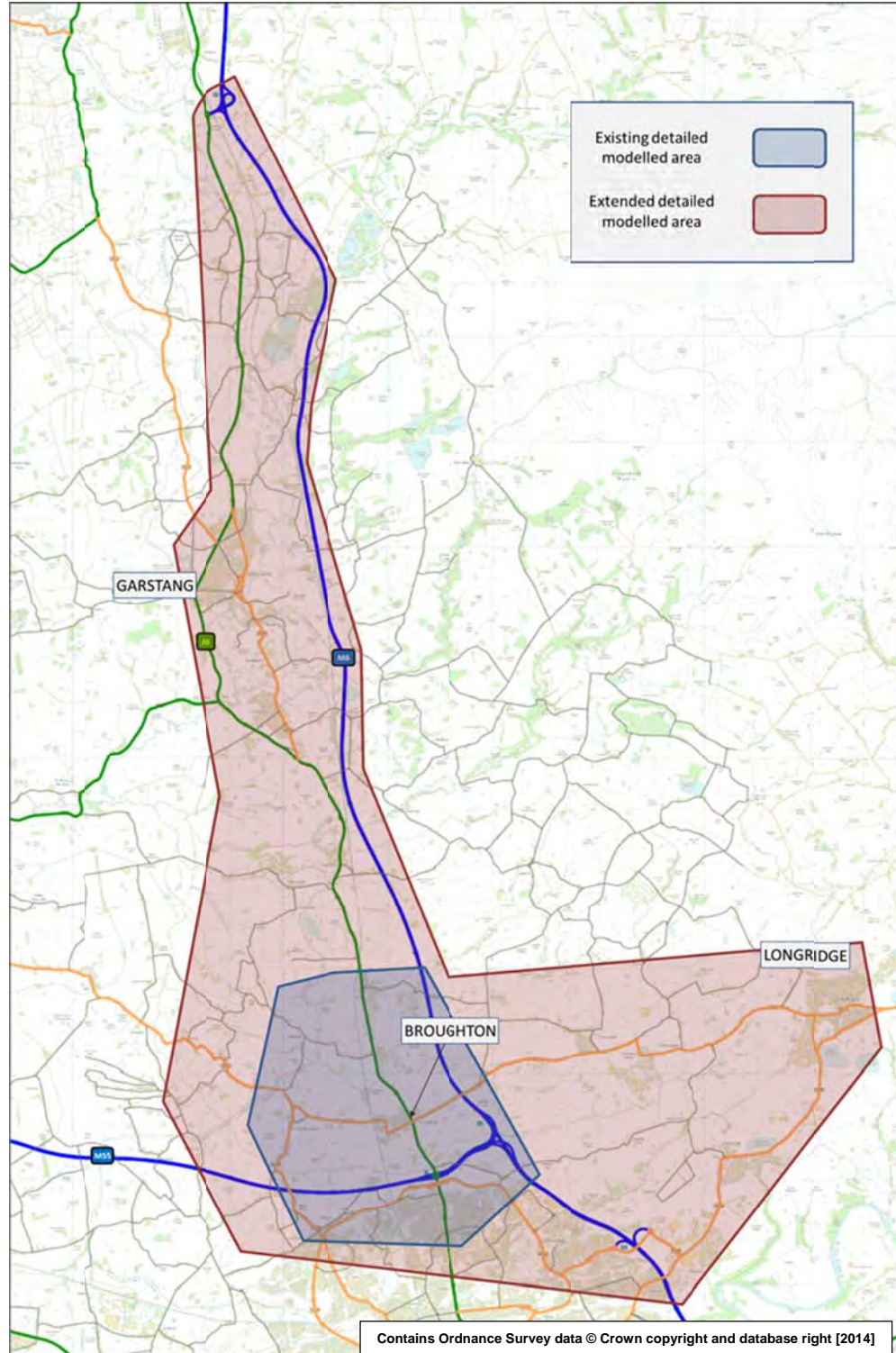
Figure 4-B   Spatial Detail in the Model

Modelling these areas with the highest level of detail in the network and zoning system ensured the key movements impacted by the presence of the bypass and also future land use developments were fully represented.

4.2   Zoning system

The model zone system was constructed using Census Output Areas (COAs) as building blocks. These COAs are used to report data from the national Census (conducted every ten years in the UK) and are the finest level of spatial detail at which such data is reported. Each output area typically comprises around 100-200 households and is designed to be as socially homogenous as possible. The COA boundaries fit within (and do not straddle) local authority boundaries. Since the demand matrix building relies on good land use data (see section 7.2.2) it was convenient to use COAs in this fashion to make maximum use of data from the 2011 Census.

Within the detailed model study area (as illustrated in Figure 4-A), the zones were comprised of COAs or aggregations thereof. In some instances, zones were based on a disaggregation of COAs in order to isolate individual pockets of land (for example, to separate large industrial land uses from residential uses). The area approximately covered by the Preston City Council boundary was zoned in this way.

Areas further away from the study area, where less spatial detail was required were based on National Trip End Model (NTEM) zone boundaries. These are usually identical to local authority districts. In the area immediately surrounding the study area (the rest of the fully modelled area, in Figure 4-A) these were mostly comprised of single NTEM zones, with some zones based on a disaggregation of NTEM. Beyond that point, in the external area of the model, several NTEM zones were aggregated to comprise the modelled zone.

Initial results from the Roadside Interview surveys indicated a small number of zones in the vicinity which had a very large number of trips originating or destinating. These zones were disaggregated further to ensure greater homogeneity of trip ends. This ensured as much as possible that the internal zones trip ends were no greater than 300, in line with WebTAG.

The zone system around Broughton and Preston is shown in detail below:
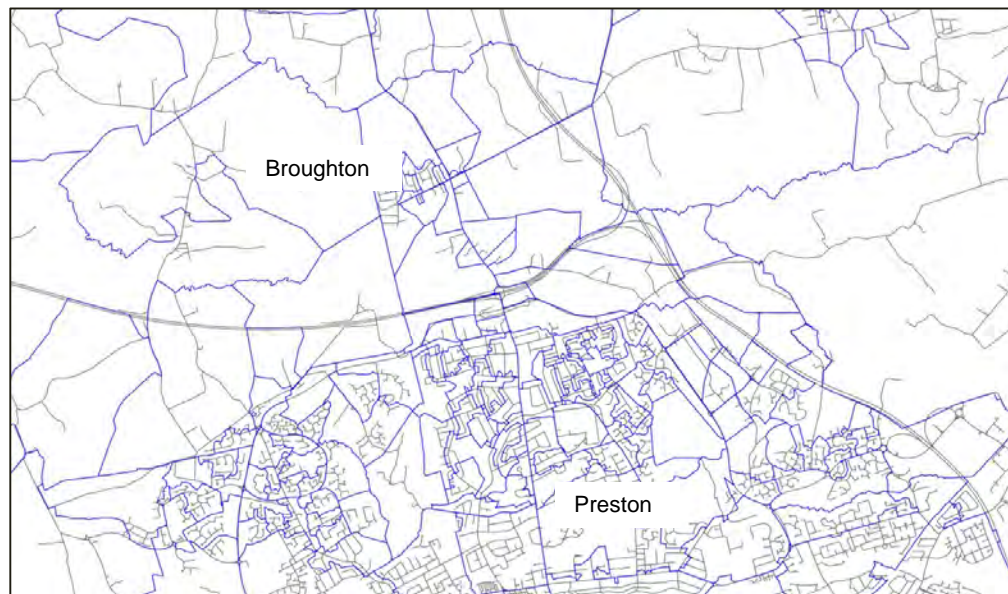
Figure 4-C   Zone System around Preston and Broughton

The zone system is shown in more detail in Appendix J.

4.2.1 Zone sectoring

For ease of reporting and analysis, the zones in the model were aggregated into 'sectors'. The sectors are shown below:
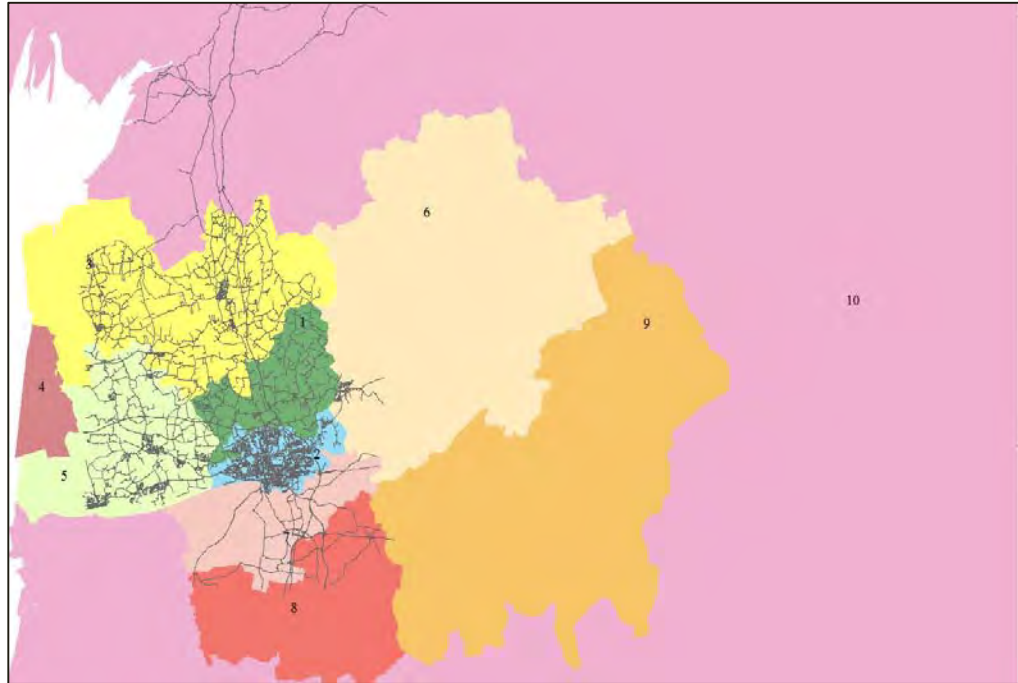
Figure 4-D   Zone Sectors Used in the Model

There are 10 sectors in total, as listed below.

Number	Sector
1	North Preston
2	South Preston
3	Wyre
4	Blackpool
5	Fylde
6	Ribble Valley
7	South Ribble
8	Chorley
9	Pendle/Burnley/Rosendale/ Blackburn/Darwen
10	Rest of the UK

Table 4-B   List of the Sectors

These sectors are used in subsequent reporting of the trip matrices.

4.3   Network Structure

The extent of the highway network is detailed below:

Figure 4-E   Highway Network of the Modelled Area

Outside of the detailed modelled area, more minor links have been stripped out of the modelled network, to reflect the more spatially aggregate nature of the zoning system. As this area is some way from the study area, it is only necessary to have enough detail to ensure that trips from these areas enter the study area at the appropriate locations.

4.4   Centroid Connectors

Zone connectors should represent 'real' junctions within the highway, i.e. not load directly onto links, where possible. In line with WebTAG Unit M3.1 guidance, the number of centroid connectors will be minimised (which will also help to avoid/ reduce convergence issues).

In general, each model zone will have one centroid connector, but there are likely to be exceptions to this where zones require multiple centroid connectors to accurately represent the loading points to / from the zone, and which will be refined in model calibration, and/or where significant delays are noted.

For the purposes of the local land-use testing within the model, and future potential links to demand models, representative costs to / from each of the development zones and locations are required in the base year model.

The connectors used in the model are illustrated by the red lines below:

Figure 4-F   Model centroid connectors

The loading node where the connector joined the road network was selected, based upon professional judgement, as the most representative place for demand to enter and exit the network. For the detailed model area every effort was made to ensure where possible that connectors did not join the network at junctions or directly onto main roads.

4.5   Time Periods

The model was built to represent three time periods, as follows:

- *AM peak hour (8-9am)*
- *PM peak hour (5-6pm)*
- *Average hour in the interpeak (10am-4pm)*

The bypass will have the greatest impact on traffic movements during the peak hours when the congestion at Broughton cross roads is greatest. It therefore follows that the AM and PM peak hours must be modelled.

Although there is less congestion in the interpeak period, it was still considered necessary to model this time period. There was no perceived need to model an off-peak or weekend period.

The time periods chosen also provides a suitable basis for the calculation of required AADT's and AAWT's for noise and air quality modelling, and for the calculation of economic impacts.

4.6 User Classes

In order for the effects of the bypass on different road users to be established, the model segregated trips by vehicle type and trip purpose. There were different levels of segregation used at different points of the model building process, as summarised in the table below:

Trip Purpose ID	Purpose	User Class (UC)	Vehicle Class (VC)
1	Home Based Work (HBW)	UC1	VC1
2	Home Based Employer's Business (HBEB)	UC2	
3	Non-Home Based Employer's Business (NHBEB)		
4	Home Based Education (HBED)	UC3	
5	Home Based Shopping (HBS)		
6	Home Based Other (HBO)		
7	Non- Home Based Other (NHBO)		
8	LGV	UC4	VC2
9	HGV	UC5	VC3

Table 4-C   Purpose/User Class/Vehicle Class Correspondence

These trip purpose and user class splits are consistent with the guidance contained in TAG Unit M3.1.

Vehicle classes 1 and 2 (cars and LGVs) were assigned a PCU factor of 1.0. HGVs were given a PCU factor of 2.0. This is consistent with guidance in TAG unit M3.1 appendix D, which advises that PCU factor on road types other than motorways and dual carriageways. Although there are motorways within the study area, the key study area, around Broughton, is made up of single carriageway roads, thus a value of 2.0 was considered most appropriate.

4.7 Assignment Methodology

The assignment method used in the software is known as "Assignment with ICA" which includes flow metering and blocking back (as summarised in Table 2-A).

As the area around Broughton is known to be very congested at peak times, particularly on the A6 between Broughton Crossroads and the motorway, it was recognised that encapsulating the effects of queuing and capacity restraint in the model would be very crucial to the performance of the model. The "Assignment with ICA" method is an iterative process for which, within each iteration an equilibrium assignment, which does not include flow metering, is run to convergence, before flow metering and blocking back is then applied. Subsequent iterations then consider the delays caused by blocking back when choosing routes. The process therefore includes the "inner iterations" of the equilibrium assignment and the "outer iterations" of the assignment with blocking back. WebTAG specifies a number of variables for measuring convergence, but of these, only GAP is reported by VISUM, and that only for the inner iterations. For the outer iterations, the differences between the total queuing volumes between iterations have been used as an indicator of model convergence. This is appropriate given that the outer iterations are directly concerned with queuing.

4.8   Generalised Cost Formulations and Parameter Values

The values of time (VOT) used in the model were taken from the TAG data book, based on 2014 values (the model base year). Similarly, vehicle operating costs were based on formulations and parameters within the TAG data book. When calculating the VOC, an average speed of 50 kph was assumed. The VOT and VOC values used are given below:

Vehicle type	Trip Purpose	Time Period	Value of Time (£/hr)	Vehicle operating cost (p/km)	Generalised cost coefficient for time (per second)	Generalised cost coefficient for distance (per metre)
Car	Business	AM	31.74	13.6	1	0.0154
Car	Commute	AM	7.87	7.0	1	0.0322
Car	Other	AM	10.03	7.0	1	0.0253
LGV	Business	AM	14.08	15.5	1	0.0396
HGV	Business	AM	14.47	42.9	1	0.1067
Car	Business	IP	31.01	13.6	1	0.0157
Car	Commute	IP	7.81	7.0	1	0.0325
Car	Other	IP	10.43	7.0	1	0.0243
LGV	Business	IP	14.08	15.5	1	0.0396
HGV	Business	IP	14.47	42.9	1	0.1067
Car	Business	PM	30.51	13.6	1	0.0160
Car	Commute	PM	7.70	7.0	1	0.0330
Car	Other	PM	10.73	7.0	1	0.0236
LGV	Business	PM	14.08	15.5	1	0.0396
HGV	Business	PM	14.47	42.9	1	0.1067

Table 4-D   Generalised Cost Parameters

For the purposes of running the matrix estimation process, it was found to be expedient to combine the business, commute and other user classes and assign as a single vehicle class. Within the assignment, the distance coefficient for the combined vehicle class was based on a trip weighted average of the coefficient for the separate user classes.

4.9   Capacity Restraint Mechanisms

4.9.1   Links

Capacity restraint on links was modelled through the use of speed flow curves, as described in section 6.

4.9.2   Junctions

All junctions within the study area were fully coded using VISUM's Intersection Capacity Analysis (ICA) functionality. This uses the junction type, number of lanes and modelled flows to calculate capacity and thereby turning delays. ICA is underpinned by the US Highway Capacity Manual.

With very few exceptions it was found that the default values (for saturation flow and gap acceptance etc.) within ICA were sufficient to yield junction delays

approximating observed delays very well. This can be seen from the journey time validation given in section 11.

Motorway merges were effectively modelled as uncontrolled junctions, effectively with no delay; it was found that modelling them as priority junctions resulted in excessive delays on slip roads. These were found to perform sufficiently well, although no further calibration work was done as it was considered unnecessary given the scope of the model.

4.10   Relationship with Other Models

The need for a variable demand model has been assessed and is the subject of a separate note. As a result of the findings detailed in that note, it is not intended to employ variable demand, and the model will instead be a fixed demand model.

Given the scope of the proposed scheme, a public transport model is not considered necessary.

5.1   Model data sources

An array of survey data was collected in order to provide a complete picture of traffic conditions in the base year. The data sources used are described in turn below.

5.2   Traffic Counts at Roadside Interview Sites

Roadside Interview Surveys were conducted in order to gather observed trip information. Alongside each survey, a two week automated traffic count (ATC), and a single day (the day of the survey) Manual Classified Count (MCC) was collected. These collected data from traffic travelling in both directions, albeit the survey was only conducted in one direction (with the exception of site 1, which was bi-directional). The location of these surveys is illustrated below:
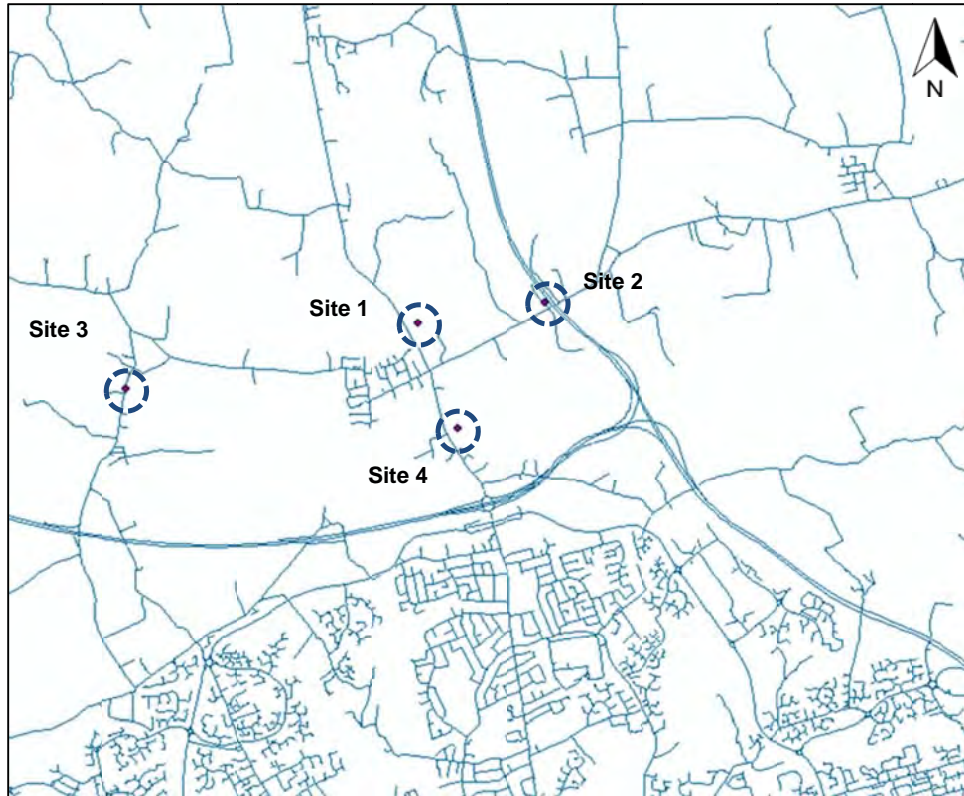
Figure 5-A   RSI Survey Locations

More information on the RSI surveys is provided in section 7. The surveys were conducted in June 2014, with the counts collected at the same time.

5.3   Traffic counts for Matrix Estimation

The traffic counts used in matrix estimation are illustrated below:

In order to check how well the model replicates real world traffic flows, it is necessary to compare modelled flows against traffic counts. To this end, several

traffic counts have been made within the study area. The location of these counts is shown below:
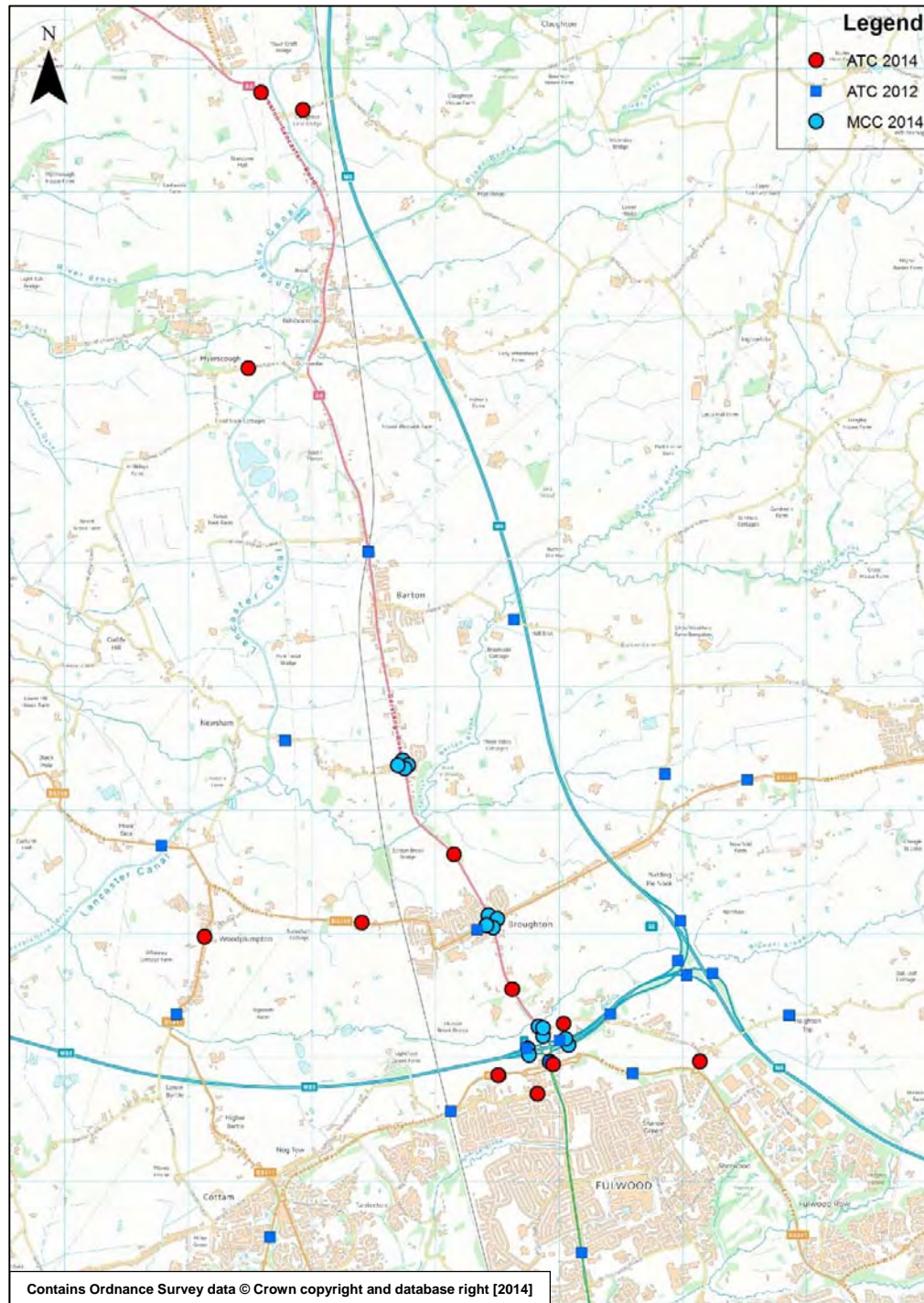
Figure 5-B   Count Locations and Types
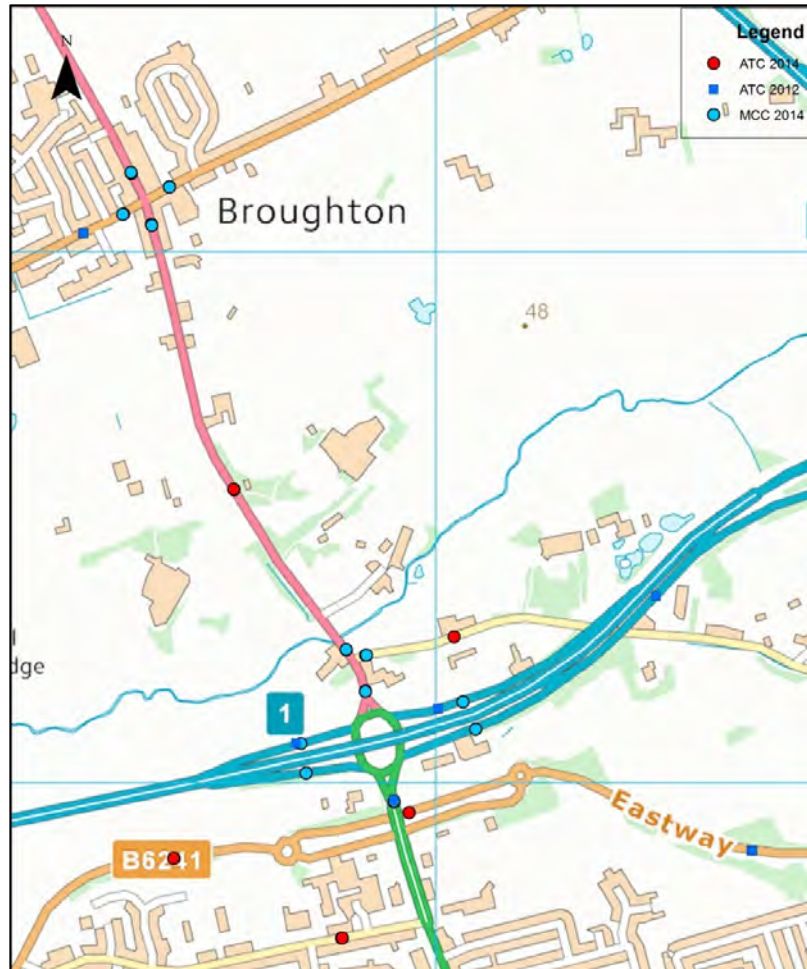
Figure 5-C   Count locations and types – detail view

The majority of counts were collected in 2014, however some counts from 2012 were used where 2014 data for a specific location was not available. These counts are shown as blue squares, in the drawing above.

In order to ensure that the 2012 counts, where used, were representative of a 2014 forecast year, the change in traffic between those two years was assessed. This change was established from the Department for Transports Road statistics website[1] which provides AAWT flows by vehicle type for all years from 2000 onwards. From the website, it was found that there was relatively little growth in car trips, however LGV and HGV flows had increased slightly. Accordingly, the 2012 counts were factored by 1.04 for LGVs and 1.08 for HGVs. Since car trips were relatively unchanged, they weren't factored.

All counts were then checked for consistency of flows. It was found that there were a small number of counts that were inconsistent with counts at nearby locations, and these were therefore excluded from the data set.

---

[1] http://www.dft.gov.uk/traffic-counts/

5.3.1 TRADS counts

For count data on the M6 and M55 motorways, TRADS data was used. Count data collected across the whole of June 2014 was used. As with the ATC data, the counts were checked for consistency. The location of the TRADS counts is shown below:

Contains Ordnance Survey data © Crown copyright and database right [2014]
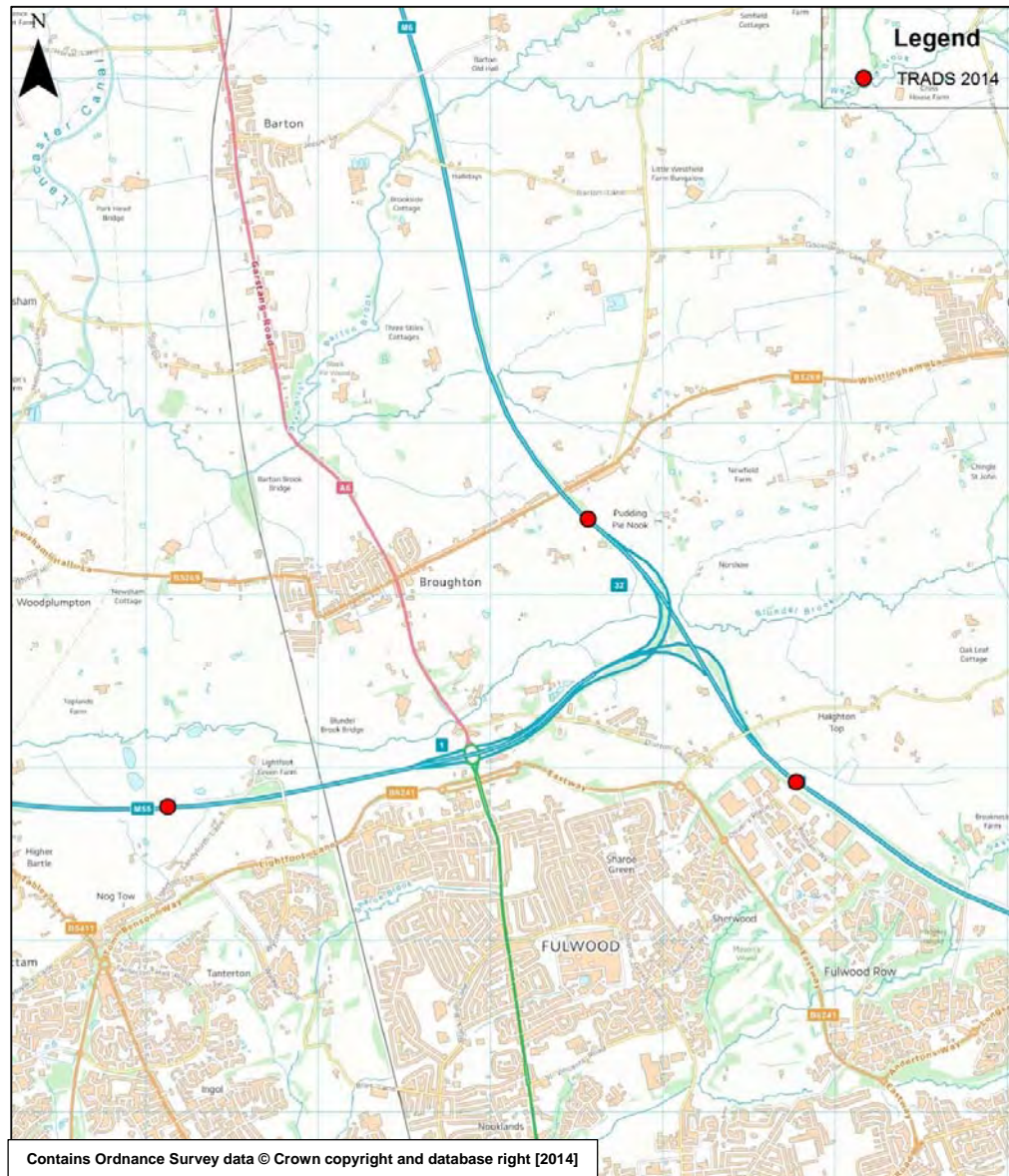
Figure 5-D   Location of TRADS counts

5.4   Traffic Counts for Validation

Some counts were separately held back from matrix estimation and used as independent validation counts. The locations of these are shown below:

Contains Ordnance Survey data © Crown copyright and database right [2014]
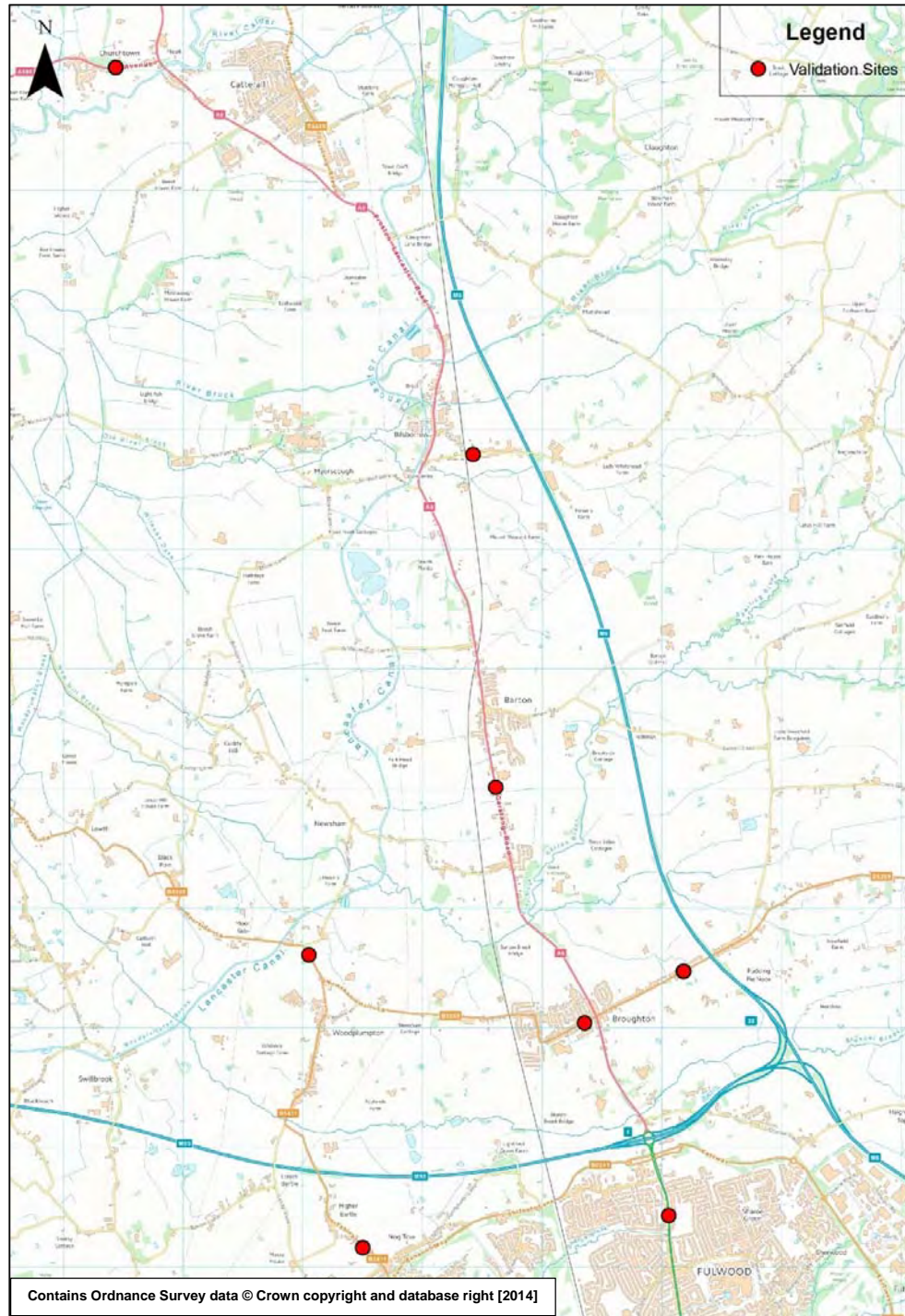
Figure 5-E   Validation Count Locations

As with the matrix estimation counts, all ATCs were collected over a two week period, and 2012 counts were factored up to 2014 levels.

5.5   Journey Time Surveys

Journey time data is used to check and compare the delays and travel times calculated by the model. Journey time data was collected from two sources: Moving observer surveys and TrafficMaster. The former is collected by an observer travelling in a car along a set journey time route, recording the time through several set 'timing points'. The latter is a dataset made available to local authorities and is based on data gathered using Satellite Navigation devices installed in cars and other vehicles. Travel times are specified for links in the Integrated Transport Network (ITN). Times along a set route are collated by aggregating the set of ITN links along the route.

The use of moving car observer methods, supported by TrafficMaster where appropriate is consistent with guidance in TAG Unit M3.1, section 4.4.

The routes along which journey time data was collected are illustrated below and for those routes collected using the moving observer method, timing points are included:

Figure 5-F   Journey Time Routes 101 & 102 (SB and NB respectively), Moving Observer Survey

Figure 5-G   Journey Time Routes 201 & 202 (SB and NB respectively), Moving Observer Survey
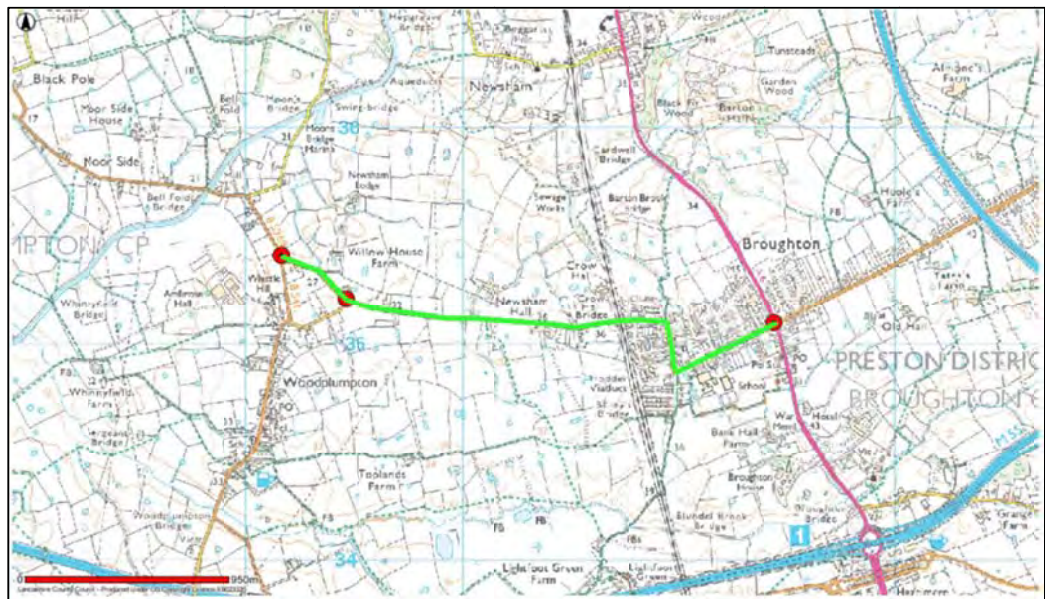
Figure 5-H   Journey Time Route 301 & 302 (WB and EB respectively), Moving Observer Survey
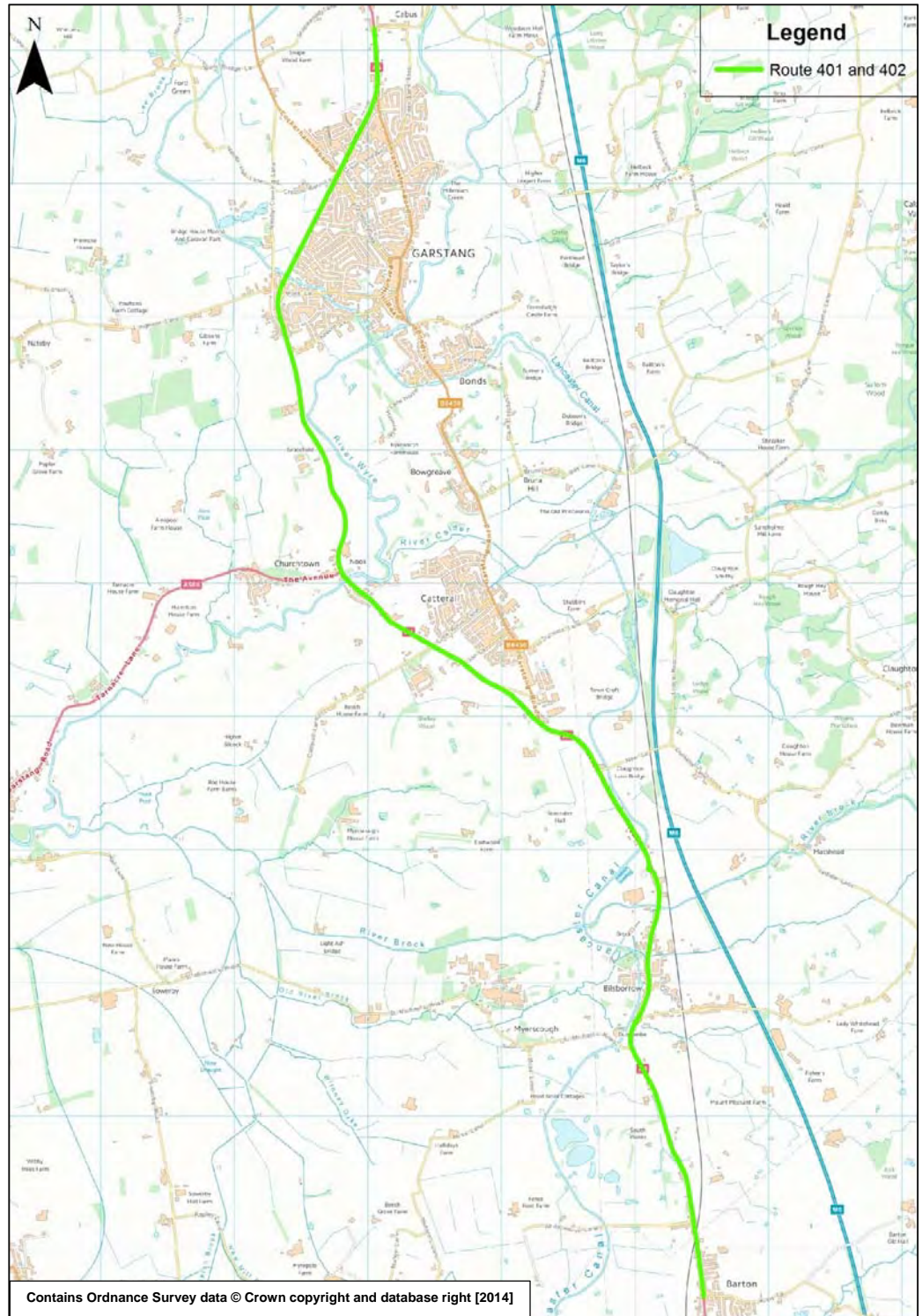
Figure 5-I   Journey Time Routes 401 & 402 (NB and SB respectively)

Figure 5-J   Journey Time Routes 501 & 502 (EB and WB respectively), Traffic Master
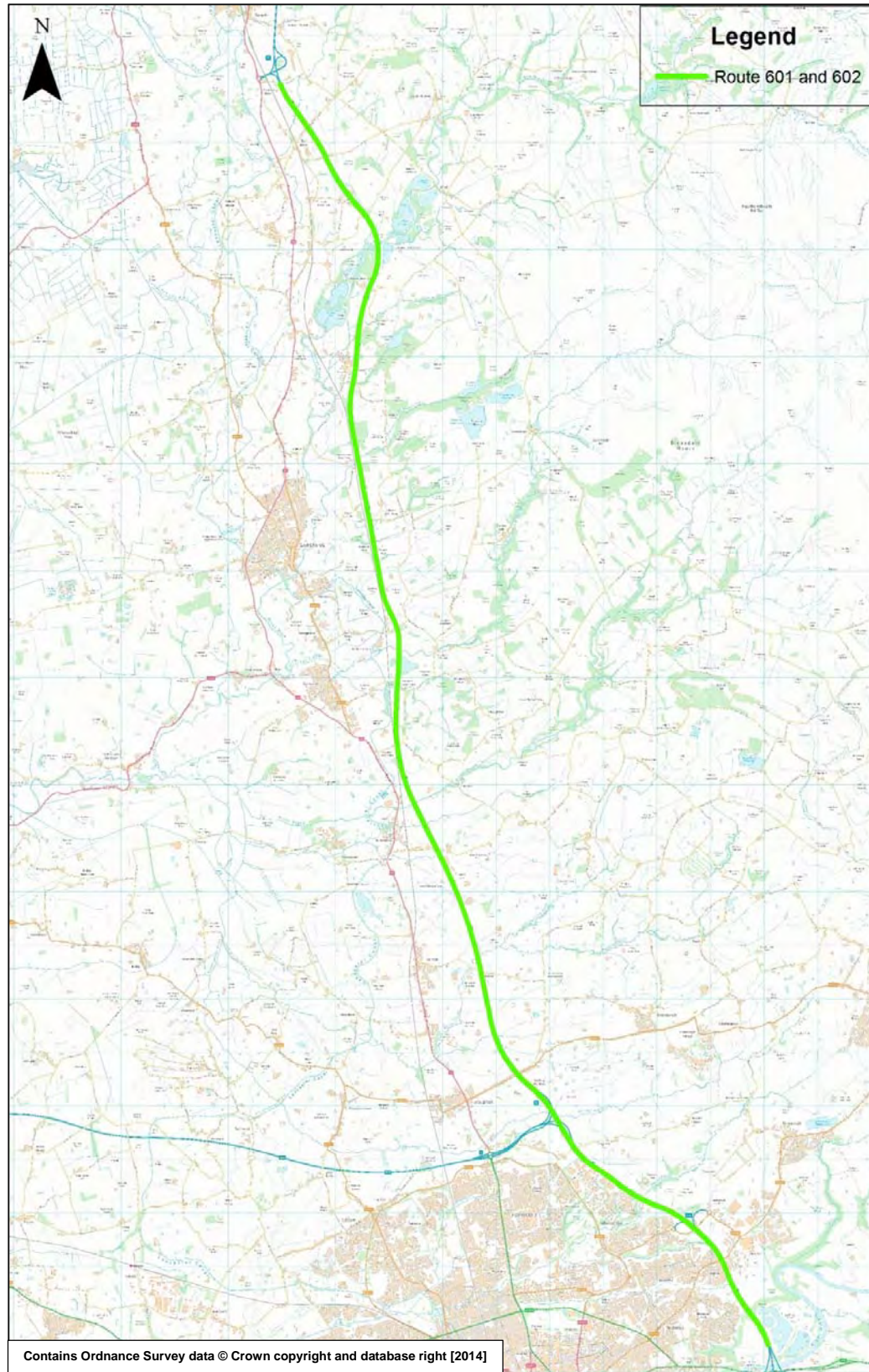
Figure 5-K   Journey Time Routes 601 & 602 (NB and SB respectively), Traffic Master

Contains Ordnance Survey data © Crown copyright and database right [2014]
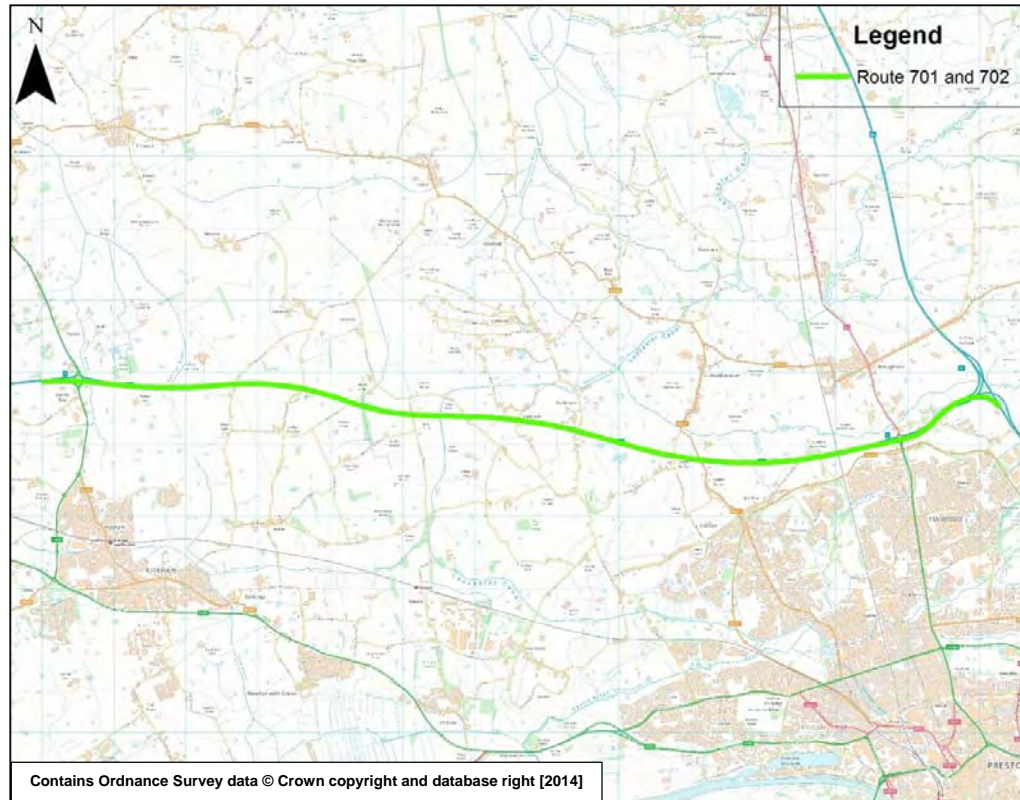
Figure 5-L   Journey Time Routes 701 & 702 (WB and EB respectively), Traffic Master

It is worth noting that journey times along motorways have been collected in order to ensure a robust economic appraisal and to cover any potential parallel routing issues in the modelling.

For the surveys collected by moving observers, the average and standard deviation values were calculated in order to gain an understanding of the level of variability in journey times. These calculations are shown below:

JACOBS

No.	Route	AM			IP			PM		
		Mean Observed Time (min:sec)	Standard Deviation (min:sec)	No. observations	Mean Observed Time (min:sec)	Standard Deviation (min:sec)	No. observations	Mean Observed Time (min:sec)	Standard Deviation (min:sec)	No. observations
101	A6 SB (through Broughton)	10:19	03:19	12	07:53	00:45	18	08:21	03:43	13
102	A6 NB (through Broughton)	13:41	01:02	14	07:55	00:33	17	13:02	01.06	10
201	Hollowforth Ln SB	11:35	00:26	5	10:30	00:12	5	10:47	00:23	4
202	Hollowforth Ln NB	11:13	00:29	3	10:17	00:37	6	10:23	00:11	4
301	Newsham Ln WB	03:20	00:10	4	03:35	00:24	6	03:21	00:13	4
302	Newsham Ln EB	06:54	02:07	5	04:36	00:40	6	05:35	01:40	4
401	A6 NB (through Garstang)	11:12	-	-	11:32	-	-	11:04	-	-
402	A6 SB (through Garstang)	10:29	-	-	11:10	-	-	10:37	-	-
501	Whittingham Lane EB	01:32	-	-	01:19	-	-	01:26	-	-
502	Whittingham Lane WB	03:43	-	-	03:47	-	-	04:06	-	-
601	M6 (between J31A and J33)	14:59	-	-	14:25	-	-	14:02	-	-
602	M6 (between J31A and J33)	14:13	-	-	14:32	-	-	15:05	-	-
701	M55 (between J32 and J3)	07:19	-	-	06:48	-	-	06:43	-	-
702	M55 (between J32 and J3)	06:56	-	-	07:01	-	-	07:03	-	-

Table 5-A   Journey Time Average and Variability

The data shows that certain journey time routes are more variable than others, in particular routes 101 and 302 show relatively high levels of variability. These routes both include approaches to Broughton Crossroads, underlining the lack of reliability of journey times through that area currently. For routes through the crossroads in particular, the analysis above serves to demonstrate that the average journey time is not always a typical representation of actual journey times.

Routes 101 and 102 were also surveyed in 2012. The comparison between the 2012 and 2014 observation is shown below:

Route No.	Route	AM		IP		PM	
		Obs. time	2012 Obs. time	Obs. time	2012 Obs. time	Obs. time	2012 Obs. time
101	A6 SB (through Broughton)	00:10:19	32:58	00:07:53	-	00:08:21	00:22:16
102	A6 NB (through Broughton)	00:13:41	18:19	00:07:55	-	00:13:02	00:11:11

Table 5-B   Comparison of 2012 and 2014 Journey Time

The comparison clearly demonstrates that there has been a significant reduction in southbound journey times on the A6 since 2012. There has also been a small reduction in northbound journey times. These reductions have been attributed to the improvements made to junction one of the M55, and validated against local experience and confirmed by Lancashire County Council.

6 Network Development

6.1   Network basis

The modelled network was created using the Integrated Transport Network (ITN), an Ordnance Survey dataset representing the Great Britain transport network as a series of links and nodes. ITN contains details of the characteristics of each road, including:

- *Road type (motorway, trunk road, local route);*
- *Number of lanes and capacity;*
- *Restrictions such as one-way streets and HGV bans; and*
- *Other elements such as bus/cycle lanes.*

The network was loaded into VISUM, which converted it into a series of links and nodes appropriate for modelling.

All of the above characteristics of the network were also sense checked through the use of Google Earth/Street View and site visits.

The application of capacity restraint mechanisms, and

6.2   Link speeds and speed-flow curves

For the links imported into the model the parameters governing speeds, capacities and the relationship between speed and traffic flow were derived from Part 5 of the COBA manual[2]. The link characteristics described in the manual were translated into parameters appropriate for use in the VISUM model. A total of 29 different link types were drawn up based on COBA, to accommodate all different combinations of urban/suburban/rural, levels of development, road widths, number of lanes, and vehicle restrictions. For each link type, the relationship between vehicle flow and average speed, also known as a speed-flow curve, or in VISUM parlance, a "Volume-delay function" was defined. The Volume-delay functions used an 'adjusted BPR' function, the formulation of which was developed by the US Bureau of Public Roads, and is repeated below:

$$
t_{cur} = \begin{cases} t_0 \left(1 + a \cdot \left(\dfrac{q}{q_{max} \cdot c} \right)^b \right), & \dfrac{q}{q_{max} \cdot c} \leq 1 \\ t_0 \left(1 + a \cdot \left(\dfrac{q}{q_{max} \cdot c} \right)^{b'} \right), & \dfrac{q}{q_{max} \cdot c} > 1 \end{cases}
$$

Where: t_{cur} is the calculated link travel time,
t_0 is the link travel time at free flow conditions,
q is the flow on the link,
q_{max} is the link capacity, and
a, b, b', and c are parameters specific to each link type.

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[2] https://www.gov.uk/government/publications/coba-11-user-manual

From the formulae, it is clear that there is a different relationship for links that are over capacity, to those which are under capacity. However, it must be noted that the propensity for this to occur is reduced as the model makes use of flow metering. This meets the guidance in TAG unit M3.1 appendix D8.

The full list of link types, along with free flow speed, capacity, and parameters for the volume-delay function is given in Appendix A, whilst the Volume-delays functions are plotted on the graph below:
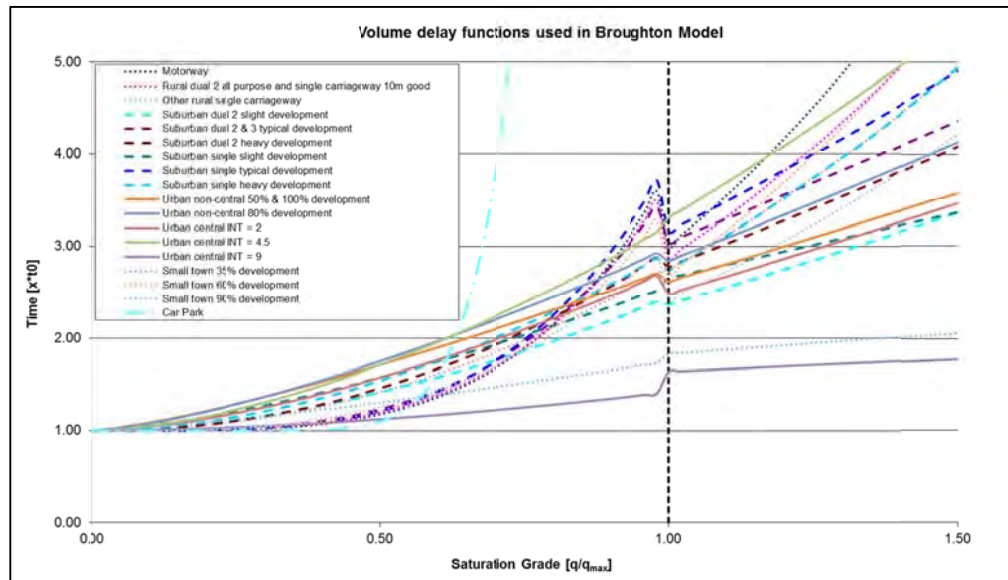
Figure 6-A   Volume-Delay Functions

These speed flow curves were applied to all links in the model.

For HGV's, the volume-delay function is adjusted such that HGVs have a maximum speed of 80km/h (50mph).

Link lengths were automatically calculated based on the scale lengths of the polylines representing the modelled links.

6.3   Junctions and Delays

All junctions within the study area, with the exception of motorway merges, were fully coded using VISUM's Intersection Capacity Analysis (ICA) functionality. This uses the junction type, number of lanes and modelled flows to calculate capacity and thereby turning delays. ICA uses formulas set by the 2010 edition of the Highway Capacity Manual, published by the US Transportation Research Board; these formulas are specific to the junction type. ICA relies on the input attributes identified above, and uses a number of default global values, to calculate the capacity and delay for each movement at a modelled junction. The default values cover aspects such as saturation flows per lane for each junction type and turn type and gap acceptance values for vehicles on a minor arm.

With very few exceptions it was found that the default values (for saturation flow and gap acceptance etc.) within ICA were sufficient to yield junction delays

approximating observed delays very well. This can be seen from the journey time validation given in section 11.

The junctions were coded with the following attributes defined:

- *Junction type*
- *Major flow (i.e. which turning movements had priority)*
- *Banned turns*
- *Number of lanes at stop lines*
- *Turn type (i.e. straight on, left, right)*
- *Lane Allocations (which turns are made from which lanes)*
- *Signal timings (for signalised junctions)*

These attributes were coded using local knowledge, Google Earth and Google StreetView and site visits to the area. For signalised junctions, timings were based on a combination of UTC/SCOOT data and observation.

7   Trip Matrix development

7.1   Overview

Two types of trip matrices were created: Observed, based on data collected from the RSI surveys; and Synthetic, using demographic data to synthesise likely movements through the study area. The two sets of matrices were then merged together using statistical methods to create a single set which was then subjected to matrix estimation techniques to derive the final demand used in the model.

Each stage of the trip matrix development is described in detail in the following sections.

7.2   Travel demand data

7.2.1   Observed trip matrices

To obtain information on the movements through the Broughton area, five roadside interview (RSI) surveys were conducted. The survey locations are shown below:
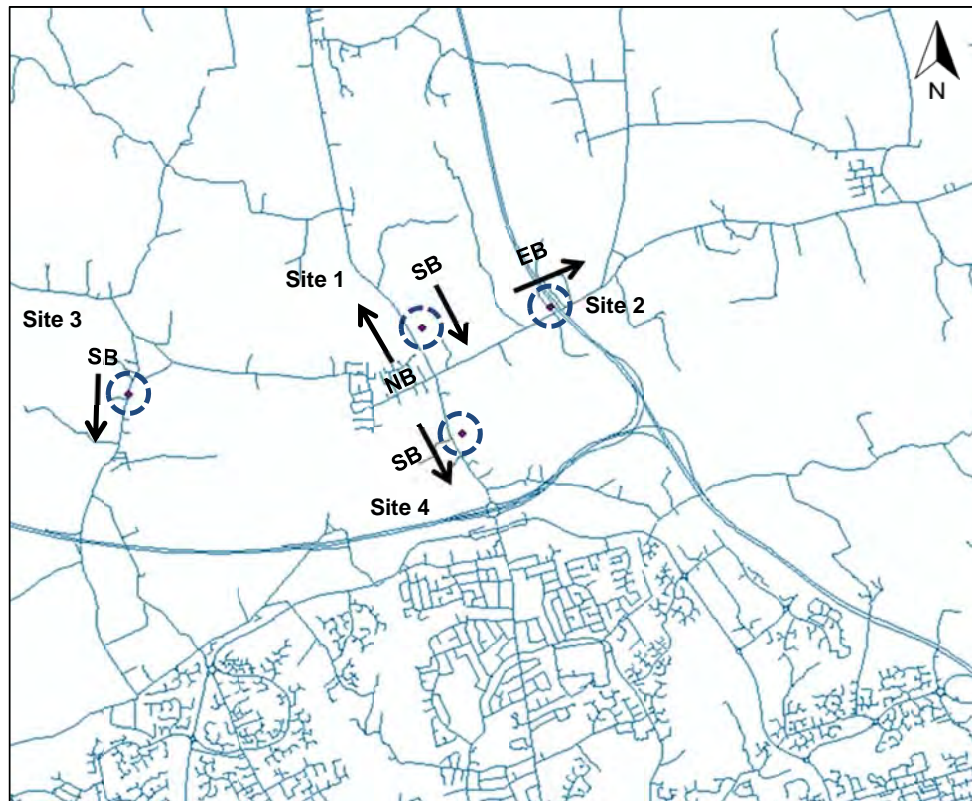
Figure 7-A   RSI Survey Locations

The survey locations form a natural cordon around Broughton, in order to capture all movements that will potentially use the proposed scheme.

The surveys were conducted between Tuesday 3rd and Thursday 5th June 2014. Each individual site was surveyed over a single day, between 07:00 and 19:00. The date that each site was surveyed, the number of surveys conducted and the total traffic flow through the site is summarised below:

Site	Date of Survey	Number of surveys	Total traffic flow	Sample Percentage
Site 1 NB	Tuesday 3rd June 2014	1292	6818	19.1
Site 1 SB	Wednesday 4th June 2014	1350	6847	19.9
Site 2 EB	Tuesday 3rd June 2014	1093	2682	41.1
Site 3 SB	Thursday 5th June 2014	549	1709	32.5
Site 4 SB	Thursday 5th June 2014	1389	9675	14.4

Table 7-A   Details of RSI Surveys

The RSI surveys were accompanied by an MCC collected on the same day of the survey, and a 2 week ATC whose collection periods included the survey day.

The surveys were conducted without any major problem, and surveys from all vehicle types were collected (Cars, LGVs and HGVs). The percentage of vehicles surveyed varied from around 14% to 40%, which represents a very good sample size.

Further information on the processing of the observed data, and the various checks that were made, follows in section 7.3.

Additional information on the RSI surveys is available in the Traffic Surveys Report for this project.

7.2.2   Synthetic trip matrices

Synthetic trip matrices were built using a number of data sources relevant to each stage of the process. First, land-use data is collected, and trip rates applied to calculate the total amount of trips generated by each modelled zone. These 'trip-ends' are then distributed to form a trip matrix. The trip distribution is calibrated using data from the National Travel Survey. The data used in each of these steps is described in more detail below.

(a)   Land use data

Land-use data is necessary to establish demographic data of people living and working within each modelled zone. Two types of information were required: demographic data based on where people live; and employment data for where people work. The 2011 Census was used to provide the demographic data, and was taken from the Office for National Statistics' (ONS) NOMIS website[3]. The data is provided at Output Area level, which is the finest level of detail for reporting Census data. This provided a wealth of information about the number and demographics of the people and households living in each output area including population split by age, gender, economic activity and car availability. The modelled zone system was built up from aggregations of output area boundaries, so it was relatively simple to generate land-use data for each zone.

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[3] http://www.nomisweb.co.uk/

Land-use data concerning car ownership was also informed by the National Car Ownership Model (NATCOP), a sub-model of the National Trip End Model (NTEM). NATCOP calculates the probability of households owning 0, 1, 2, 3 or more cars for a given year, based on demographic data. It is usually used to provide forecasts car ownership, but the same principles were applied to calculate car ownership in the base year.

For employment data, information was taken from a database of employment locations provided by the third party contractor "Blue Sheep". In this case NOMIS was used to extract data from the Business register and employment survey and the finest level of detail for reporting was Lower Super Output Area. The Blue Sheep employment data relies on twelve different data sources (including from Companies House) to give details for every business in the UK. The details include postcode and grid reference for the location of the business, the Standard Industry Classification, and the number of employees. Where a single business has multiple offices or branches, the database records the number of employees at each individual branch or office location, rather than just the UK total reported at the head office. The data set has been used previously on other Jacobs's projects and is incorporated within our standard, approved synthetic trip ends development process, JTREND.

Finally, to ensure the land use approximation was consistent with national data sets, the land uses were factored to be consistent with the assumed land uses used with the National Trip End Model (NTEM).

(b)   Trip rates

24 hour trip rates for highway and PT modes were applied to the land-use data at a zonal level to derive total trip ends. These trip rates were based on those used in the DfT's CtripEnd programme, which forms a part of the National Trip End Model, and in turn derives its trip rates from the National Travel Survey (NTS). The NTS is a household survey of travel patterns and has been running continuously since 1988. Around 20,000 individuals across 8,000 households take part in the survey each year, and the data collected (including trip rates) is considered standard by national guidance.

(c)   Trip distribution

The trip ends were distributed using a gravity model to form the demand matrices. The distribution was calibrated so that the trip lengths in the demand matrices replicated those collected from the National Travel Survey 2013. The trip length distributions of the matrices were also compared with those from the observed matrices, as detailed in section 7.4.6.

7.2.3   Synthetic trip matrices – goods vehicles

The data sources used to generate synthetic trip matrices for cars do not provide sufficient information to build trip matrices for goods vehicles, therefore, additional data was required. Trip rates were based on data from the TRICS programme, based on employment sites applied per job. There was no data available on goods vehicle trip lengths, as the NTS only collected data on private, rather than freight, travel.

7.3 Partial Trip Matrices from Surveys

Observed trip matrices were built exclusively from the observations made during the RSI surveys, the locations of which are illustrated in Figure 7-A in section 3.3.1.

At each site, surveys of vehicles travelling through the site were conducted over a twelve hour period. The survey collected the following information from each driver surveyed:

- *Start location (origin) of the trip being made*
- *End location (destination) of the trip being made*
- *Reason for being at the start and end locations (e.g. home, workplace, etc.)*
- *The type of vehicle (car, LGV, HGV, etc.)*
- *The number of people travelling in the vehicle*
- *The journey frequency (how often that particular trip is made)*
- *Time of the survey*

A copy of the questionnaire used in the survey is in Appendix F.

Following the completion of the survey, the specified location data was converted to Ordnance Survey coordinates to pinpoint the exact location. This was done by the survey contractor and double checked by Jacobs.

At each survey location, a two-week ATC and a one day MCC was also collected. The data from these counts was used to check the sampling level of the RSI sites, and derive expansion factors which when applied to the survey records and summed ensure that the surveys are representative of the full volume of traffic through the site.

7.3.1 Checking survey records

For a number of reasons, the data recorded in the survey may not be an accurate representation of the trip being made. The survey errors generally fall into two categories: 1. Location information is incorrect. 2. Reason for being at the particular location is incorrect. In the case of the former, reasons for incorrect locations being recorded include the driver (wilfully or accidentally) giving the wrong location of either their journey start or journey end, or the surveyor recording a different location to the one specified (for example if they misheard the given location). It is worth noting however that the survey data collection was done using tablet computers which had a database of postcodes to help identify incorrect addresses.

To ensure that these erroneous surveys are excluded from the set of data from which observed trip matrices would be created, all records collected from the survey were checked, both in terms of the specified journey start and end locations, and the journey purpose.

(a) Check on journey start and end locations

The recorded origin and destination of each journey should represent a sensible trip movement given the location of the RSI survey. For example, given that these particular RSI surveys were conducted in Broughton, one would expect to observe trips between, say, Preston and Garstang, but trips between Manchester and Wigan (for example) would not be expected. Any survey records which represent illogical or

unexpected trips were to be discarded so as to ensure the observed trip matrices would be representative of actual trips through Broughton.

To ensure that illogical trips were discarded, each survey record was used to plot a desire line representing the movement for the surveyed trip. This desire line was checked against the survey location, and if it did not pass within a certain distance of the survey, the record was discarded. An illustration of some logical and illogical desire lines for the trips surveyed at site 1 northbound is below:
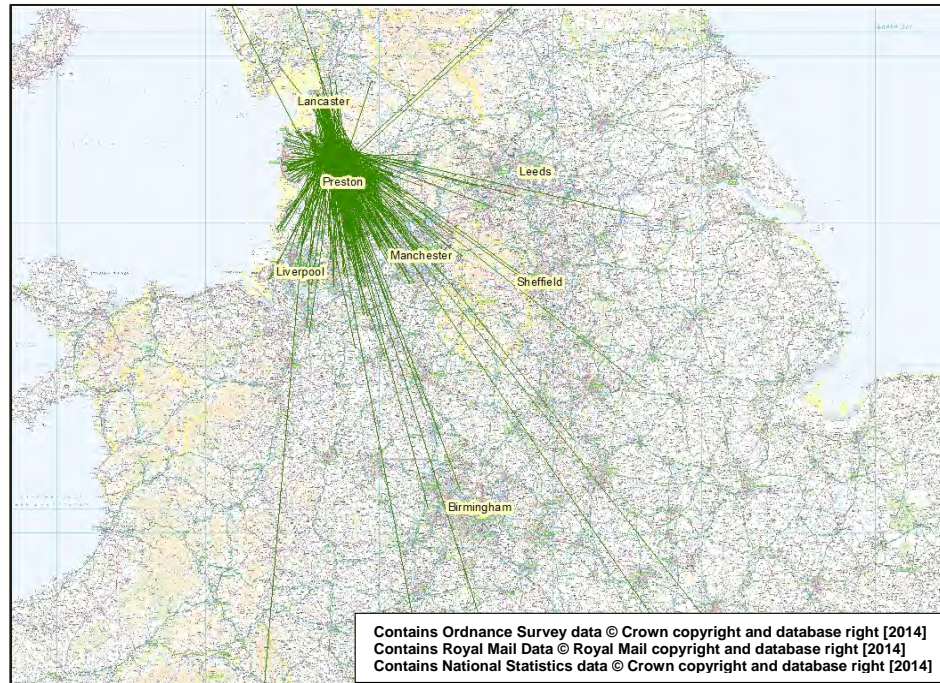
Figure 7-B   Correct Desire Lines, 1NB

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Contains Royal Mail Data © Royal Mail copyright and database right [2014]
Contains National Statistics data © Crown copyright and database right [2014]
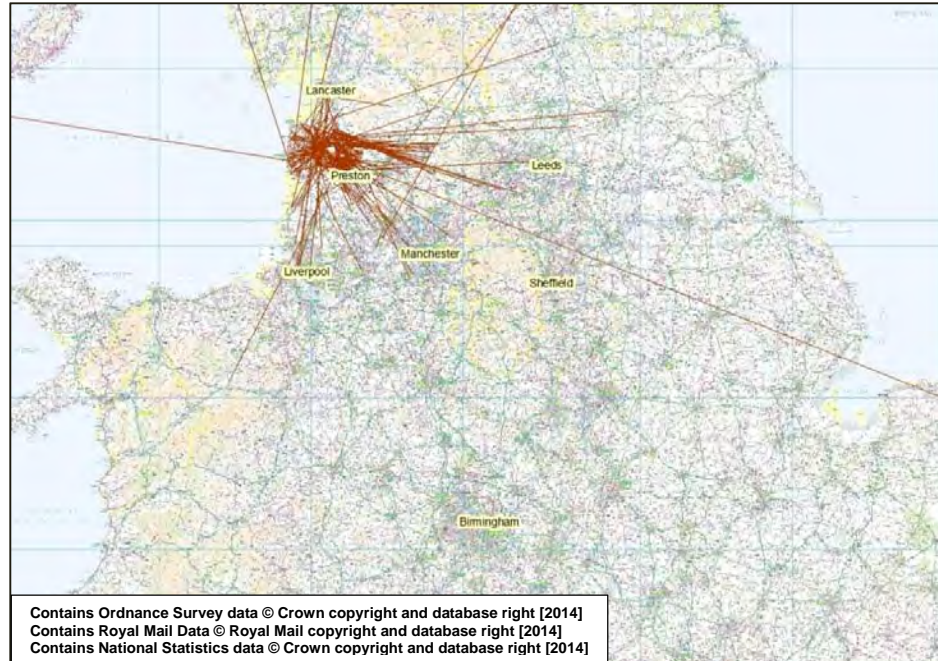
Figure 7-C   Incorrect Desire lines, 1 NB

There were some survey records for which the desire line would represent a logical trip were it not for the fact that the line is in the wrong direction (e.g. the desire line is northbound whilst the survey was conducted in the southbound direction). These records were identified by comparing the compass bearing of the desire lie against the survey direction. In those cases in which the bearing was incorrect, the record was not discarded, but the origin and destination locations were swapped round.

A summary of the number of records discarded or corrected (due to wrong directions of the desire lines) is below:

Site	Number of records	Number of discarded records	%	Number wrong direction (corrected)	%
1 NB	1292	133	10%	39	3%
1 SB	1350	136	10%	39	3%
2 EB	1093	180	16%	115	11%
3 SB	549	93	17%	14	3%
4 SB	1389	208	15%	44	3%

Table 7-B   Table Summarising Discarded Records from Desired Line Checks

(b)   Check on reason for being at the journey start/end

The specified reason for being at the journey start and end points were used to identify the journey purpose for each trip. In order to ensure that the observed trip matrices are representative, it is important that, as much as possible, the recorded trip purpose is accurate. The amount of checks that can be done in this regard are limited however checks on shopping trips and education trips have been possible. For all survey records that identified the reason for being at a specific location as shopping or education, those locations were checked to ensure that there was a shop or education establishment, using Google Earth. Where these checks suggested that the reason may have been recorded incorrectly, the record was

corrected by changing the 'reason' to one that was appropriate for the location; for example, if for an education trip the location was actually identified to be an office block, the 'reason' was change to "workplace". In total, 103 origin locations and 75 destination locations had the 'reason' for being there changed. This represented less than 2% of survey records.

Whilst it was desirable to have checked other trip purposes than shopping and education, there was no straightforward way to do this. For example, a location that was specified as being for work could be a shop, a school a household, or any manner of location. It was therefore not possible to check other journey purpose and it had to be assumed that the specified data was correct. Trip purpose splits from the surveys are detailed in section 7.3.5.

7.3.2 Expanding records to match count data

Once the data was checked and any unsuitable records removed, expansion factors were calculated. The factors are used to ensure that the sample of survey records represent the full amount of traffic passing through the survey site. The expansion factor is calculated for each fifteen minute interval, for each vehicle type, and is calculated by dividing the total traffic volume by the number of survey records. The reciprocal of the expansion factor is equivalent to the sampling rate.

An example of the expansion factors calculated at site 2 eastbound during an interpeak hour is given below:

Time	Car	LGV	OGV1	OGV2
08:00 - 08:15	3.42	3.49	8.74	14.66
08:15 - 08:30	1.80	3.49	8.74	14.66
08:30 - 08:45	2.31	3.49	8.74	14.66
08:45 - 09:00	5.43	3.49	8.74	14.66

Table 7-C   *Example Expansion Factor for Site 2 Eastbound Direction*

In the example given above, the expansion factors for cars was calculated based on data collected during each fifteen minute period (i.e. the count over fifteen minutes divided by the number of vehicles surveyed over the same fifteen minute period), but for LGVs and HGVs (i.e. OGV1 and OGV2), the factors were derived from data based on the more aggregate three hour AM peak period. This was due to greater variation in frequency of surveying of these vehicles compared to that of cars. The average expansion factor (and by extension the sampling rate) for each vehicle type at each site throughout the survey period is summarised below:

Site and direction	Car	LGV	OGV1	OGV2
1 NB	5.9	5.6	10.8	3.6
1 SB	5.5	6.1	9.6	4.5
2 EB	2.7	3.4	6.2	6.3
3 SB	3.7	3.3	11.7	13.0
4 SB	8.2	8.3	22.9	3.6

Table 7-D   *Average Expansion Factors for all Sites*

As the table shows, expansion factors for cars and LGVs are relatively low suggesting a good sample rate. For HGVs however, the expansion factors are that much higher indicating they were disproportionately less observed. With higher expansion factors there is a greater risk of introducing bias into the survey, whereby the few HGVs that were observed are over represented at the expense of those

which were not. This is undesirable as it is more likely to lead to trip matrices that are unrepresentative of HGV movements. For that reason, the HGV trips observed in the RSI surveys were not used in the final demand matrices. Even using expansion factors based on the total daily count would not have avoided this issue.

A full list of expansions factors for each site, broken down by time period is contained in Appendix G.

7.3.3   Building trip matrices for each site

As detailed above the survey records included OS grid coordinates for the trip origin and destination. This allowed these points to be plotted on a map. The points were overlaid with a GIS layer of the modelled zone system, and within GIS a spatial join was implemented to append the number of the zone that the point lies within, to the record.

The surveyed 'reason for being' at the origin and destination location, once checked, was used to identify an overall trip purpose for each record in the survey. The allocation of overall trip purpose to origin and destination reason is illustrated below:

Origin Purpose	Destination Purpose									
		Home	Holiday home/Hotel	Work	On employer's business	Education	Shopping	Personal business	Visiting friend	Social or recreational	Other
	Home	HBO	HBO	HBW	HBEB	HBED	HBS	HBO	HBO	HBO	HBO
	Holiday home/Hotel	HBO	NHBO	NHBO	NHBEB	NHBO	NHBO	NHBO	NHBO	NHBO	NHBO
	Work	HBW	NHBO	NHBEB	NHBEB	NHBO	NHBO	NHBO	NHBO	NHBO	NHBO
	On employer's business	HBEB	NHBEB	NHBEB	NHBEB	NHBEB	NHBEB	NHBEB	NHBEB	NHBEB	NHBEB
	Education	HBED	NHBO	NHBO	NHBEB	NHBO	NHBO	NHBO	NHBO	NHBO	NHBO
	Shopping	HBS	NHBO	NHBO	NHBEB	NHBO	NHBO	NHBO	NHBO	NHBO	NHBO
	Personal business	HBO	NHBO	NHBO	NHBEB	NHBO	NHBO	NHBO	NHBO	NHBO	NHBO
	Visiting friend	HBO	NHBO	NHBO	NHBEB	NHBO	NHBO	NHBO	NHBO	NHBO	NHBO
	Social or recreational	HBO	NHBO	NHBO	NHBEB	NHBO	NHBO	NHBO	NHBO	NHBO	NHBO
	Other	HBO	NHBO	NHBO	NHBEB	NHBO	NHBO	NHBO	NHBO	NHBO	NHBO

Table 7-E   Table of Journey Purpose

The journey purpose codes in the table above are elaborated upon below:

- *HBW – Home based work*
- *HBEB – Home based employer's business*
- *HBED – Home based education*
- *HBS – Home based shopping*
- *HBO – Home based other*
- *NHBEB – Non-home based employer's business*
- *NHBO – Non-home based other*

Finally, the recorded time at which each particular survey was conducted was used to identify the time period; either AM peak (7-10am), interpeak (10am-4pm) or PM peak (4pm-7pm).

Following completion of all the processing steps, each surveyed record had an origin zone, destination zone, trip purpose, vehicle type, time period and expansion factor. Using this information, a trip matrix was constructed for each site, time period, trip purpose and vehicle type (car, LGV but NOT HGV see section 7.3.2 above); 135 matrices were created in total (5 sites * 3 time periods * 9 trip purposes/vehicle types). Each cell in the trip matrices was populated with the sum of the expansion factor of those survey records with the corresponding origin and destination zone. Finally, once the trip matrix for each time period is built, it is factored so that the flows are representative of the modelled hour: either 8-9am (AM peak), an average interpeak hour (10am-4pm), or 5-6pm (Pm peak). The interpeak matrix is factored by 1/6 (there are six hours in the interpeak period). For the AM and PM peak hours, an appropriate factor is derived from count data, to essentially convert, for each vehicle type, from a three hour period to a single peak hour (the factor is therefore the three hour count divided by the peak hour count). The factors used are below:

Site	AM factor			PM factor		
	Car	LGV	HGV	Car	LGV	HGV
1 NB	0.364	0.311	0.300	0.352	0.349	0.279
1 SB	0.359	0.283	0.396	0.364	0.307	0.154
2 EB	0.398	0.356	0.414	0.344	0.306	0.465
3 SB	0.549	0.495	0.153	0.394	0.346	0.148
4 SB	0.346	0.211	0.309	0.345	0.353	0.099

Table 7-F   Peak Hour Factors

Applying a factor to the full period data, rather than just simply building matrices from only the survey records collected over the single hour, ensures a larger sample of data is used in the final trip matrices.

Each trip matrix had a parallel 'variance' matrix, which represented the observed variance for each origin and destination zone pair, as defined below:

$$Var_{ij} = \sum_n e_{ij}\left(e_{ij} - 1\right)$$

Where *Var_{ij}* is the variance for the trip between zone *i* and zone *j*, and for each survey record *n*, *e_{ij}* is the expansion factor for the surveyed trip.

This variance matrix was required for the subsequent matrix merging.

7.3.4   Merging trip matrices from all sites

In order to combine the trip matrices from all sites, some consideration of the expected movements through each site was required. It was important to ensure that when merging the data together, there was no double counting of trips. This would occur when a single trip travels through two survey sites and is surveyed twice; for example, a trip from Garstang to Preston could potentially be surveyed at both the 1 SB site and the 3SB site. The schematic below was used to clarify the position with regard to movements through the surveyed locations:
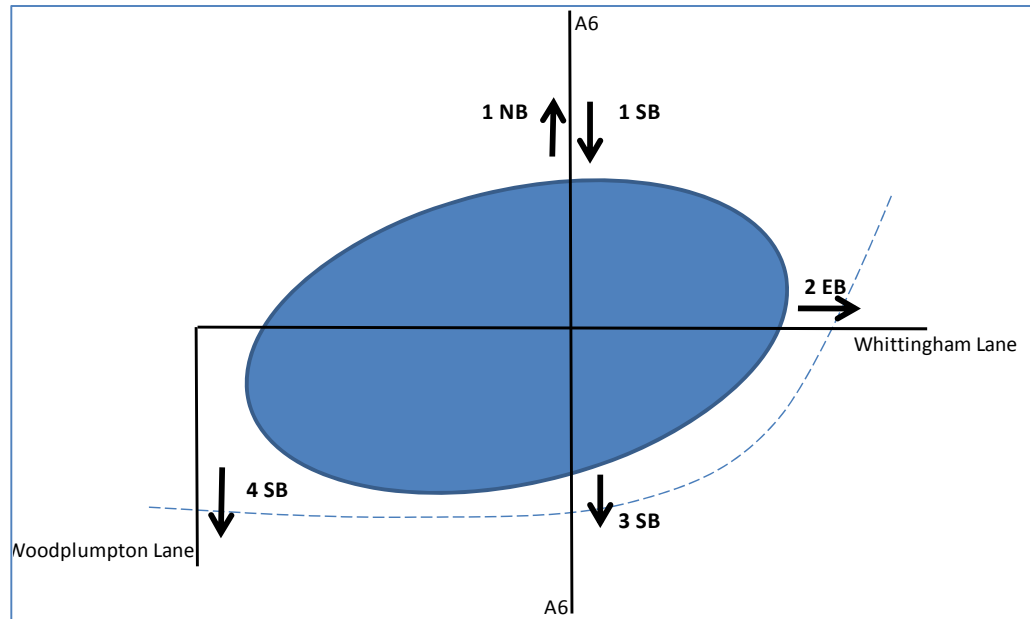
Figure 7-D   RSI Location Schematic

RSI site locations are shown as arrows indicating the location and direction of the survey.

The first point to note is that any trips observed across the screenline, shown above as a blue dashed line MUST have been separate trips. It would not be possible for a single trip to be observed at more than one of the three survey locations on that screenline; such a trip would be completely incomprehensible. This therefore rules out the possibility that any trip across the screenline could be double counted and it is therefore acceptable for the observed trip matrices (for each time period and trip purpose) from these three sites to be simply added together to create an 'observed screenline' matrix. The variance matrix from each site was added together in a similar fashion.

The screenline matrices (for each time period and trip purpose) were then combined with the matrices from site 1 SB. In this case, it is quite possible for a single trip to have been observed at both sites 1 SB and a survey site on the screenline. Combining the matrices therefore needed to pay heed to this possibility and deal with similar trips appropriately. To that end, the matrices were merged according to the methodology used with the DfT's ERICA software, that is, to calculate an index of dispersion, and use that as a weight to calculate a weighted average trip. The index of dispersion for a given zone to zone movement is calculated according to the formula below:

$$I_{ij} = \frac{Var_{ij}}{\sum_n e_{ij}}$$

Where I_{ij} is the index of dispersion for the trip between zone *i* and zone *j*, Var_{ij}, *n* and *e* are as defined in the previous equation.

The merging of the matrices then uses the following equation:

$$T_m = \frac{T_1 I_2 + T_2 I_1}{I_1 + I_2}$$

Where T_m is the merged trip, T_1 and I_1 are respectively the trip and index of dispersion for the first matrix and T_2 and I_2 are respectively the trip and index of dispersion for the second matrix.

The above method was used where movements between a particular ij pair were present in *both* matrices.

Where a particular ij trip is zero in one matrix and non-zero in the other, the non-zero trip arises either because the particular trip was not recorded (due to sampling only a limited number of vehicles through the site) or because the trip was genuinely not present at the survey site. Given the relative proximity of the 1 SB site and the screenline, the only way in which an ij movement could genuinely be observed at one site but not the other is if the trip either started or finished at a location between the two, i.e. within the blue shaded area of the schematic. In this case, it would not have been possible for that trip to be double counted, so for those trips, the merged matrix takes the trips entirely from the matrix where it was observed; the weighted average method is not required.

If the ij movement does not fall into that criterion, then the non-zero could only have arisen because the trip was not observed due to sampling only a portion of all trips through a site. In this case, it would have been necessary to estimate the level of confidence (i.e. the index of dispersion) in the zero trip to then calculate a weighted average. One approach to this is to use an average index of dispersion based on the trip matrix as a whole (rather than just for a single ij pair) as an estimate of the index of dispersion for the zero observation. This method was originally tried but ultimately when checked led to too few trips in the merged matrix. Instead, rather than a weighted average, the merged trip was simply based on the number of trips from the one matrix where the ij movement was observed, factored down by the ratio of the number of sites at which the trip is observed to the number of times it is expected to be observed. Thus if a particular ij pair is expected at two different survey sites, but is only observed at one of them, the ij cell in the final merged matrix is factored by 1/2. This method yielded the best results (as detailed in section 7.3.5).

Finally, the observed matrix created from the survey at site 1 northbound was added in. Since this survey only picked up trips travelling in the northbound direction and all other sites surveyed trips travelling southbound or eastbound it would have been impossible for a single trip to appear at site 1 NB and any of the other sites. Therefore, there is no possibility of double counting, and the trip matrix can simply be added to the matrix produced by merging the 1 SB and screenline matrices.

The entire procedure is illustrated in the flow chart below:
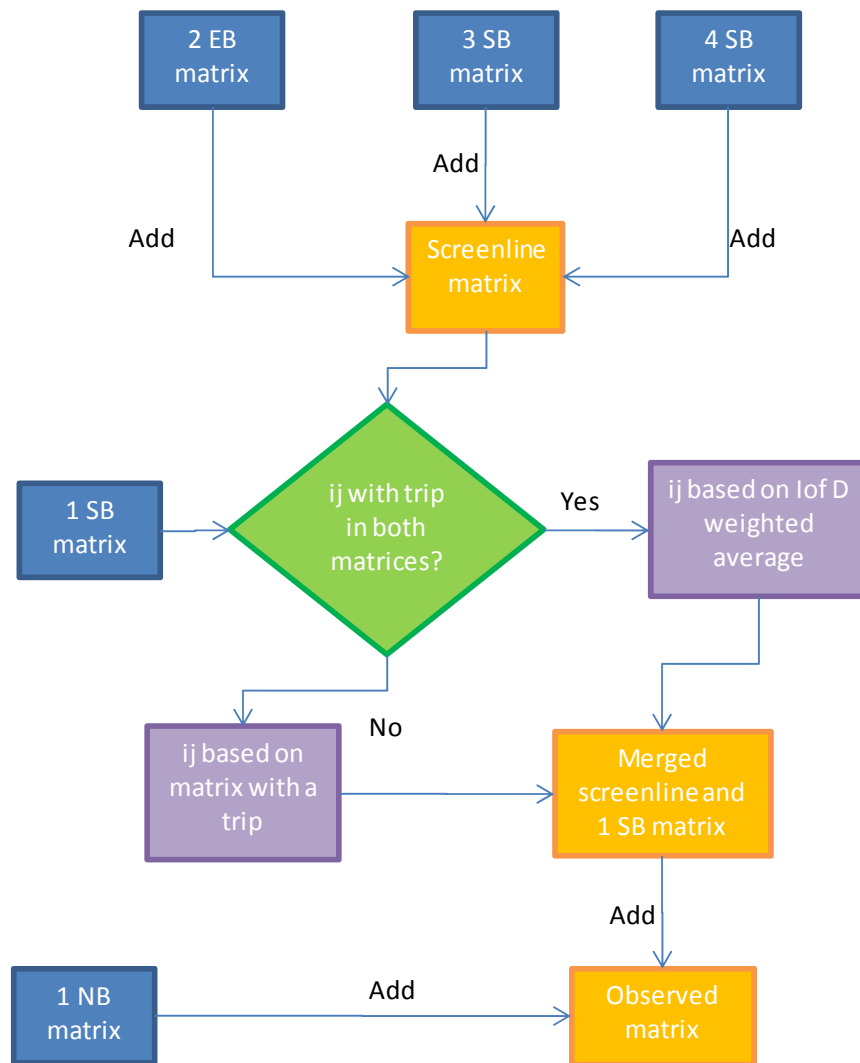
Figure 7-E   Matrix Merging Flow Chart

7.3.5   Observed trip matrix validation

The observed matrices were checked by assigning the final observed matrix to the modelled network, in order to check how well the assigned flows replicate the counts collected during the RSI surveys. In theory, since all the trips observed at the RSI surveys were added into the observed matrices, there is no reason why the modelled flows should be different to the observed flows.

In practice, there are a number of reasons why this may not be the case. First of all, it may not be possible to ensure that the paths used in the model are the same as used in real life; by assigning only the observed trip matrix, the model will be relatively uncongested, and all the real-life impacts on route choice will be absent. Also, because each RSI survey represents only a sample of trips, each different survey will have a slightly different 'version' of the trips running through the area. The process of combining the matrices from different sites seeks to address this issue, but it will not be possible to completely eliminate any discrepancies between different sites.

To address the issue of the modelled assignment using different paths, a distance only based assignment was used, meaning paths were chosen on the basis of shortest distance. Additionally, as much as possible, paths are restricted to only those which go through the location of an RSI site. This was done by banning links on alternative routes.

The flows resulting from an assignment of the AM peak matrix is shown below:

Figure 7-F   Assigned Observed Matrix Flows

The comparison of assigned RSI flows against RSI counts is presented below:

Site	Direction	Location	Observed	Modelled	% Difference
1	NB	A6_NB	527	434	18%
1	SB	A6_SB	675	820	-22%
2	EB	B5269 west of A6_EB	265	62	77%
3	SB	Woodplumpton Road @ Whittle Hill_SB	315	64	80%
4	SB	A6 just north of M55_SB	918	1,051	-15%

*Table 7-G**   **AM Peak Comparison*

Site	Direction	Location	Observed	Modelled	% Difference
1	NB	A6_NB	572	453	21%
1	SB	A6_SB	558	645	-16%
2	EB	B5269 west of A6_EB	211	57	73%
3	SB	Woodplumpton Road @ Whittle Hill_SB	100	55	45%
4	SB	A6 just north of M55_SB	785	810	-3%

*Table 7-H**   **Inter Peak Comparison*

Site	Direction	Location	Observed	Modelled	% Difference
1	NB	A6_NB	685	557	19%
1	SB	A6_SB	622	778	-25%
2	EB	B5269 west of A6_EB	291	95	67%
3	SB	Woodplumpton Road @ Whittle Hill_SB	203	61	70%
4	SB	A6 just north of M55_SB	844	960	-14%

*Table 7-I**   **PM Peak Comparison*

The assignment shows, by and large a good match between observed and modelled flows on sites on the A6. This is encouraging and suggests that the data from different sites has been merged correctly. It is noted that at sites 2 and 3, the comparison is quite poor, as the modelled flows are very low compared to the count. However, it is considered given the location of these sites that this discrepancy is a function of the crude assignment method used in the test, rather than a failure of the observed trip matrix.

An additional sense check on the data was to extract the trip purpose proportions from the final combined matrices for each time period. These are shown below:

Trip Purpose	AM	IP	PM
Home Based Work	54%	9%	35%
Home Based Employer Business	6%	4%	5%
Non-home Based Employer Business	4%	10%	4%
Home Based Education	5%	8%	4%
Home Based Shop	6%	18%	8%
Home Based Other	19%	40%	32%
Non-home Based Other	6%	12%	13%

*Table 7-J**   **Observed Trip Purpose Proportions*

The trip purpose proportions shown in the table above accord with general perceptions about travel at those times. The data also shows a good comparison

against the Tag Data book, which shows commuting vehicle trip proportions are 41%, 12% and 32% respectively in the AM, IP and PM periods. Business trip proportions in the data book are 7%, 8% and 6% which is somewhat lower than the business trips surveyed, however, it should be noted, that when considering distance travelled, the TAG data book values are higher. The values observed are between the TAG vehicle trip and vehicle distance proportions.

7.4   Trip Synthesis

Synthetic trip matrices were built using information from secondary data sources (i.e. those not collected directly for the purposes of building the model). For each zone in the model, the residential and workplace population was ascertained, to which trip rates were applied to estimate the total trip generation (in terms of productions and attractions) of the zone over a 24 hour period. These 'trip ends' were then used in combination with the generalised cost and an appropriate gravity model to distribute the trip ends across all zones in the model, and thereby generate a 24 hour production-attraction matrix for people in cars. This matrix was then converted from people to vehicles, from production-attraction to origin-destination, and from a 24 hour period to the specific time periods used in the model.

Each aspect of this process is described in more detail below.

7.4.1   Land Uses

The method for generating trip ends for each zone required certain specific information about the population and employment within each zone. Population data was gathered using the 2011 national census, a process which was facilitated by having zone boundaries based on Census output areas. Employment data was gathered from Business directory information. These two facets of land use are described in more detail in the following sections.

(a)   Population and demographics

The following aspects associated with the people living within each modelled zone were required for the purposes of generating trip ends:

Person types:
- *children (0 to 15)*
- *males in full time employment (16 to 64)*
- *males in part time employment (16 to 64)*
- *male student*
- *male not employed / students (16 to 64), unemployed, other Inactive*
- *male 65+*
- *females in full time employment*
- *females in part time employment (16 to 64)*
- *female student*
- *female not employed / students (16 to 64), unemployed, other Inactive*
- *female 65+*

Household types:
- *1 adult households with no car*
- *1 adult households with one or more cars*
- *2 adult households with no car*
- *2 adult households with one car*

-    *2 adult households with two or more cars*
-    *3+ adult households with no car*
-    *3+ adult households with one car*
-    *3+ adult households with two or more cars*

All of this required information can be ascertained from the 2011 Census Key statistics. This information was extracted for each output area in the country, and then aggregated from output areas to modelled zones. For zones that were generated by aggregations of district, county and regional boundaries forecasts data was taken from the National Trip End Model, which provides this information at a more aggregate level.

(b)   **Employment data**

To generate trip ends at the attraction end, data on employment within each zone was required. This included the number of jobs in pre-specified employment categories, as listed below:

-    *Primary and Secondary Education*
-    *Higher Education*
-    *Adult/Other Education*
-    *Hotels, Campsites etc.*
-    *Retail*
-    *Health/Medical*
-    *Services (business & other)*
-    *Industry, Construction and Transport*
-    *Restaurants & Bars*
-    *Recreation & Sport*
-    *Agriculture & Fishing*
-    *Business*

The number of jobs in each category was based on employment data provided by Blue Sheep, a B2B data services company. That data set is called the "Complete Business Universe" and is based on a variety of data sources including Companies House. The data set contains details of over 4 million workplaces (in theory, this includes all workplaces in the UK) and provides the number of employees by business type (using the UKSIC92 standard industrial classification) and location (locations are specified in British National Grid coordinates). The data also included profit and turnover, although this was not needed for the purposes of the model.

7.4.2 Trip Ends

With the zonal land uses established, trip rates derived from the National Travel Survey for each population demographic and employment category are applied to generate the total trip generation within each zone. The trips are segregated by trip purpose, and at the production end are further split by time of day and car availability.

The whole process of applying trip rates to the land use data is done using a bespoke trip end modelling tool developed by Jacobs called "JTREND". This combines elements of CTripEnd, the trip end calculation programme used within the National Trip End Model (NTEM) and NATCOP, the car ownership model also used within NTEM. The resulting trip productions, when aggregated to NTEM zone boundaries, are consistent with outputs from Tempro, using the NTEM 6.2 dataset.

7.4.3 Trip Distribution

The trips are distributed using a gravity model, the general formulation of which is given below:

$$T_{ij} = k_{ij}P_iA_jf(U_{ij})$$

Where, for each ij pair,

T is the number of trips between production i and attraction j,
P_i is the total number of trip productions for zone i,
A_j is the total number of attractions for zone j and
$f(U)$ is a function of the utility (see below).

k is a scaling factor determined such that the row and column totals of the resulting trip matrix matches the total productions (P) and attractions (A) for each zone.

For the Broughton Bypass model, the gravity formulation was a negative exponential function, and the utility was generalised cost. The function is shown below:

$$f(U_{ij}) = e^{-\lambda U_{ij}}$$

Where λ is a calibration parameter to be modified in order to produce the desired trip length distribution.

The gravity model was calibrated to reproduce average trip lengths by journey purpose from the National Travel Survey (2013). These are reproduced below:

Trip purpose	Mean trip length (km)
Home Based Work	16.05
Home Based Employer's Business	33.14
Home Based Education	6.65
Home Based Other	17.76
Home Based Shopping	9.67
Non Home Based Employer's business	16.05
Non Home Based Other	17.76

Table 7-K   Mean Trip Length by Journey Purpose

The model was applied to 24 hour production and attraction trip ends by trip purpose, to produce a production-attraction (PA) matrix for an average 24 hour weekday period. Productions by time period (produced by JTREND) were used to split the 24 hour matrix into PA matrices by time period, and so-called 'phi factors' were used to convert the PA matrices into origin-destination (OD) matrices. The phi factors determine for each outbound trip (i.e. from the production end to the attraction end) by time period and trip purpose, what the likely time period and trip purpose of the return trip will be.

For example, the morning period, home based work trip purpose PA matrix will contain a number of trips between a production (home) and attraction (work). The PA matrix effectively provides the OD matrix for the outbound (from home) trip. The PA matrix also contains details of the return trip (back home from work) and the phi factors specify in what time period the trip will return, and what the trip purpose would be. The return trip purpose may be different to the outbound trip purpose if for

example the individual stopped at the shops on the way home from work (the return trip purpose would therefore by home based shopping). There are a set of phi factors for morning peak home based work trips, which determine what the return trip purpose and time period. In the specific example the following proportions are applied to the return trips (note due to rounding figures below add to 99%):

- *63% of trips will return as a home based work trip in the evening peak,*
- *19% will return as home based work in the interpeak,*
- *8% will return as home based work in the off peak*
- *4% will return as home based work in the morning peak*
- *2% will return as home based shopping in the evening peak*
- *2% will return as home based employers business in the evening peak*
- *1% will return as home based shopping in the interpeak*

Similar factors are specified for all combinations of outbound trip purpose and time period.

The result applying the phi factors is OD matrices by time period and trip purpose. For each time period, the matrices by trip purpose were aggregated to the user classes in the model. A vehicle occupancy factor was then used to convert the matrices from person trips to vehicle trips, and a further factor applied to convert from the time period to the modelled hour. The occupancies were derived from the RSI surveys.

7.4.4   Synthetic matrices – goods vehicles

The method used to generate trip ends for cars could not be applied to produce trip ends for LGVs and HGVs. This is because it relied on use of NTEM data, which is concerned only with private, rather than freight or business, trips. Therefore, an alternative methodology was employed.

In considering the method to be used, due regard needs to be given to the amount of detail required. Goods vehicles make up only a small proportion of all vehicles, and therefore will have much less of an impact in determining scheme impacts than cars will. For example, LGVs and HGVs combined make up just 15% of vehicles on the A6 to the north of Broughton crossroads in the AM peak, and only 11% in the PM peak. In the Interpeak, the value is higher at 18%, but still relatively low. In addition there is much less data available on goods vehicle movements than car movements and that which is available is considered less reliable. The lesser importance of these vehicles and the limited data availability determined that a much simpler method could be employed in creating synthetic matrices, with no loss of reliability in the end result.

The alternative methodology used OGV trip rates extracted from TRICS as a proxy for HGV trips. The rates were calculated on a "per job" basis for each of the employment land use categories identified in section 7.4.1, to generate the total HYGV OD trip ends per zone. LGV trip ends were calculated by applying a factor to the HGV trip ends. The factor itself was derived from count data and represented the relative proportion of LGVs compared to HGVs.

Trips were then distributed using the same distribution function and parameters applied to the 'non-home based employers business' trips for cars.

7.4.5 Synthetic matrix factoring

The synthetic trip matrices were assigned to the modelled network to check how well they replicated observed flows. The assignment used free flow journey times for the purposes of route choice ensuring that any unusual routing patterns (caused for example by an insufficiently calibrated network) were minimised.

The check was made on a screenline basis for cars only, using four screenlines drawn up around Broughton. These screenlines are illustrated below:
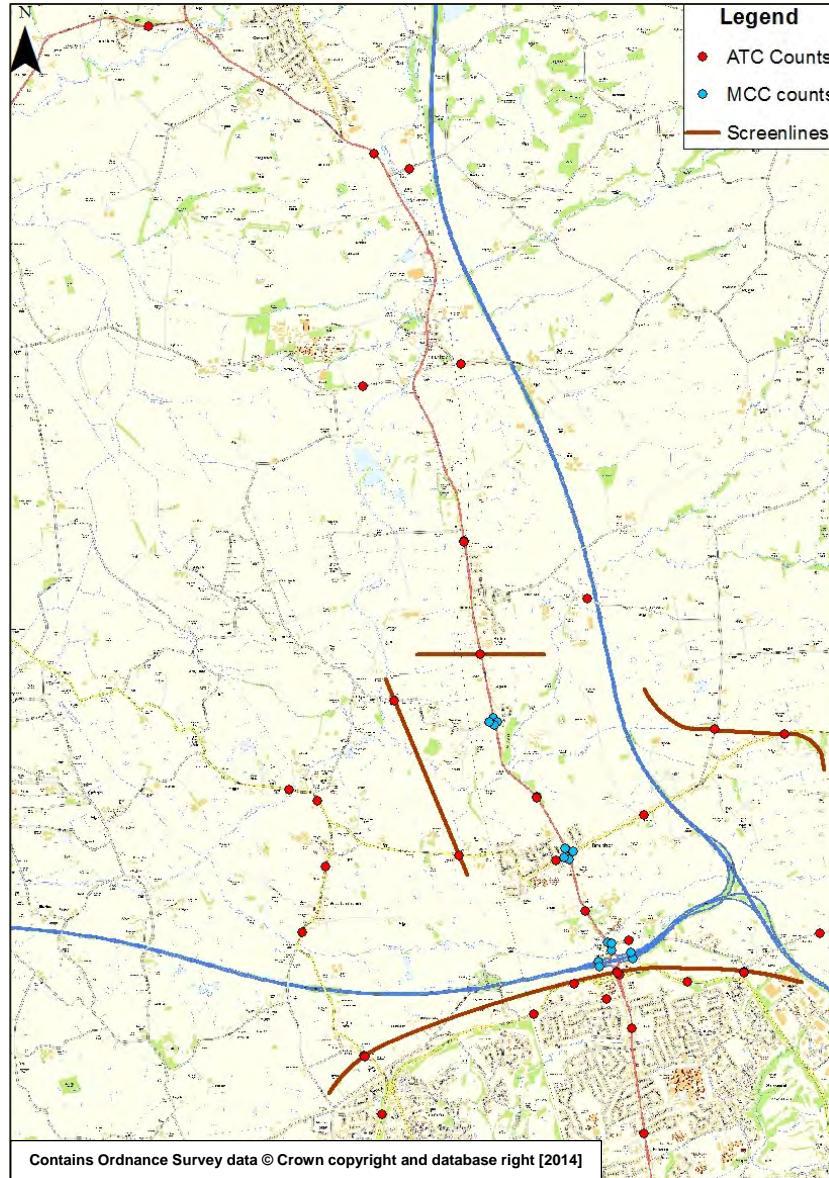
Figure 7-G   Screenlines Used in the Model

The trip matrices were factored to ensure that the total assigned flows across the screenline matched the counts as much as possible. The factoring was applied only to those trips crossing the screenlines.

For LGV and HGV matrices, a check was made only on how well the assigned flows replicated the screenline flows *as a whole*. A single global factor was applied to ensure that the total flows and counts were a close match.

The synthetic trip matrix totals are summarised below:

Trip purpose	Time period					
	AM	%	IP	%	PM	%
Business	504,540	8%	418,890	9%	477,585	6%
Commute	3,905,640	59%	817,358	18%	3,159,427	41%
Other	2,201,237	33%	3,294,210	73%	4,048,614	53%

Table 7-L   Synthetic trip matrix totals

Compared against the TAG data book, the business trip proportions are very similar. The commuting proportions are slightly higher than the values given in table A1.3.4 of the data book, and the other proportion slightly lower, although broadly, the proportions are within ten percentage points.

7.4.6   Synthetic matrix validation

The synthetic matrices were validated by comparing their trip length distributions against that of the observed matrix and also those of the NTS. That comparison is shown below:
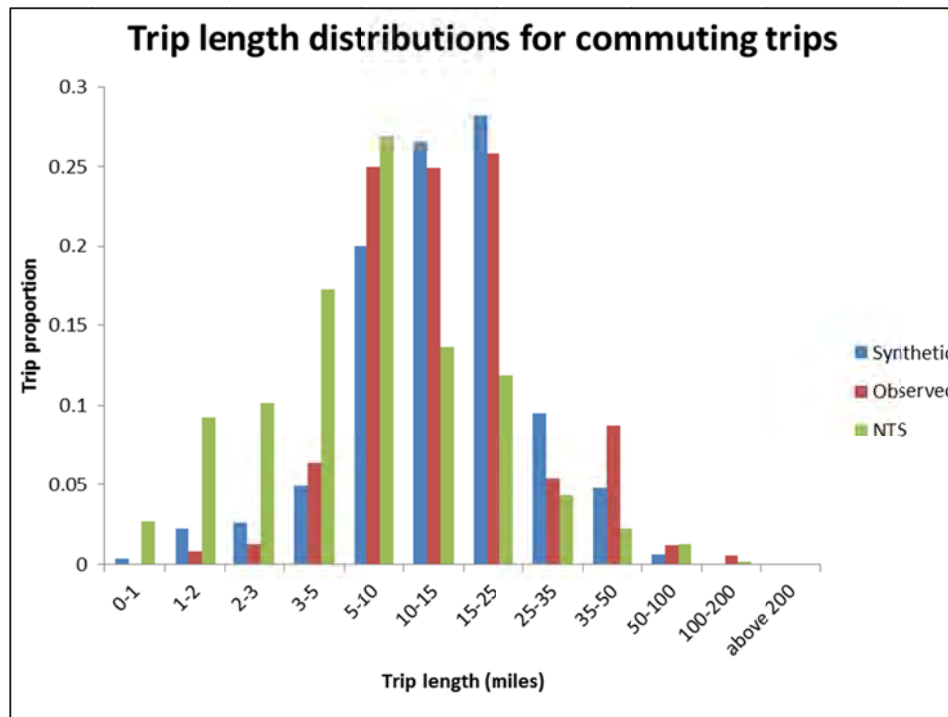
Figure 7-H   Trip Length Distributions for Commuting Trips
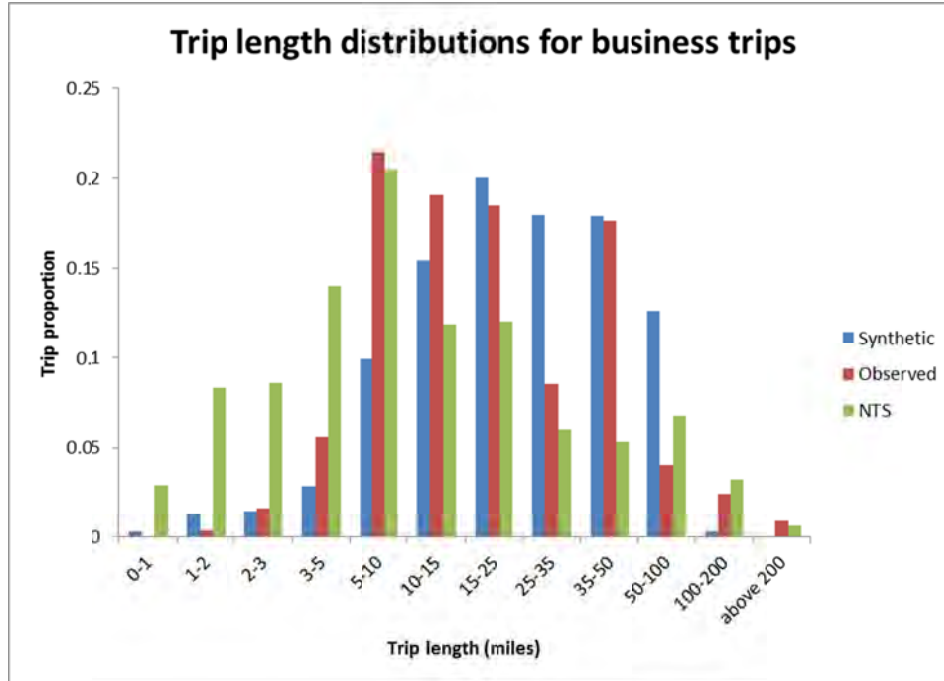
Figure 7-I   Trip Length Distributions for Business Trips
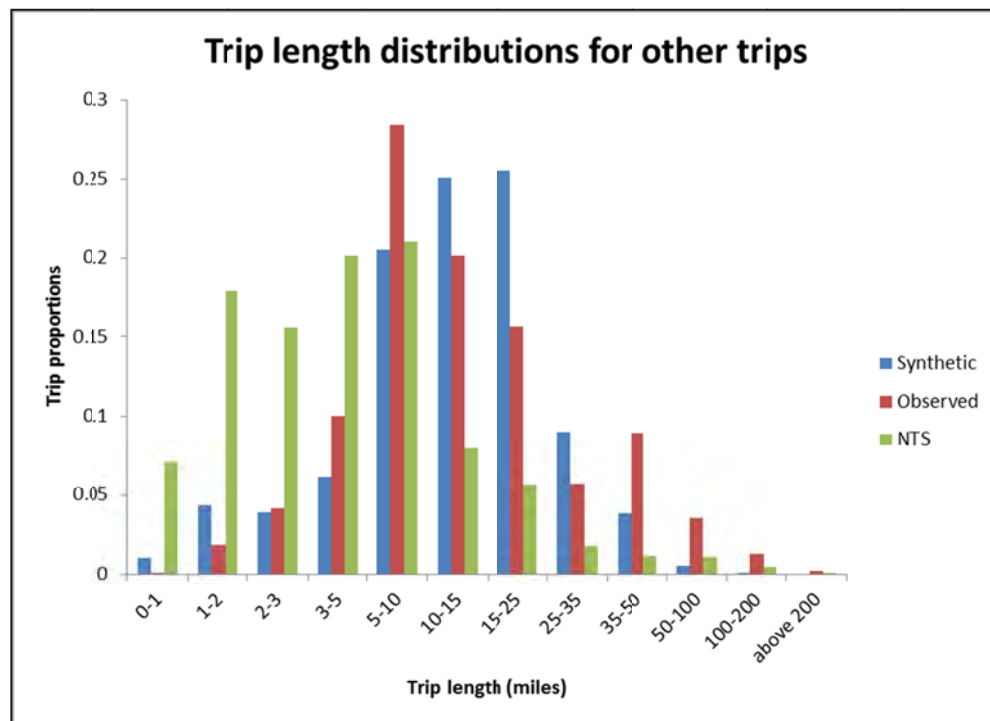
Figure 7-J   Trip length distributions for other trips

As the NTS data is given for all trips regardless of time period, the synthetic and observed data included in the graphs are similarly for all time periods combined. Note also that the graph shows, for each type of data, the relative proportion of the

total trips at each distance band, rather than the absolute totals. Showing absolute totals would render any comparison impossible.

The matrices were also checked by comparing the assigned flows across screenlines against the total count, as described in the previous section. That comparison is shown below:

Screenlines	AM			IP			PM		
	Obs.	Mod.	% Diff.	Obs.	Mod.	% Diff.	Obs.	Mod.	% Diff.
Southern (NB/EB)	1,697	2,019	19%	1,038	1,221	18%	1,767	2,093	18%
Southern (WB/SB)	2,174	2,444	12%	1,063	1,269	19%	1,935	2,210	14%
Eastern (NB/EB)	209	194	-7%	145	132	-9%	200	179	-11%
Eastern (WB/SB)	163	183	12%	150	136	9%	221	265	20%
Western (NB/EB)	248	230	-7%	96	95	-1%	244	231	-5%
Western (WB/SB)	328	322	-2%	94	94	0%	210	202	-4%
Northern (NB/EB)	470	391	-17%	460	412	-11%	630	629	0%
Northern (WB/SB)	429	372	-13%	436	388	-11%	546	437	-20%

Table 7-M   Comparison of Total Flows Across the Screenlines

The route choice used in the assignment of the synthetic matrices was based on free flow travel times, to negate the impact of inappropriate delays in the early stages of network development. The comparison shows that for all screenlines, the differences between the modelled and observed flows were never greater than twenty per cent. Given that this comparison arose from matrices which were entirely synthetic, this was considered a satisfactory outcome. Further work on reducing the differences was attempted, however, in improving the match across one screenline, it invariably made the comparison worse across the other screenlines.

7.5   Merging Data from Surveys and Trip Synthesis

Once created, the observed and synthetic trip matrices were merged together to form a single trip matrix for each time period and trip purpose. The general principle of this merging process is that where the RSI surveys intercepted a trip between a given origin and destination pair, the merged matrix should be based in some way on observed data. For an origin-destination pair that were not intercepted by the RSI surveys, the merged matrix should be based on the synthetic trips. This principle is complicated by the fact that the observed matrix is based on a sample of data, i.e. not all origin-destination movements that went through the RSI survey sites were surveyed. Those trips that were surveyed were expanded to account for those trips that were missed, and whilst this leads to an observed trip matrix with the correct total number of trips, it is over-representative of trips that were sampled and does not at all represent the trips that were missed. The matrix is considered to be 'lumpy'. Before the observed matrix could be merged with the synthetic matrix it needed to be 'smoothed'. The smoothing process is described below. It was used for car and LGV trips, but not HGV trips (observed HGV data was not used in the final matrix).

7.5.1 Smoothing observed trip matrices

As described above, because the RSI surveys only intercepted a sample of all trips, the resulting observed trip matrix is lumpy. Rather than having a small number of trips for all the origin-destination pairs that travelled through the survey site, the matrix has a large number of trips for the (relatively) small number of origin-destination pairs that were actually surveyed. This apparent bias in the observed matrix needed to be removed before the data could be merged with the synthetic trip matrices.

The principle behind the 'smoothing' process was to take the large trip volumes from the small number of origin destination pairs, and portion them out to other origin-destination pairs representing a similar movement, which did not have any observed trips. In such a way, there would be more cells in the matrix containing trips, with no single cell containing inordinately more trips than any other.

For each non-zero cell in the observed matrix, the origin and destination was noted and a cluster of 'candidate' origin and destination zones were selected. These candidate zones were selected based on distance from the original zone; all zones within 2.0 km (as defined by a free flow distance skim from the model) were considered candidates. All movements between the set of candidate origin zones and the set of candidate destination zones were represented by a block of cells in the trip matrix, and the observed trip was apportioned out to these cells. The proportions used were based on the relative proportions of the same block of cells in the synthetic trip matrix. This was done for all non-zero cells in the observed matrix.

The matrix resulting from this process is considered a 'smoothed' matrix and suitable for merging with the synthetic trips.

7.5.2 Merging smoothed observed and synthetic matrices

The smoothed observed and the synthetic matrices were merged together by taking a simple average. If the smoothed observed matrix did not have any trips for a given origin-destination pair, then it was because such a movement could not be observed at the RSI sites and therefore the merged matrix was based on the synthetic value only.

Sectored matrices showing combined car and LGV trips for the synthetic, smoothed observed and merged matrices are summarised below. In the tables, any cells with synthetic trips greater than 2,000 are highlighted, as are any with observed trips greater than 100:

Sectors	North Preston	South Preston	Wyre	Blackpool	Fylde	Ribble Valley	South Ribble	Chorley	Pendle/Burnley/Rossendale/Blackburn/Darwen	Rest of the UK
Synthetic										
North Preston	208	318	204	86	140	113	95	66	94	75
South Preston	331	9302	482	411	983	464	1794	682	960	1298
Wyre	198	564	7781	2039	1394	240	299	216	314	667
Blackpool	124	611	2707	11620	2603	151	265	183	278	516
Fylde	108	887	1222	1434	4394	136	467	269	343	326
Ribble Valley	156	575	279	118	211	4254	285	261	365	257
South Ribble	107	2737	311	218	734	313	3597	1479	1812	1438
Chorley	78	913	248	152	477	296	1797	6119	2126	1217
Pendle/Burnley/Rossendale/Blackburn/Darwen	135	1590	453	287	742	495	2631	2666	44754	2052
Rest of the UK	97	1894	961	385	565	253	1385	1229	1484	6496821
Observed										
North Preston	70	283	36	14	37	20	49	19	17	41
South Preston	44	1	118	0	0	6	0	0	0	7
Wyre	26	349	2	9	15	22	60	28	46	119
Blackpool	8	2	7	0	0	2	2	2	0	2
Fylde	10	8	16	0	0	5	0	0	0	0
Ribble Valley	3	7	27	6	13	0	0	0	2	1
South Ribble	19	2	50	0	0	1	0	0	0	2
Chorley	7	0	35	0	0	0	0	0	0	0
Pendle/Burnley/Rossendale/Blackburn/Darwen	5	0	45	0	0	0	0	0	0	0
Rest of the UK	23	35	75	0	3	4	8	0	2	3
Merged										
North Preston	223	414	216	87	129	119	103	68	95	93
South Preston	342	9302	510	411	983	452	1794	682	960	1294
Wyre	207	671	7782	2015	1388	245	313	223	326	717
Blackpool	121	611	2685	11620	2603	125	265	169	278	483
Fylde	108	875	1220	1434	4394	132	467	269	343	326
Ribble Valley	152	576	286	101	200	4254	285	261	365	257
South Ribble	109	2733	318	218	734	311	3597	1479	1812	1439
Chorley	80	913	253	152	477	296	1797	6119	2126	1217
Pendle/Burnley/Rossendale/Blackburn/Darwen	137	1590	464	287	742	495	2631	2666	44754	2052
Rest of the UK	102	1852	990	385	551	250	1378	1229	1480	6496816

Table 7-N   AM Peak Sector Matrices

Sectors	North Preston	South Preston	Wyre	Blackpool	Fylde	Ribble Valley	South Ribble	Chorley	Pendle/Burnley/Rosendale/Blackburn/Darwen	Rest of the UK
Synthetic										
North Preston	105	178	106	66	59	87	67	51	75	48
South Preston	183	5499	290	257	403	367	1414	457	698	867
Wyre	117	316	5726	970	815	149	168	120	175	430
Blackpool	68	259	847	7795	831	111	160	116	184	237
Fylde	62	395	760	869	2738	77	244	138	183	156
Ribble Valley	93	407	168	137	90	2275	282	263	356	185
South Ribble	64	1329	141	143	212	205	2100	1073	1332	732
Chorley	49	399	99	106	121	196	1077	3994	1491	649
Pendle/Burnley/Rosendale/Blackburn/Darwen	84	714	171	201	191	311	1556	1759	27669	1024
Rest of the UK	61	1189	570	303	179	179	924	809	1058	4485637
Observed										
North Preston	51	202	39	12	13	16	33	6	12	34
South Preston	68	1	161	2	1	6	0	0	0	20
Wyre	39	244	2	8	16	15	64	22	36	108
Blackpool	5	1	11	0	0	3	0	0	0	3
Fylde	11	2	15	0	0	4	0	0	0	6
Ribble Valley	7	6	15	4	0	0	1	0	0	3
South Ribble	16	0	32	0	0	2	0	0	0	3
Chorley	2	0	19	0	0	0	0	0	0	1
Pendle/Burnley/Rosendale/Blackburn/Darwen	2	1	22	0	0	0	0	0	0	0
Rest of the UK	13	33	73	1	5	6	7	2	5	18
Merged										
North Preston	120	245	118	62	56	86	69	44	71	60
South Preston	198	5498	331	254	403	335	1414	457	697	843
Wyre	126	387	5705	931	801	142	178	103	161	474
Blackpool	64	257	823	7795	831	78	160	116	173	186
Fylde	62	394	752	869	2738	73	244	138	183	153
Ribble Valley	92	409	170	123	90	2275	268	263	356	185
South Ribble	67	1320	147	143	212	191	2100	1073	1332	730
Chorley	48	399	84	106	121	180	1077	3994	1491	631
Pendle/Burnley/Rosendale/Blackburn/Darwen	84	675	173	201	191	311	1556	1759	27669	1024
Rest of the UK	66	1152	595	247	174	176	910	770	1040	4485589

Table 7-O   Inter-Peak Sector Matrices

Sectors	North Preston	South Preston	Wyre	Blackpool	Fylde	Ribble Valley	South Ribble	Chorley	Pendle/Burnley/Rosendale/Blackburn/Darwen	Rest of the UK
Synthetic										
North Preston	124	288	186	110	98	127	82	72	116	77
South Preston	273	8836	523	414	656	403	3992	640	1051	1742
Wyre	182	565	7642	2495	1258	244	199	242	402	611
Blackpool	123	514	2541	12087	1803	139	173	194	341	493
Fylde	152	944	1594	2280	4429	173	447	408	604	472
Ribble Valley	113	475	236	130	127	3835	185	301	461	236
South Ribble	68	3081	160	118	244	117	3770	671	984	1341
Chorley	90	775	280	204	313	283	983	6114	2924	1339
Pendle/Burnley/Rosendale/Blackburn/Darwen	139	1261	441	348	452	427	1396	2824	45958	1841
Rest of the UK	90	1805	658	461	358	247	1776	1255	2042	7612364
Observed										
North Preston	71	221	28	16	28	15	55	28	19	41
South Preston	97	0	224	0	0	6	0	0	0	35
Wyre	45	259	0	9	23	24	80	54	49	111
Blackpool	7	0	12	0	0	3	0	0	0	0
Fylde	19	3	20	0	0	11	1	0	1	5
Ribble Valley	9	7	15	3	8	0	2	0	0	0
South Ribble	5	1	43	0	0	1	0	0	0	3
Chorley	2	0	15	0	0	1	0	0	0	1
Pendle/Burnley/Rosendale/Blackburn/Darwen	12	0	44	0	2	0	0	0	0	2
Rest of the UK	30	47	71	0	0	11	11	5	5	15
Merged										
North Preston	145	360	195	100	103	130	98	75	114	90
South Preston	307	8836	593	414	656	399	3992	640	1040	1695
Wyre	189	658	7642	2464	1260	239	225	249	379	658
Blackpool	118	514	2525	12087	1803	120	173	194	325	493
Fylde	149	935	1580	2280	4429	159	448	408	601	462
Ribble Valley	116	474	238	115	129	3835	186	301	461	236
South Ribble	70	3075	175	118	244	116	3770	671	984	1328
Chorley	89	775	273	204	313	282	983	6114	2924	1307
Pendle/Burnley/Rosendale/Blackburn/Darwen	144	1261	444	348	451	427	1396	2824	45958	1830
Rest of the UK	101	1753	675	461	358	251	1746	1228	2018	7612355

Table 7-P   PM Peak Sector Matrices

The tables show that combining the trip matrices in this way ensures that the merged trip matrix total is similar to the synthetic trip matrix total. This is to be expected given that the synthetic matrix approximates all trips in the study area (and beyond) whereas the observed matrix is representative only of those trips that would be expected to travel through one of the RSI site locations. The pattern of changes demonstrates that where there isn't any observed data, the sector matrix value is the same as in the synthetic matrix. Where observed data is present (for example between North and South Preston and Wyre), the merging generally increases the number of trips from that in the synthetic matrices.

8 Network Calibration and Validation

8.1 Network checking and calibration

Based on the coded characteristics of each link, a number of checks of the network were made. The first of these was the standard network check offered by the modelling package, which checked things like network connectivity and illogical coding of junctions.

A network check list, informed by advice in TAG Unit M3.1 was created and the model was checked against each aspect of the list. The list is reproduced in Appendix H.

Additional checking focussed on the coded attributes of the links, including link speeds, number of lanes and capacity, as detailed below.

Free flow link speeds are a function of the link type (as specified in Appendix A). The free flow speeds in the model were checked by plotting the links in GIS and colouring them according to speed, in bands of 10km/h. This plot is shown below for the detailed study area:
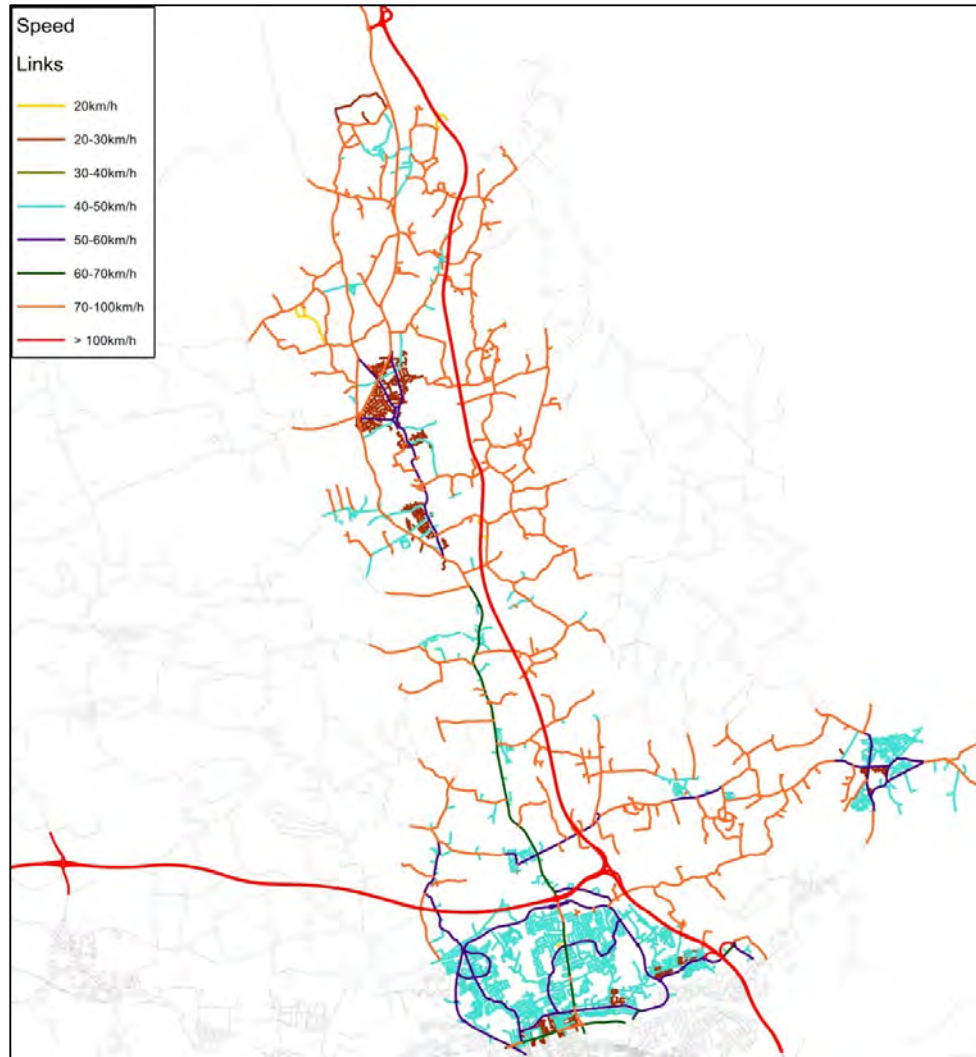
Figure 8-A   Modelled Link Speeds

The plot shows that urban areas such as Preston, Broughton and Longridge had coded free flow speeds of around 40-50kph on residential streets, and 50-60kph on main through roads. These speeds generally accord with speed limits and driver behaviour in those areas. In rural areas the free flow speed was between 70kph and 100kph; these roads are national speed limit roads. Finally, it's notable that the free flow speed on the M6 and M55 was in excess of 100kph, as would be expected for a motorway.

The coded number of lanes was plotted in a similar manner, with the plot of this shown below, and the results cross checked against local knowledge, Google Earth and Google Street View:
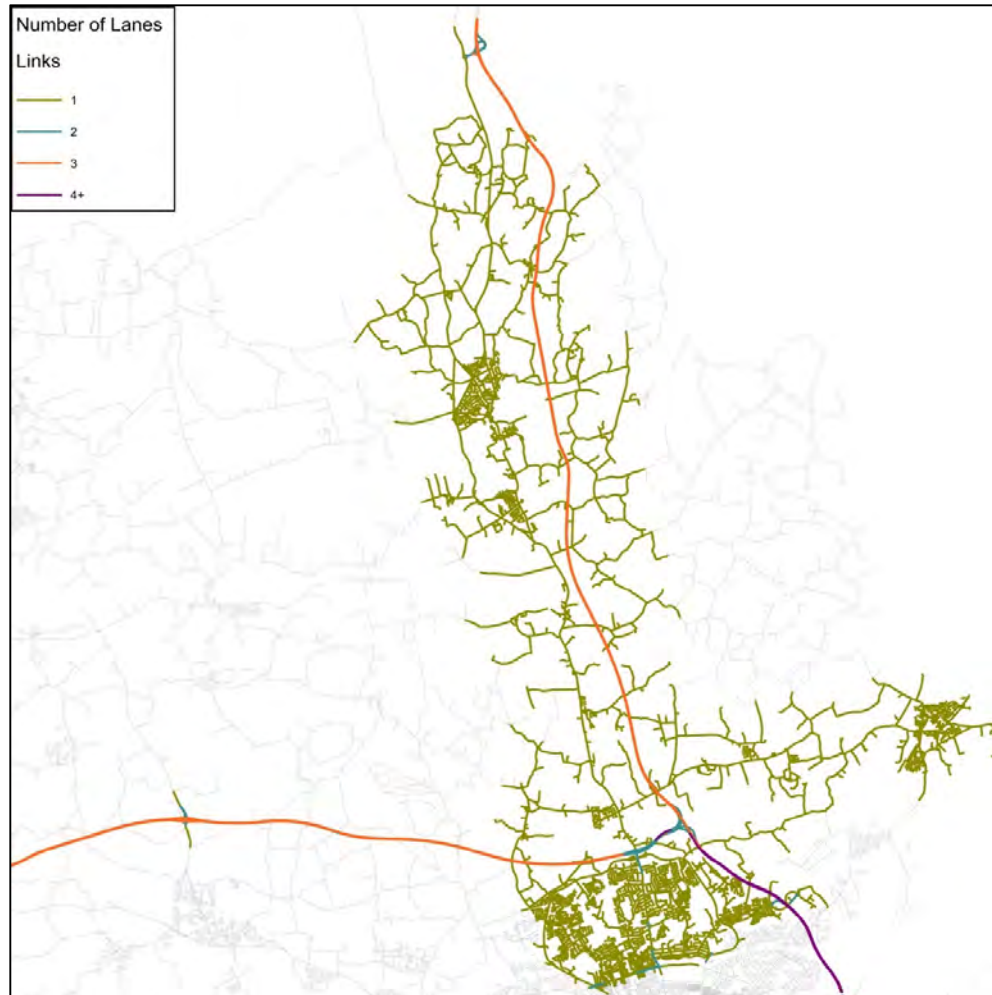
Figure 8-B   Number of Lanes in Various Link Types

The plot shows that, with the exception of the motorway, all links were coded as a single lane, as expected from knowledge of the local area. It should be noted that junction flares, where the number of lanes increases at stop lines, were not reflected in the link type; these were included as part of the individual junction coding.

Link capacity was checked in a similar fashion, as shown below, with capacity in bands of 500 vehicles an hour shown as different colours:
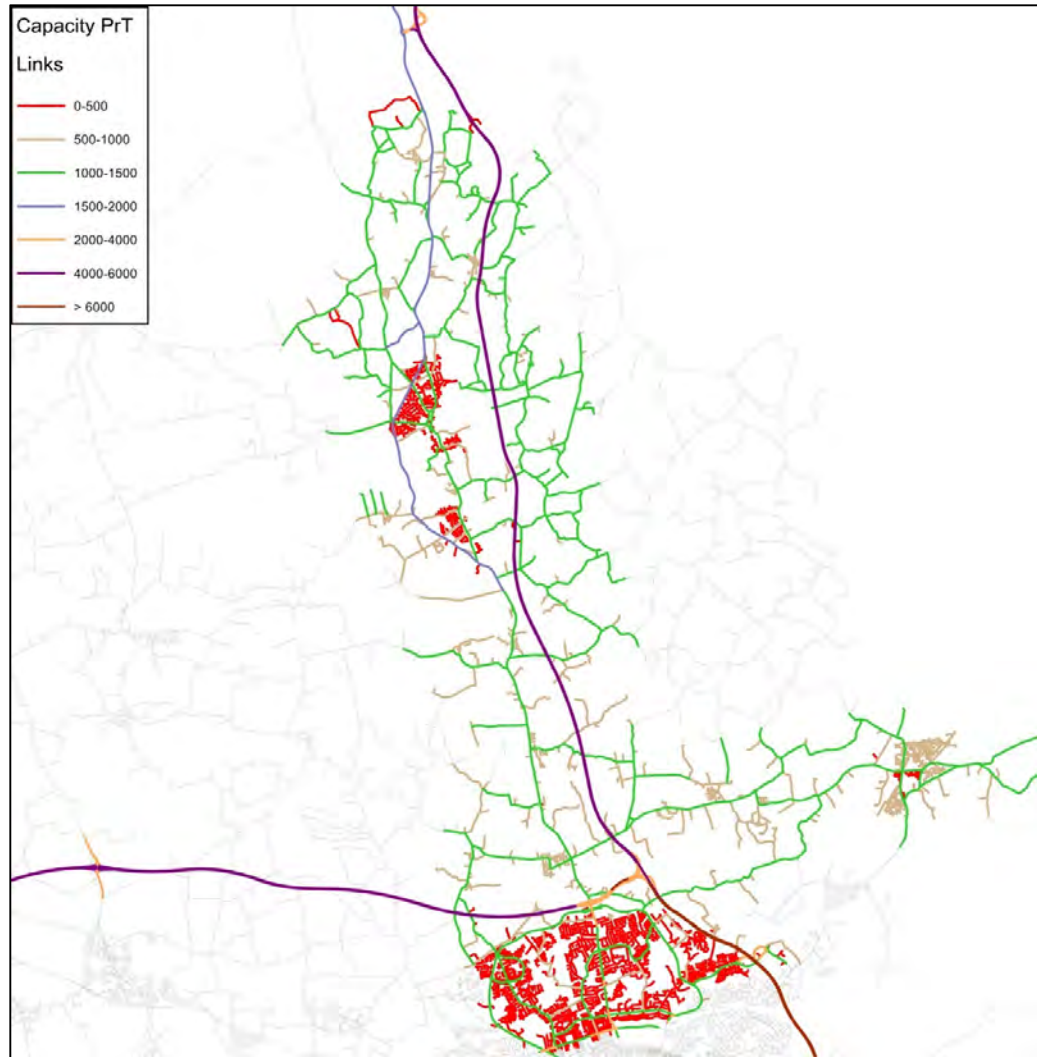
Figure 8-C   Capacity of Various Link Types

Urban residential roads show the lowest capacities of around 500 vehicles per hour or less, whilst motorways have the largest. Rural roads tend to have a capacity of around 1000-1500 vehicles per hour, although the A6 around and to the north of Garstang has a higher capacity.

To aid checks on the network, 'stress testing' was undertaken, in which the base year matrices were factored up and assigned to the network, to see where the increased demand leads to excessive delays. This more easily identified junctions which required coding changes.

Finally, it should be noted that checks were made to ensure that there was consistency of coding across all time periods, with only signal timings differing across the periods.

9   Route Choice Calibration and Validation

9.1   Routing through the modelled network

The model was further checked by examining shortest paths and minimum generalised cost routes through the network. These checks were done at an early stage of the model development, using an assignment of very early versions of the synthetic trip matrices, and again towards the end of the model development process, with later versions of the trip matrices. Major urban areas covered by the network were identified, and routes between them checked against local knowledge, common sense, and also routes suggested by the AA route-planner website and Google Maps. The urban areas identified are listed below:

- *Garstang*
- *Preston*
- *Blackpool*
- *Longridge*
- *Woodplumpton*
- *Broughton*
- *Blackburn*
- *Carlisle*
- *Birmingham*

All combinations of routes were checked, for a total of 72 routes, which far exceeds guidance on the number of routes to be checked. According to TAG unit M3.1, the number of routes that should be checked is defined by:

(Number of zones in model)$^{0.25}$ × number of user classes.

On that basis, with 245 zones and 5 user classes, 20 routes should be checked. The routes selected by combinations of the urban areas listed above all meet the criteria for routes which advises that they should:

- *Relate to significant number of trips*
- *Are of significant length*
- *Pass through areas of interest*
- *Include both directions of travel*
- *Link different compass areas*
- *Coincide with journey time routes as appropriate*

The route used in the model was assessed by checking both the shortest path, using the bespoke VISUM tool for the task, and also the assigned route. Some examples of the routes checked in the model are illustrated below, with the route shown in light blue:
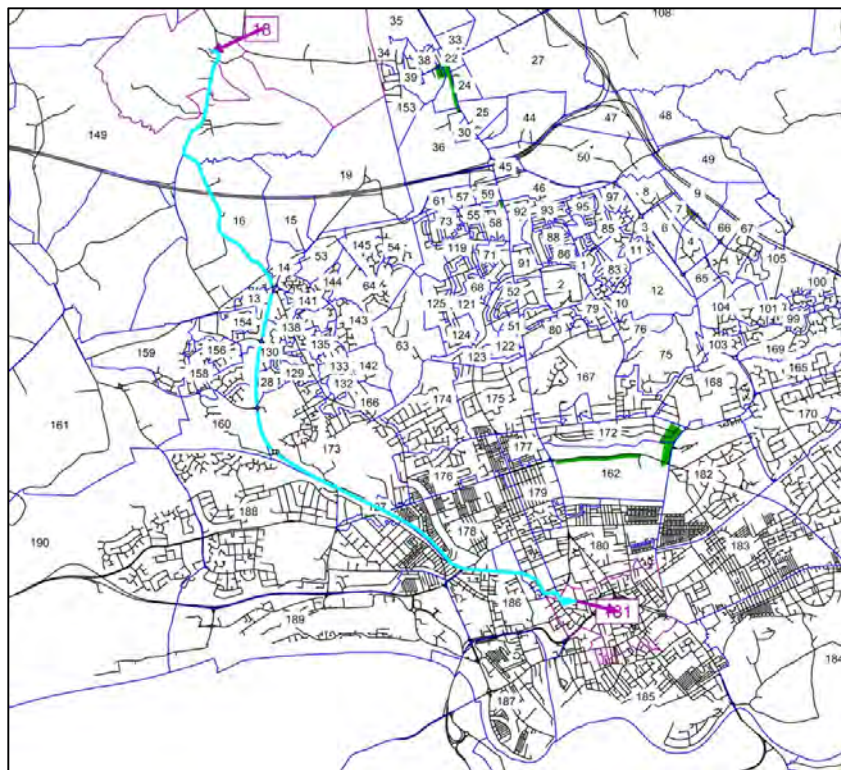
Figure 9-A   Modelled routing between Woodplumpton and Preston
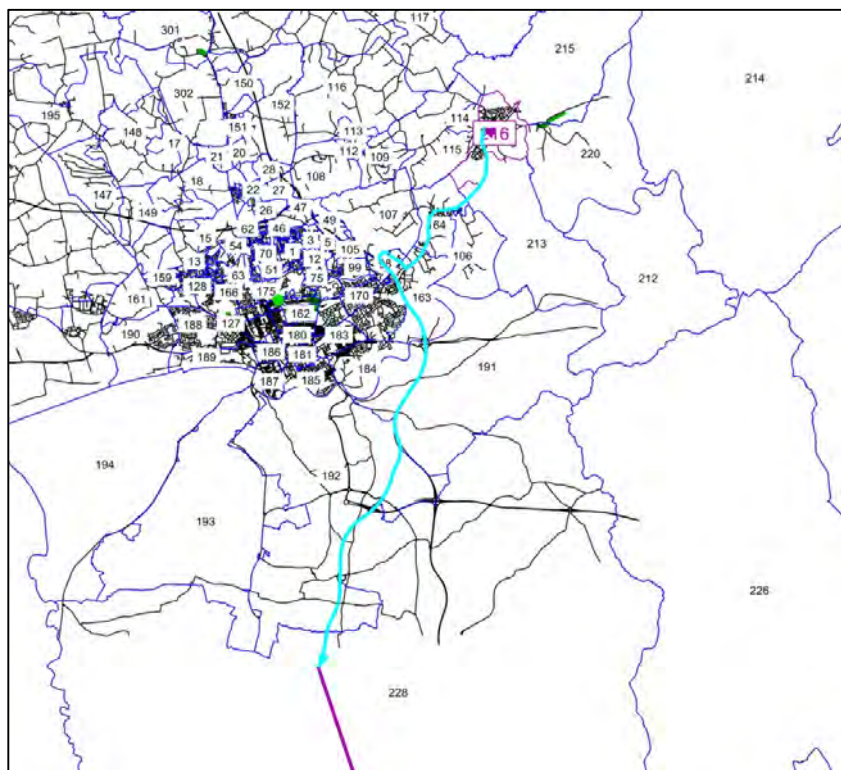
Figure 9-B   Modelled routing between Longridge and Birmingham

Figure 9-C   Modelled routing between Preston and Garstang

Where the route used in the model was contrary to expectations, the modelled network was adjusted to correct the route. In most cases a change of link type was sufficient to correct the route; in a small number of cases centroid connectors were altered.

To meet with the WebTAG criteria, twenty of the routes that were checked are detailed in Appendix I.

10   Trip Matrix Calibration and Validation

10.1   Matrix estimation

After an initial assignment and refining of the modelled network and indeed the assignment methodology, the trip matrices underwent a process of 'matrix estimation' whereby trip matrices are adjusted such that the resulting assigned flows matches count data better. The "TFlowFuzzy" module within VISUM was used for this process. The process of matrix estimation in general is well understood within the modelling community and will not be expanded upon here. The VISUM manual contains details of the specifics of the TFlowFuzzy process, but in principal it is much the same as any other matrix estimation process in any other modelling package.

Because the available count data is given for cars, LGVs and HGVs at the finest level of detail, the matrix estimation was run for these same vehicle types. With specific reference to car trips, the separate user class matrices (commute, business, and other) were combined into a single car trip matrix before matrix estimation was run. To disaggregate the post-ME matrix back into separate user classes, a proportional split from the separate prior-ME matrices was required.

It is important when running a matrix estimation process that the original 'prior' (to estimation) trip matrices are not distorted such that the underlying trip patterns are altered. To test whether this altering process has occurred, the guidelines set out within WebTAG2 unit M3-1 in table 5 were applied to the prior- and post-ME matrices, as detailed below:

Measure	Significance Criteria
Matrix zonal cell values	Slope within 0.98and 1.02 Intercept near zero R^2 in excess of 0.95
Matrix zone 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%

Table 10-A   Significance of Matrix Estimation Changes

The significance of matrix estimation for each measure detailed in the above table is described in turn in the following section.

10.1.1 Matrix cell value changes

The graph below shows for each time period and vehicle type (in terms of light vehicles – cars and LGVs, and heavies – HGVs), the cell values of the prior matrix plotted (on the horizontal axis) against the values in the same cell of the post matrix (on the vertical axis). A trend line, with equation and R^2 value has also been plotted:
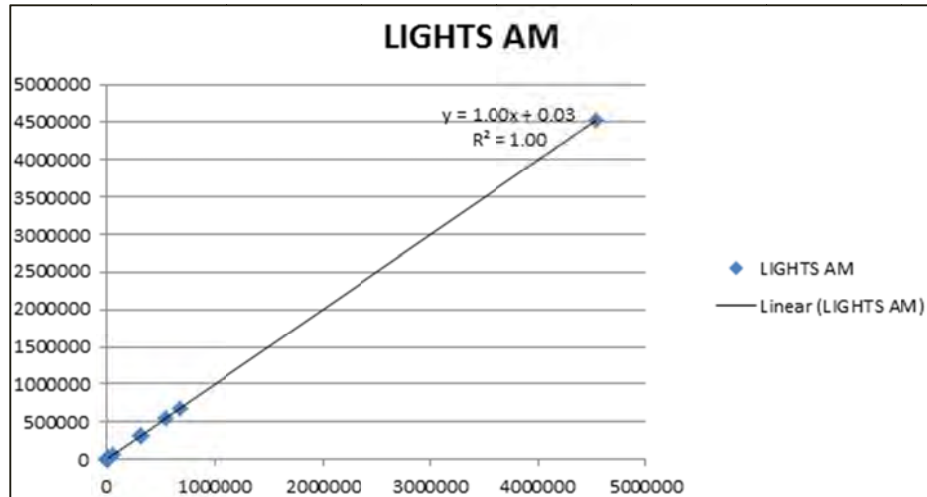
Figure 10-A   Cell Value of Prior Matrix against Post Matrix, Lights AM
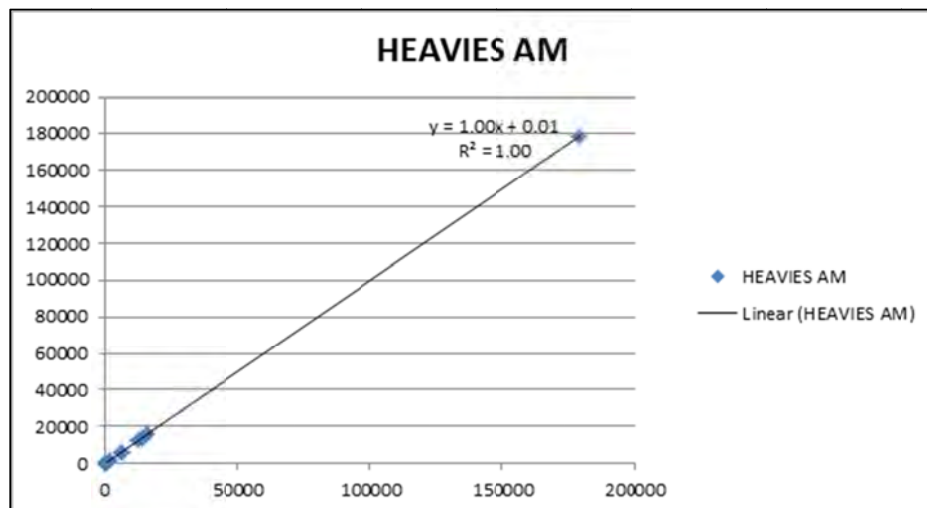
Figure 10-B   Cell Value of Prior Matrix against Post Matrix, Heavies AM
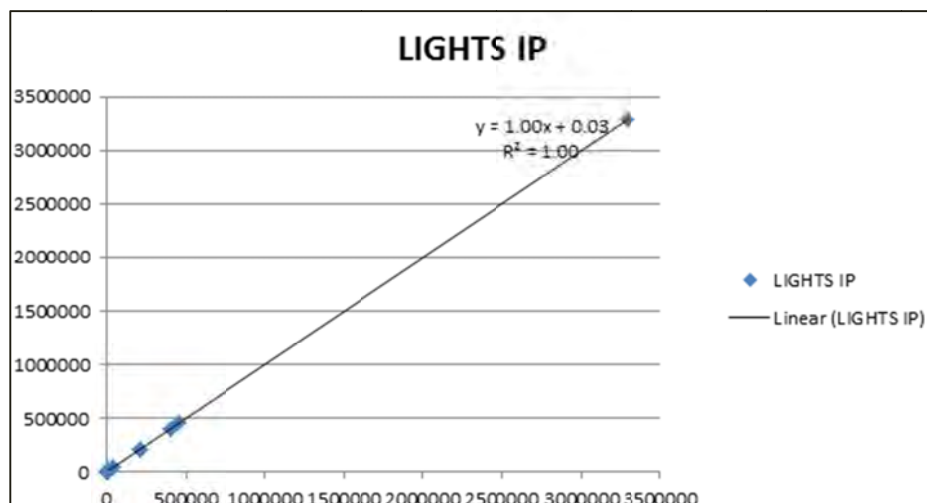
Figure 10-C   Cell Value of Prior Matrix against Post Matrix, Lights IP

Broughton Bypass Model, Local Model Validation Report, August 2015
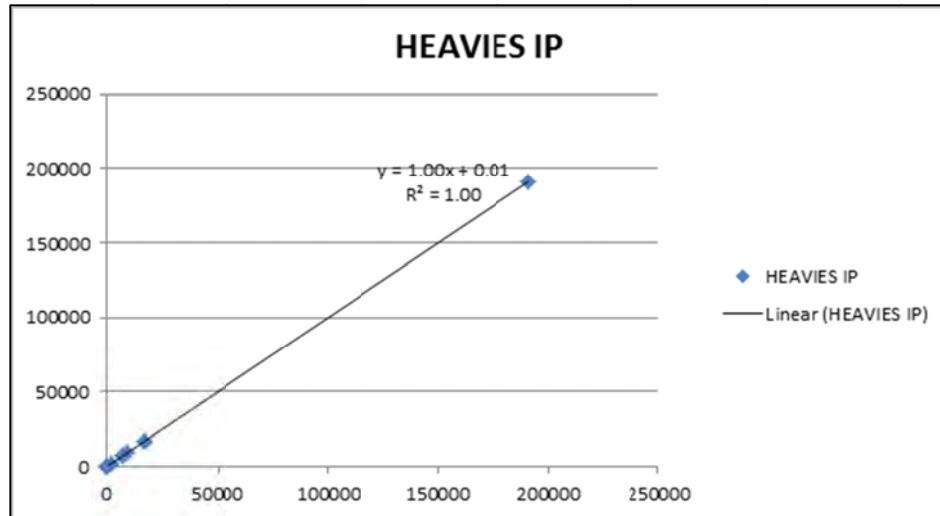
Figure 10-D   Cell Value of Prior Matrix against Post Matrix, Heavies IP
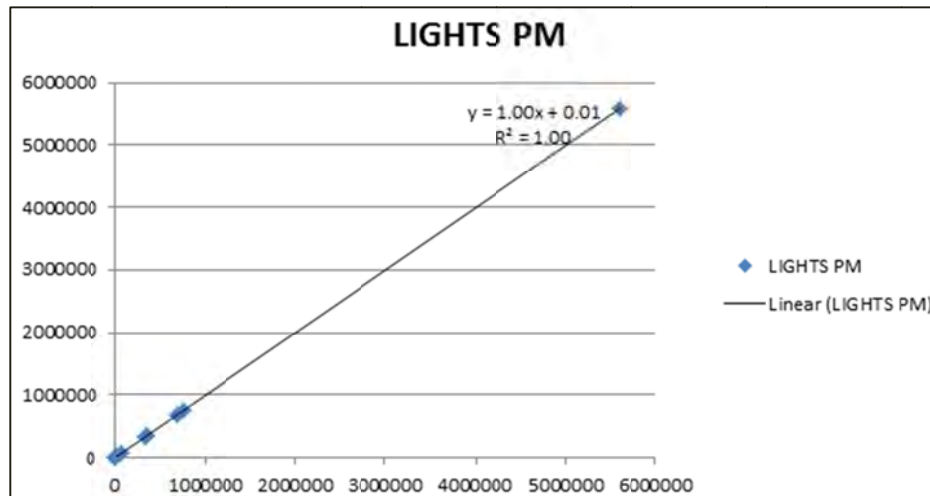
Figure 10-E   Cell Value of Prior Matrix against Post Matrix, Lights PM
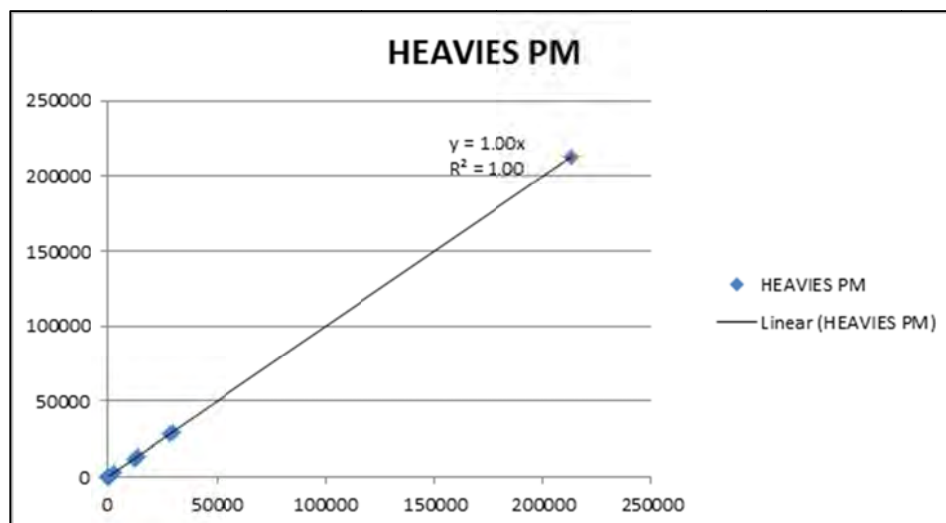
Figure 10-F   Cell Value of Prior Matrix against Post Matrix, Heavies PM

The guidance states that the trend line must have a gradient between 0.98 and 1.02, an intercept close to zero, and an R^2 value exceeding 0.95. Clearly, these conditions are met for all matrices.

10.1.2 Matrix trip end changes

The check on how much matrix trip ends have been affected by matrix estimation is a similar one to the check on individual cell values in that the prior and post trip ends must be plotted on a graph and a trend line added. The graphs showing these are below:
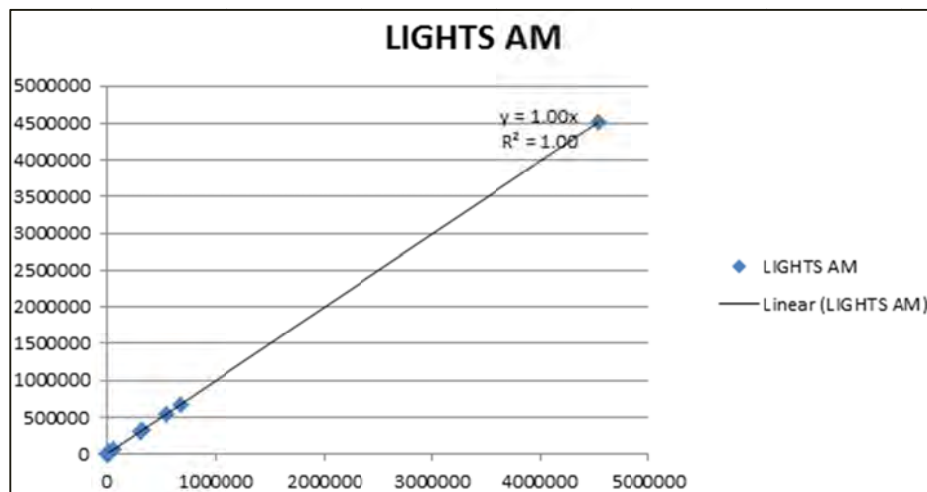
Figure 10-G   Trip End Changes, Lights AM
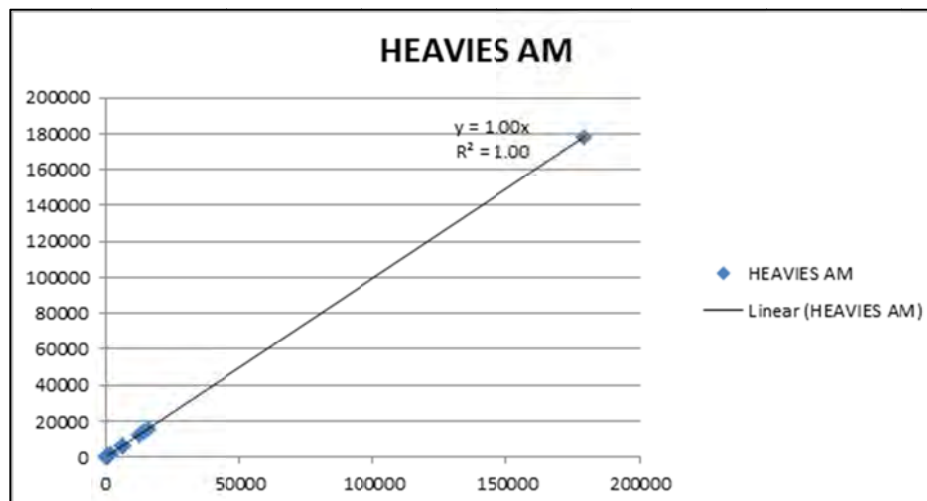
Figure 10-H   Trip End Changes, Heavies AM
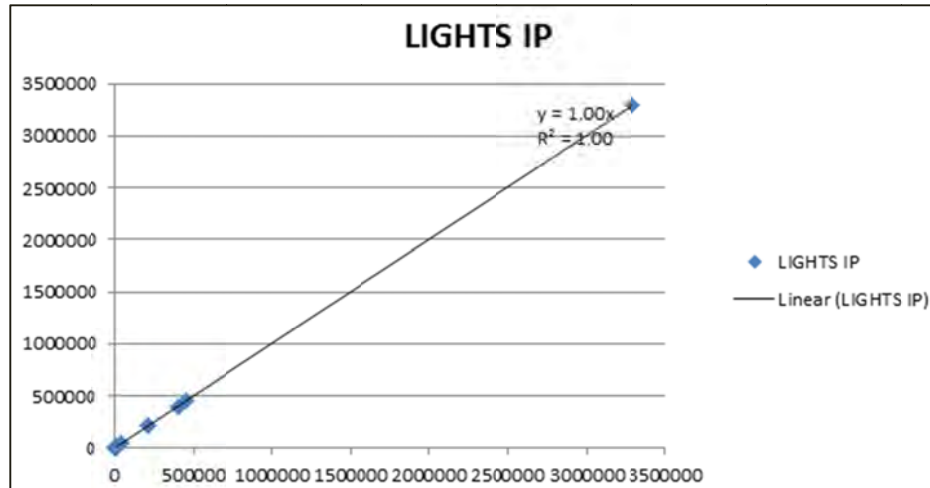
Figure 10-I   Trip End Changes, Lights IP
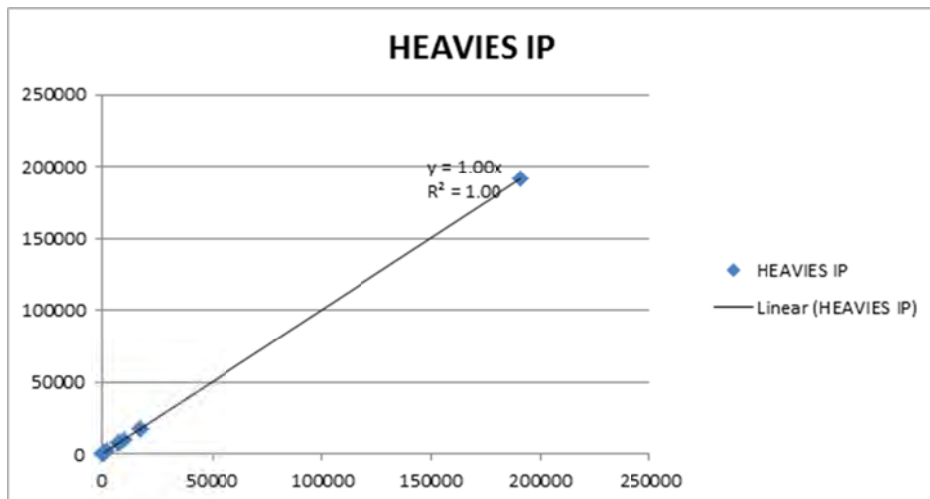
Figure 10-J   Trip End Changes, Heavies IP
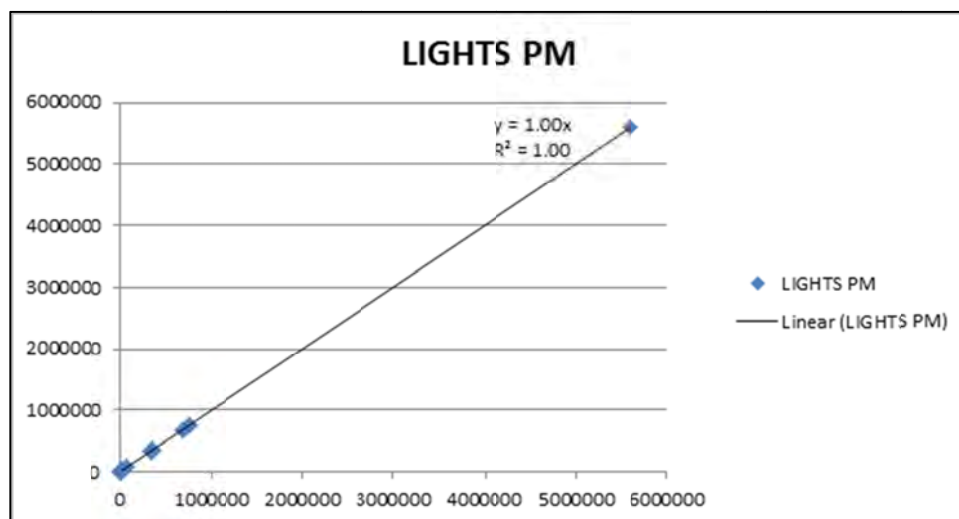
Figure 10-K   Trip End Changes, Lights PM
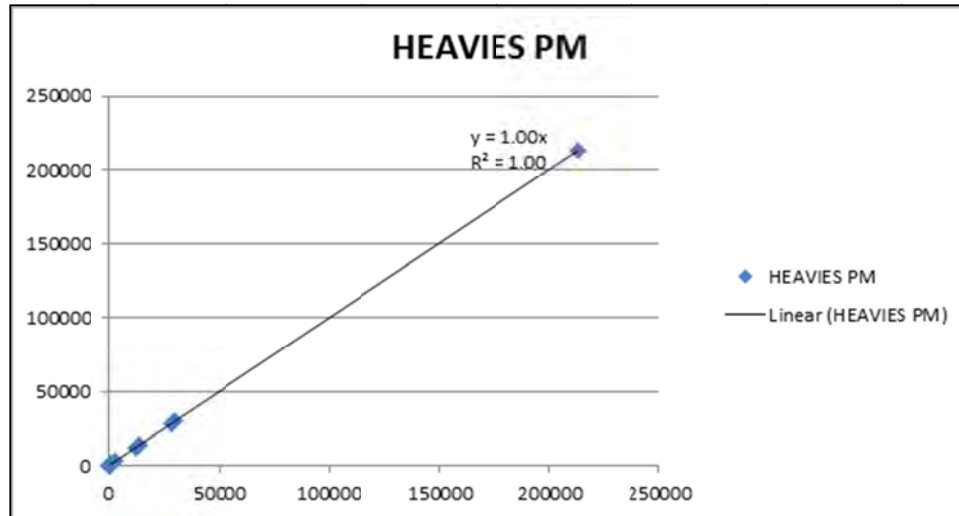
Figure 10-L   Trip End Changes, Heavies PM

The guidance on these trend lines is the following:

- Slope to be within 0.99 and 1.01
- Intercept near zero
- R Squared in excess of 0.98

As with the test on cell values, all matrices meet the criteria.

10.1.3 Trip length distributions

For trip length distributions, it is stipulated in WebTAG that both the mean and standard deviation of the post matrix trip lengths must not differ by more than 5% from those of the prior matrices. The means and standard deviations for all the matrices (not including intrazonal trips) are summarised in the table below:

Time and trip type	Lights - prior	Lights - prior	Change	Heavies – prior	Heavies - post	Change
AM Average Trip Length (km)	183.5	183.5	0.00%	192.3	192.1	-0.10%
AM Standard Deviation (km)	72.3	72.3	0.00%	63.9	63.9	0.10%
IP Average Trip Length (km)	186.4	186.3	0.00%	192.2	191.9	-0.20%
IP Standard Deviation (km)	70.8	70.8	0.00%	63.7	64	0.40%
PM Average Trip Length (km)	187.0	186.9	0.0%	186.9	186.9	0.0%
PM Standard Deviation (km)	70.7	70.7	0.0%	71.9	71.8	0.0%

Table 10-B   Table of Trip Lengths and Standard Deviation

The table shows that the change in average and standard deviation trip lengths is minimal and well within guidelines. This, coupled with tests described earlier indicates that matrix estimation has not had a significant impact on the underlying trip patterns of the matrices.

10.1.4 Sector to Sector movements

Finally, the guidelines require a check on the matrix cells on a sector basis. The guidelines state that trips should not change by more than 5%. Using the same sectors identified in section 4.2.1, the percentage change in light and heavy vehicle trips for each sector to sector movement as a result of matrix estimation is shown below:

% Change	North Preston	South Preston	Wyre	Blackpool	Fylde	Ribble Valley	South Ribble	Chorley	Pendle/Burnley/Rosendale / Blackburn/Darwen	Rest of the UK
North Preston	-23.6%	-41.0%	5.4%	-16.4%	-3.8%	3.4%	9.0%	21.5%	18.3%	-10.4%
South Preston	-33.9%	-5.8%	12.1%	21.7%	-7.5%	4.3%	-2.4%	-1.2%	-0.5%	-12.3%
Wyre	-3.7%	3.2%	0.5%	-0.1%	0.9%	14.5%	21.4%	24.2%	24.1%	7.7%
Blackpool	2.2%	13.2%	0.4%	0.0%	0.0%	33.1%	25.4%	12.5%	11.1%	1.1%
Fylde	4.4%	-11.8%	0.9%	0.0%	0.0%	17.5%	0.6%	9.0%	9.0%	5.5%
Ribble Valley	5.9%	0.1%	29.8%	-20.7%	23.2%	0.1%	1.2%	1.2%	1.3%	-19.9%
South Ribble	2.2%	-1.2%	5.3%	14.1%	0.1%	0.5%	0.0%	0.0%	0.0%	-6.9%
Chorley	22.4%	0.7%	3.8%	-16.2%	2.7%	0.5%	0.0%	0.0%	0.0%	-14.7%
Pendle/Burnley/ Rosendale/ Blackburn/Darwen	21.2%	1.1%	1.6%	-16.6%	2.7%	0.5%	0.0%	0.0%	0.0%	-16.2%
Rest of the UK	-21.4%	-7.2%	-0.5%	19.5%	1.4%	-14.8%	-3.0%	-7.4%	-6.9%	0.0%

Table 10-C   **Percentage Change, Lights AM**

% Change	North Preston	South Preston	Wyre	Blackpool	Fylde	Ribble Valley	South Ribble	Chorley	Pendle/Burnley/Rosendale / Blackburn/Darwen	Rest of the UK
North Preston	30.5%	26.8%	12.1%	-0.1%	87.4%	-14.0%	90.7%	64.7%	-7.5%	80.9%
South Preston	64.0%	-3.7%	46.6%	-17.2%	-3.3%	2.1%	6.3%	8.1%	3.9%	-12.8%
Wyre	36.5%	74.3%	-0.5%	0.0%	0.0%	-39.2%	92.3%	35.0%	-1.2%	56.3%
Blackpool	18.9%	5.1%	-0.4%	0.0%	0.0%	-183.4%	3.0%	0.0%	-383.8%	-132.5%
Fylde	11.2%	-7.6%	-0.1%	0.0%	0.0%	22.6%	0.0%	0.0%	-23.6%	0.0%
Ribble Valley	12.9%	12.5%	-173.0%	-467.8%	0.3%	0.0%	1.1%	0.0%	0.0%	-6.9%
South Ribble	74.7%	1.5%	92.3%	0.0%	0.0%	0.8%	0.0%	0.0%	0.0%	-246.9%
Chorley	66.9%	2.9%	94.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-3.8%
Pendle/Burnley/ Rosendale/ Blackburn/Darwen	-51.5%	1.9%	42.9%	-948.5%	-54.8%	0.0%	0.0%	0.0%	0.0%	-5.3%
Rest of the UK	0.2%	-18.4%	-13.0%	-293.3%	0.0%	-53.2%	4.4%	-31.9%	-25.4%	-0.1%

Table 10-D   **Percentage Change, Heavies AM**

% Change	North Preston	South Preston	Wyre	Blackpool	Fylde	Ribble Valley	South Ribble	Chorley	Pendle/Burnley/Rosendale / Blackburn/Darwen	Rest of the UK
North Preston	5.6%	-4.8%	0.2%	5.5%	-30.4%	18.7%	23.0%	28.0%	29.8%	1.5%
South Preston	-5.3%	-4.4%	-13.4%	4.3%	-7.6%	7.9%	-0.6%	3.7%	3.7%	-13.5%
Wyre	-7.7%	-0.7%	0.6%	0.6%	0.7%	13.4%	10.3%	-2.4%	-1.0%	1.0%
Blackpool	16.8%	12.9%	1.1%	0.0%	0.0%	16.3%	10.0%	-18.1%	-28.2%	-20.3%
Fylde	-14.2%	-13.1%	0.6%	0.0%	0.0%	24.8%	0.1%	1.1%	1.2%	-0.3%
Ribble Valley	13.7%	9.4%	27.5%	32.6%	12.6%	0.1%	0.8%	0.8%	0.7%	-21.3%
South Ribble	13.6%	-0.8%	3.1%	5.1%	0.0%	1.1%	0.0%	0.0%	0.0%	-10.1%
Chorley	45.0%	1.3%	1.0%	-23.3%	-1.7%	1.2%	0.0%	0.0%	0.0%	-17.4%
Pendle/Burnley/ Rosendale/ Blackburn/Darwen	40.9%	1.4%	-3.1%	-33.6%	-2.3%	0.9%	0.0%	0.0%	0.0%	-20.4%
Rest of the UK	-23.7%	-6.7%	-3.7%	-10.0%	-1.1%	-22.6%	-6.9%	-16.1%	-19.0%	0.0%

Table 10-E   ***Percentage Change, Lights IP***

% Change	North Preston	South Preston	Wyre	Blackpool	Fylde	Ribble Valley	South Ribble	Chorley	Pendle/Burnley/Rosendale / Blackburn/Darwen	Rest of the UK
North Preston	-401.0%	83.1%	-320.1%	-337.2%	34.7%	-124.3%	92.2%	78.8%	-57.7%	8.0%
South Preston	76.9%	-13.3%	57.8%	-57.6%	-21.5%	12.8%	-0.7%	-0.7%	-0.4%	-53.5%
Wyre	-54.0%	67.4%	-6.9%	-5.0%	-1.3%	-64.8%	52.3%	87.1%	-147.5%	48.4%
Blackpool	-157.3%	-3.2%	-0.6%	0.0%	0.0%	-5.9%	5.1%	0.0%	-455.1%	-160.3%
Fylde	13.1%	-21.4%	-0.2%	0.0%	0.0%	19.5%	0.0%	0.0%	-7.0%	0.0%
Ribble Valley	-179.5%	3.0%	-80.2%	-354.2%	5.7%	0.0%	0.8%	0.0%	0.0%	-111.8%
South Ribble	70.0%	-3.3%	87.8%	5.3%	0.0%	1.0%	0.0%	0.0%	0.0%	-3.8%
Chorley	72.5%	-4.3%	38.8%	0.0%	0.0%	1.0%	0.0%	0.0%	0.0%	-42.5%
Pendle/Burnley/Ro sendale/ Blackburn/Darwen	-57.6%	-4.9%	-24.5%	-395.0%	-9.3%	0.5%	0.0%	0.0%	0.0%	-57.8%
Rest of the UK	-83.6%	-68.4%	49.6%	-243.8%	0.0%	-95.2%	3.2%	-39.1%	-29.0%	-0.2%

Table 10-F   ***Percentage Change, Heavies IP***

% Change	North Preston	South Preston	Wyre	Blackpool	Fylde	Ribble Valley	South Ribble	Chorley	Pendle/Burnley/Rosendale / Blackburn/Darwen	Rest of the UK
North Preston	-13.0%	-20.3%	-17.5%	28.1%	-20.9%	-23.8%	16.4%	33.7%	30.0%	11.3%
South Preston	4.4%	-4.7%	4.9%	42.0%	-9.4%	8.7%	1.5%	3.5%	3.1%	-2.9%
Wyre	4.9%	17.5%	0.1%	0.6%	0.8%	10.1%	13.1%	6.9%	4.8%	2.0%
Blackpool	25.6%	32.2%	0.7%	0.0%	0.0%	14.3%	22.8%	2.1%	-0.3%	-6.5%
Fylde	28.9%	-6.4%	0.9%	0.0%	0.0%	23.8%	0.5%	10.5%	24.0%	10.6%
Ribble Valley	6.6%	1.7%	14.6%	9.1%	-0.4%	0.1%	0.4%	0.3%	0.3%	-12.6%
South Ribble	18.7%	0.9%	4.6%	10.9%	-0.1%	1.9%	0.0%	0.0%	0.0%	-7.6%
Chorley	52.0%	4.4%	1.1%	-14.6%	-2.8%	2.5%	0.0%	0.0%	0.0%	-7.2%
Pendle/Burnley/ Rosendale/ Blackburn/Darwen	49.5%	3.2%	-2.1%	-22.1%	-0.4%	2.7%	0.0%	0.0%	0.0%	-7.3%
Rest of the UK	22.0%	-3.6%	-1.1%	25.6%	-1.4%	-11.3%	-4.9%	-10.4%	-10.2%	0.0%

Table 10-G   Percentage Change, Lights PM

% Change	North Preston	South Preston	Wyre	Blackpool	Fylde	Ribble Valley	South Ribble	Chorley	Pendle/Burnley/Rosendale / Blackburn/Darwen	Rest of the UK
North Preston	69.3%	50.3%	-310.4%	-466.4%	14.8%	-277.3%	70.7%	12.6%	2.4%	-69.3%
South Preston	67.8%	18.8%	63.4%	-74.3%	43.0%	33.4%	49.1%	24.4%	43.4%	-1.8%
Wyre	-359.2%	53.1%	37.8%	19.3%	55.9%	-117.2%	12.6%	82.5%	-655.7%	17.8%
Blackpool	-469.8%	21.4%	-1.2%	-13.8%	45.1%	-302.5%	48.9%	19.8%	-234.2%	-107.2%
Fylde	-49.7%	43.7%	37.8%	27.0%	63.8%	63.8%	67.6%	51.8%	61.3%	54.3%
Ribble Valley	-213.2%	32.8%	-183.5%	-375.1%	57.4%	36.6%	53.0%	29.3%	46.9%	-38.9%
South Ribble	70.1%	44.5%	81.8%	24.4%	65.9%	39.6%	62.5%	43.4%	57.5%	48.6%
Chorley	62.3%	20.2%	43.2%	-14.0%	51.3%	16.1%	46.7%	19.6%	39.7%	2.3%
Pendle/Burnley/ Rosendale/ Blackburn/Darwen	-77.7%	32.0%	-140.4%	-377.2%	54.9%	28.6%	55.1%	32.0%	48.3%	18.0%
Rest of the UK	-290.1%	0.3%	49.1%	-103.5%	66.8%	-5.3%	54.3%	1.2%	27.7%	19.3%

Table 10-H   Percentage Change, Heavies PM

Clearly, from the tables given above most of the sector to sector movements fail the 5% criteria. However, according to guidelines, the criteria is to be applied regardless of the number of trips in the sector; for sector to sector movements with relatively few trips, it is more difficult to stay within the 5% criteria. It should also be noted that none of the sector to sector movements would be considered 'fully observed', and as a result, some more significant change in trips would be expected.

It is notable that there are considerable changes made to the HGV matrix sector trips. Given the relative lack of observed origin-destination data in the demand, this is to be expected.

11 Assignment, Calibration and Validation

11.1 Convergence

A summary of the assignment method used was given in section 4.7.

The convergence statistics for each time period are given below:

Outer iteration	Proportion of turns with GEH <= 0.5 between current and previous iteration	Proportion of turns with GEH <= 0.5 between current iteration and smoothed ICA assignment	Proportion of turns with relative gap between ICA wait time and VDF wait time <= 0.05	Total queues on links	Total queues on connectors	Final %GAP value for inner iteration	Number of inner iterations
1	0.669	1	0.492	0	0	1.58E-03	40
2	0.753	0.832	0.9	7403.815	395.869	1.00E+00	150
3	0.784	0.861	0.91	9277.666	192.58	3.82E-04	150
4	0.818	0.895	0.943	2205.819	15.738	5.48E-04	67
5	0.848	0.918	0.949	4499.459	7.284	2.74E-04	140
6	0.874	0.929	0.96	1155.416	0	7.51E-05	150
7	0.893	0.944	0.967	680.546	0	1.21E-04	150
8	0.911	0.956	0.971	561.437	0	2.59E-05	140
9	0.915	0.956	0.976	430.363	6.906	2.12E-04	150
10	0.913	0.96	0.978	360.879	11.259	1.00E+00	150
11	0.914	0.961	0.98	280.796	11.961	2.32E-03	74
12	0.908	0.953	0.971	246.936	12.115	1.03E-03	75
13	0.9	0.957	0.979	206.658	12.161	1.06E-03	40
14	0.911	0.961	0.976	218.652	12.175	1.14E-03	61
15	0.922	0.968	0.981	165.986	12.179	5.53E-04	54
16	0.921	0.968	0.983	151.238	12.18	9.57E-04	39
17	0.923	0.965	0.976	138.982	12.185	1.43E-03	53
18	0.922	0.972	0.984	226.92	12.181	2.10E-04	52
19	0.928	0.964	0.984	199.036	12.181	3.77E-04	50
20	0.919	0.964	0.98	163.166	12.181	1.56E-03	48
21	0.923	0.964	0.982	157.194	12.181	1.00E+00	66
22	0.912	0.963	0.983	166.218	11.313	1.13E-03	34
23	0.923	0.971	0.984	135.452	11.971	4.31E-04	50
24	0.929	0.968	0.984	133.678	12.118	1.76E-03	40
25	0.916	0.97	0.984	115.343	12.166	6.84E-04	57
26	0.923	0.966	0.982	149.401	12.175	1.62E-03	43
27	0.925	0.967	0.982	191.781	12.179	1.36E-03	49
28	0.919	0.962	0.974	145.53	12.18	1.18E-03	36
29	0.914	0.961	0.973	150.354	12.181	1.61E-03	35
30	0.917	0.967	0.975	192.2	12.185	1.00E+00	52

Table 11-A   Details of ICA Assignment, AM

Outer iteration	Proportion of turns with GEH <= 0.5 between current and previous iteration	Proportion of turns with GEH <= 0.5 between current iteration and smoothed ICA assignment	Proportion of turns with relative gap between ICA wait time and VDF wait time <= 0.05	Total queues on links	Total queues on connectors	Final %GAP value for inner iteration	Number of inner iterations
1	0.684	1	0.491	0	0	2.90E-03	10
2	0.786	0.857	0.921	0	0	1.12E-03	10
3	0.856	0.917	0.953	2603.697	40.546	1.66E-04	26
4	0.889	0.927	0.954	78.482	1.766	6.12E-04	11
5	0.914	0.943	0.974	11.297	8.399	7.03E-04	12
6	0.912	0.954	0.977	11.297	9.866	3.48E-04	11
7	0.911	0.955	0.973	11.297	12.922	6.74E-04	12
8	0.907	0.96	0.978	11.297	13.596	1.17E-03	12
9	0.912	0.964	0.975	11.297	13.737	1.07E-03	12
10	0.921	0.97	0.983	11.297	13.384	5.89E-04	10
11	0.911	0.964	0.98	11.297	13.668	6.61E-04	11
12	0.911	0.969	0.982	11.297	12.889	7.24E-04	10
13	0.914	0.968	0.984	11.297	13.568	1.97E-03	9
14	0.909	0.968	0.985	11.297	13.275	1.22E-03	11
15	0.911	0.964	0.981	11.297	13.158	1.67E-03	10
16	0.91	0.967	0.984	11.297	13.122	1.77E-03	9
17	0.912	0.973	0.985	11.297	13.632	8.65E-04	10
18	0.916	0.972	0.983	11.297	13.319	9.42E-04	10
19	0.912	0.97	0.98	11.297	13.171	9.11E-04	10
20	0.924	0.969	0.981	11.297	13.646	1.05E-03	10

*Table 11-B   Details of ICA Assignment, IP*

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Outer iteration	Proportion of turns with GEH <= 0.5 between current and previous iteration	Proportion of turns with GEH <= 0.5 between current iteration and smoothed ICA assignment	Proportion of turns with relative gap between ICA wait time and VDF wait time <= 0.05	Total queues on links	Total queues on connectors	Final %GAP value for inner iteration	Number of inner iterations
1	0.666	1	0.492	0	0	7.16E-04	42
2	0.748	0.83	0.89	11514.644	1018.946	5.71E-04	150
3	0.814	0.857	0.906	5648.145	37.251	5.38E-04	54
4	0.848	0.903	0.95	1179.785	0	5.68E-04	53
5	0.889	0.93	0.96	961.373	0	8.93E-04	46
6	0.908	0.945	0.971	790.303	0	4.14E-04	44
7	0.908	0.953	0.977	671.939	0	8.92E-04	33
8	0.913	0.952	0.98	551.733	32.433	3.30E-04	46
9	0.913	0.956	0.975	485.964	55.773	3.60E-04	47
10	0.905	0.956	0.981	614.469	90.005	9.87E-04	52
11	0.9	0.95	0.977	513.329	101.773	9.44E-04	38
12	0.906	0.951	0.979	512.783	112.959	4.69E-04	37
13	0.905	0.956	0.975	508.442	113.048	8.02E-04	38
14	0.903	0.949	0.977	532.557	114.767	1.01E-03	32
15	0.902	0.947	0.976	561.92	119.945	2.54E-04	63
16	0.892	0.946	0.973	480.426	114.093	5.63E-04	37
17	0.898	0.954	0.979	561.921	123.067	9.25E-04	38
18	0.901	0.956	0.979	522.782	120.057	5.19E-04	46
19	0.904	0.953	0.98	512.914	120.043	6.33E-04	53
20	0.908	0.955	0.98	472.069	134.975	6.44E-04	45

Table 11-C   Details of ICA Assignment, PM

WebTAG2 requires a GAP value of less than 0.1%, a criterion which is exceed in all time periods. In addition, the "outer" iterations show that queuing volumes settle down to a relatively stable solution within thirty iterations for AM and twenty for IP and PM peak period. Although guidance does not require this attribute to be checked, it nonetheless provides another useful indication of the state of convergence of the model.

11.2 Count Calibration

The locations of counts used for calibration (i.e. those counts used as part of the creation of the trip matrices and/or the matrix estimation) are shown below:
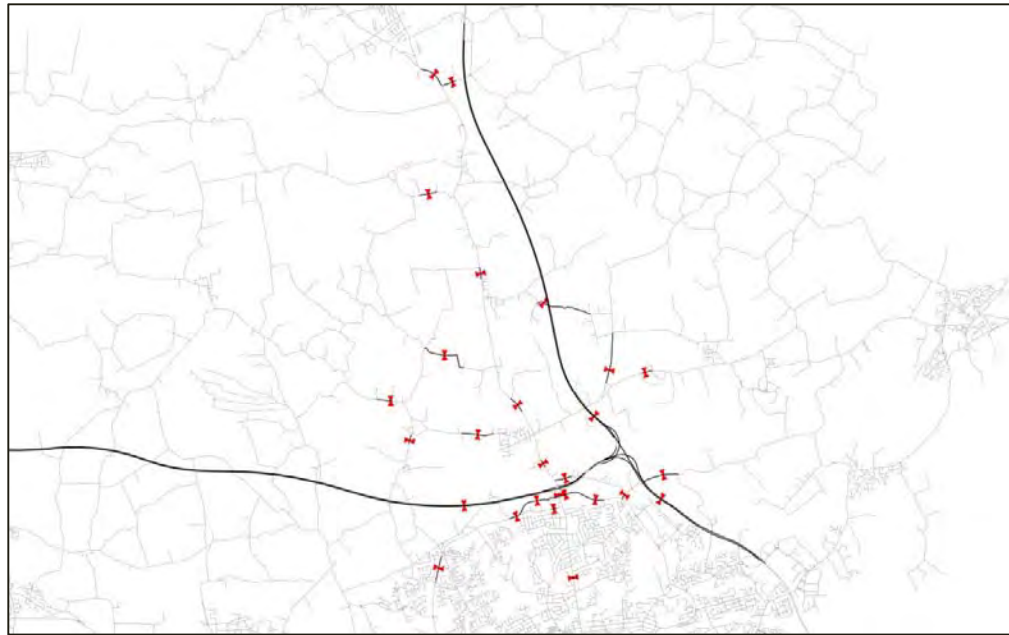
Figure 11-A   Image of Calibration Counts

The performance of the model in terms of comparisons with count data are measured in two ways. The first of these is the GEH statistic, as defined below:

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

Where: *M* is the modelled flow on a link, and C is the counted flow.

The second is made by reference to the following table, extracted from WebTAG2 Unit M 3-1:

Size of observed flow	Criteria for valid modelled flow
< 700 vehicles/hour	Modelled flow within 100 vehicles/hour of observed flow
700-2,700 vehicles/hour	Modelled flow within 15% of observed flow
> 2,700 vehicles/hour	Modelled flow within 400 vehicles/hour of observed

Table 11-D   Link Flow Validation Criterion

WebTAG advises that in ordinary circumstances the practitioner should aim to reach a state where 85% of modelled links have a GEH of less than 5 or satisfy the criterion in Table 11-D.

There were 63 calibration counts used in the base year model. The comparison of modelled flows against these counts is summarised below:

Measure	AM peak		Interpeak		PM peak	
	Cars	Total Vehicles	Cars	Total Vehicles	Cars	Total Vehicles
No. links with modelled flows meeting criteria	55/63	52/63	61/63	60/63	53/63	51/63
% links with modelled flows meeting criteria	87%	83%	97%	95%	84%	81%

Table 11-E   Calibration Link Flow Comparison with Observed Flows (Cars and Total Vehicles)

In line with guidance, the statistics are shown for all vehicles combined and for cars separately. The LGV and HGV statistics are based upon a generally less reliable count set, and are not separately reported.

The table demonstrates that the 85% criterion is achieved or almost achieved for all time periods. This is encouraging as it gives confidence that modelled flows as a whole are representative of real life traffic flows. It is notable that the PM peak calibration is not as good as the other time periods, and is reflective of the higher levels of congestion in that time period.

A full breakdown of the comparison at the individual count level is included in Appendix B.

11.2.1 Calibration screenlines

As indicated in Figure 7-G, some of the counts are arranged along screenlines. WebTAG2 has a separate criterion for total screenline flows, which is that total modelled flows on all links crossing a screenline must be within 5% of the observed totals.

The performance of the model along the calibration screenlines is summarised below:

Screenline	No. links	AM			IP			PM		
		Obs.	Mod.	% Diff.	Obs.	Mod.	% Diff.	Obs.	Mod.	% Diff.
Southern (Northbound)	3	1,697	1,748	-3%	1,038	1,165	-12%	1,767	1,910	-8%
Southern (Southbound)	3	2,174	2,579	-19%	1,063	1,238	-16%	1,935	2,148	-11%
Eastern (Eastbound)	2	209	298	-43%	145	185	-28%	200	304	-52%
Eastern (Westbound)	2	163	252	-54%	150	160	-6%	221	262	-18%
Western (Eastbound)	2	248	265	-7%	96	105	-9%	244	302	-24%
Western (Westbound)	2	328	311	5%	94	82	13%	210	207	1%
Northern (Northbound)	1	470	551	-17%	540	529	-15%	630	699	-11%

Northern (Southbound)	1	429	598	-39%	436	517	-19%	546	605	-11%

Table 11-F   ***Screenline comparison table***

The modelled and observed flow differences across the screenlines mostly exceed the 5% criteria. This reflects negatively on the model, however it is worth noting that that given the relatively small study area, the screenlines necessarily contain relatively few links. These links generally satisfy the link flow criteria, but it is much more difficult to meet the 5% criteria, as with only a small number of links, the total observed flow is particularly small, and the 5% margin is itself very small. For example, on the Eastern screenline in the westbound direction in the AM peak, there are two links with a total count of 163. To be within 5% the modelled flow must be within 8 vehicles of the observed flow, which is likely to be less than the day to day variance and it is therefore, in this example, unrealistic to expect the 5% criteria to be achieved. As an alternative to the 5% check, it is worth noting that for the screenlines comprising just one or two counts, the modelled flow is within 200 vehicles of the observed flow.

Further information on the screenline calibration is given in Appendix D.

11.3   Count validation

Count validation relies on making similar comparisons to the ones made for the count calibration, but against *independent* counts, i.e. those not used in the model building process up to this point, in either the matrix building or the matrix estimation.

The locations of these independent counts are show in the figure below:

Figure 11-B   Map of Independent Counts Location

There are 16 counts used in the validation, and the model's performance against these counts is summarised below:

| Measure	AM peak		Interpeak		PM peak	
	Cars	Total Vehicles	Cars	Total Vehicles	Cars	Total Vehicles
No. links with modelled flows meeting criteria	15/16	14/16	16/16	16/16	14/16	14/16
% links with modelled flows meeting criteria	94%	88%	100%	100%	88%	88%

Table 11-G   Validation Link Flow Comparison with Observed Flows (Cars and Total Vehicles)

The table above shows that the 85% criteria for validation counts is exceeded in every time period for cars and total vehicles. As with the calibration count comparison, this gives more confidence that the model is representing base year traffic flows realistically. Given that this criteria is met even for independent validation counts, this should increase confidence in the model.

The full breakdown of the count validation is given in Appendix C.

11.4   Modelled flows directly affecting the study area

Although the modelled flows as a whole were representative of observed flows in the study area, it was important to also ensure that the links in the immediate vicinity of the proposed scheme were well validated. The image below shows the observed, modelled and GEH values for those locations, for all three time periods:
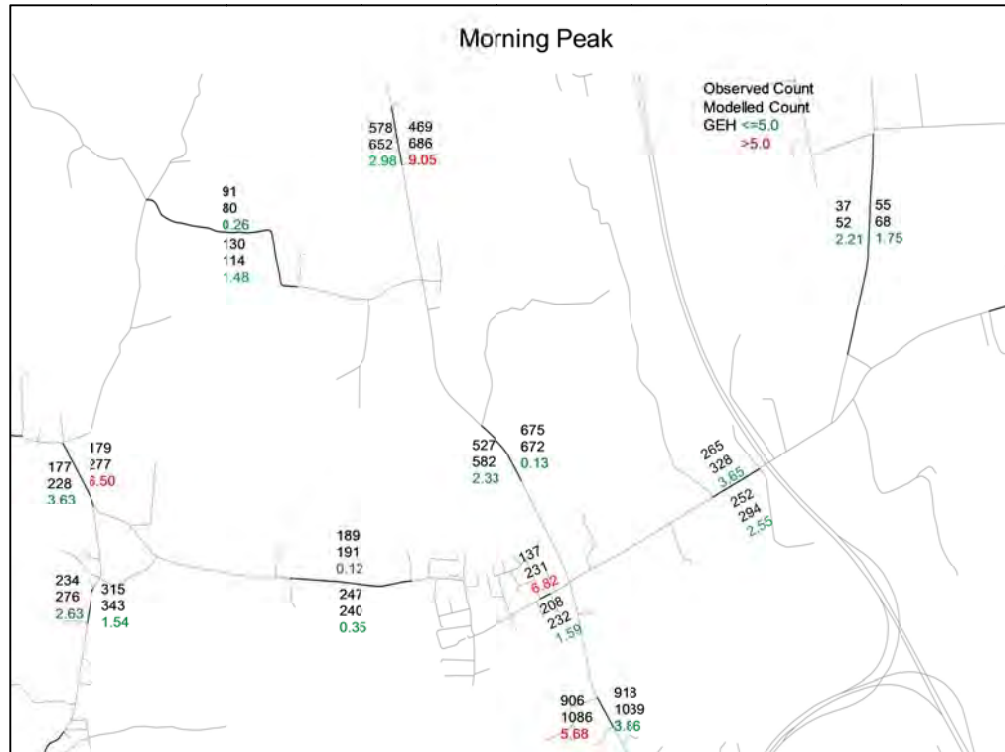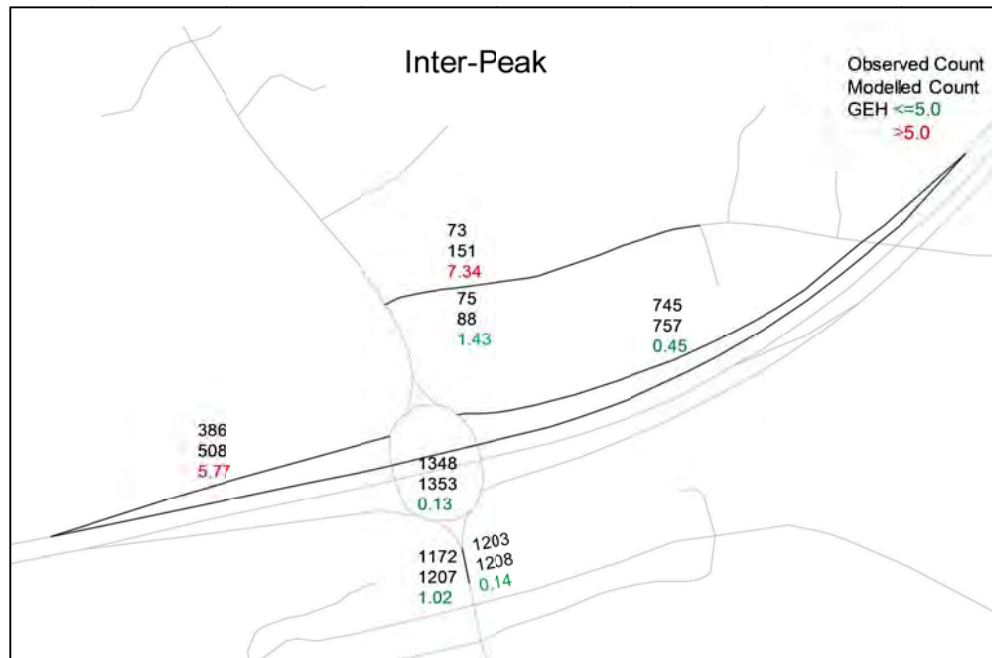
Figure 11-C   AM Peak Flows
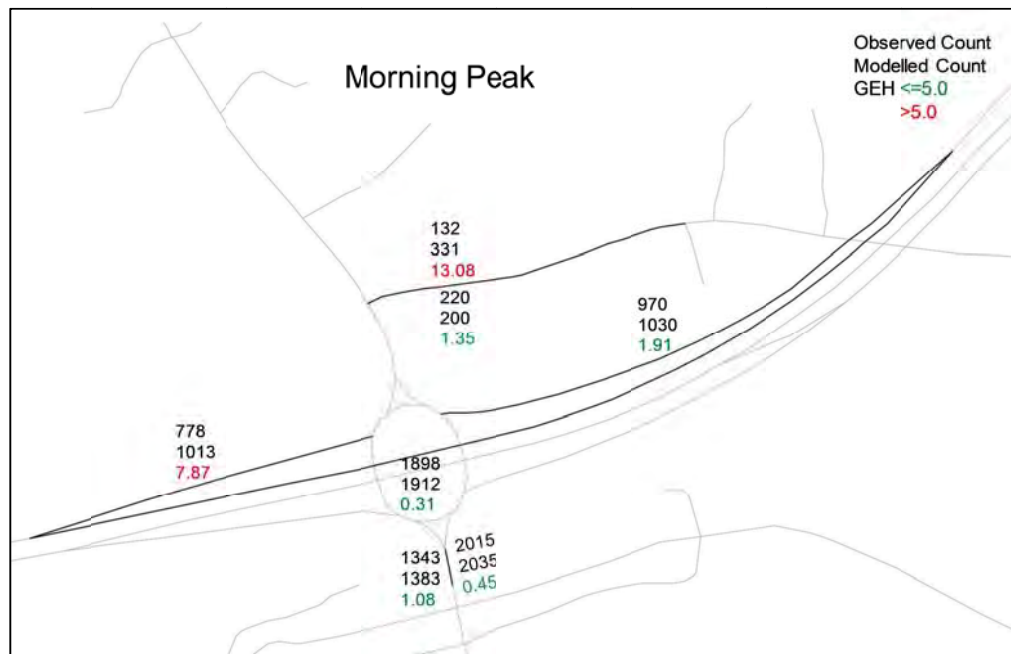
Figure 11-D AM peak flows at M55 J1
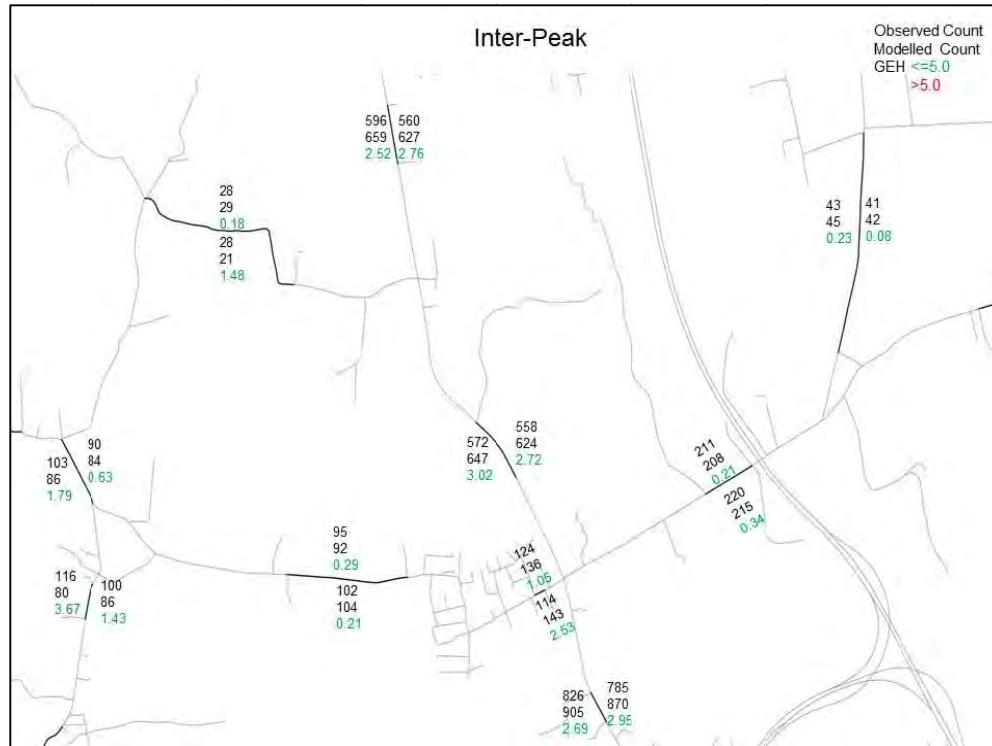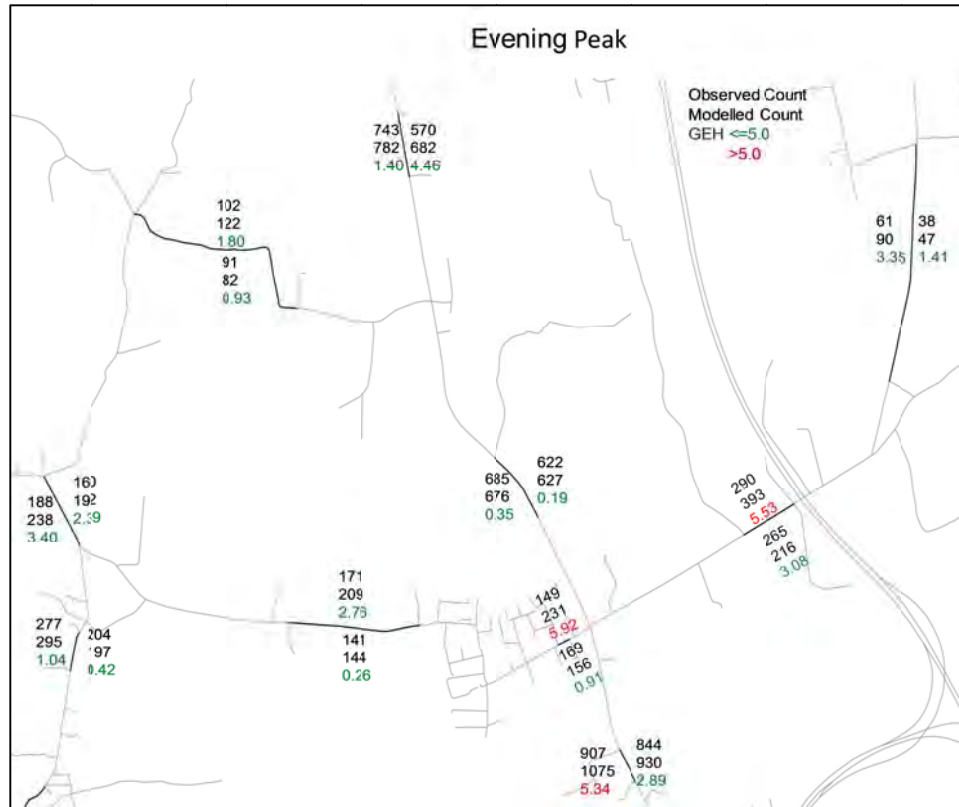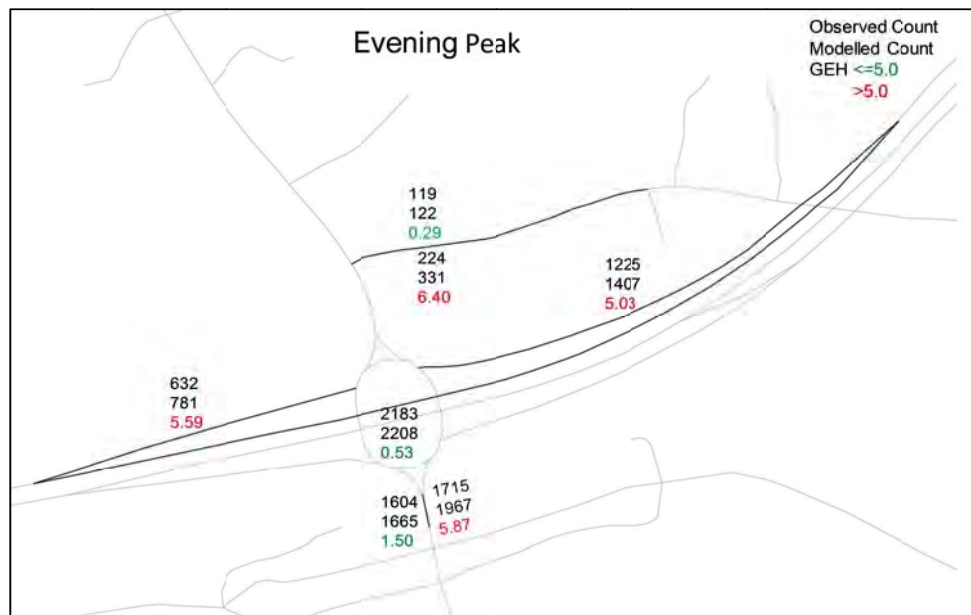
Figure 11-E   Inter Peak Flows

Figure 11-F Interpeak flows at M55 J1

Figure 11-G   PM Peak Flows

Figure 11-H PM peak flows at M55 J1

It is noted that in the AM and PM peak models, there is a count on the A6 northbound between the M55 and the crossroads for which the GEH exceeds five. ; 5.68 in the AM peak, and 5.34 in the PM peak. However, it must be noted that the count data at that location shows some significant flow variation over the two week period for which counts were collected. Over both the AM and PM peak hours, the observed flows showed day to day variation from the mean of up to 9% on certain days, with a flow range of 18%.

The result of this is that on three of those days the AM peak modelled flow would have a GEH below five, and on five of those days, the PM peak modelled flow would have a GEH below five. It would therefore be incorrect to say that as a result of the comparison of the average count data, the modelled flow is unrepresentative of actual traffic conditions at that location, given the variability.

In addition to this, it is significant that for the count location to the north of the crossroads, the modelled flow matches the average observed flow to a high level of accuracy (GEH of 2.33 in the AM peak and 0.35 in the PM peak). Given that the economic benefit of the scheme is derived from the journey time savings of north/south movements through the crossroads, there is sufficient evidence to support the view that the model is representative of through traffic through the area and thus provides a reliable basis on which to make an economic assessment of the scheme.

Away from that count, the images above confirm that modelled flows reflect count data very well, which gives more confidence in the model's abilities to represent actual traffic conditions.

11.5   Journey times

Journey times within the model were checked by comparison of the modelled journey times against the observed times along the routes identified in section 5.5. WebTAG2 requires that for the total route length, the modelled journey time from start to finish be within 15% of the observed time, and this must be the case for 85% of all the routes. However, that simple comparison ignores the fact that modelled and observed journey times could deviate significantly from each other along specific sections of a route, and the overall time still be within the specified acceptance criteria. To ensure rigour in the modelled delays and journey times, the model has been developed in order to ensure that the modelled times match the observed times not just for the total time along the routes, but also at all points of the routes. To that end, distance versus time graphs for the modelled and observed times are also provided.

The following table summarises the performance of the model in terms of the WebTAG criteria:

No.	Description	Modelled time [min:sec]	Observed time [min:sec]	% Difference
101	A6 SB (through Broughton)	10:13	10:19	-0.97%
102	A6 NB (through Broughton)	12:04	13:41	-11.81%
201	Hollowforth Ln SB	09:52	11:35	-14.82%
202	Hollowforth Ln NB	10:04	11:13	-10.25%
301	Newsham Ln WB	03:31	03:20	5.50%
302	Newsham Ln EB	05:44	06:54	-16.91%
401	A6 NB (through Garstang)	10:07	11:20	-10.72%
402	A6 SB (through Garstang)	10:51	10:55	-0.66%
501	Whittingham Lane EB	01:26	01:32	-6.50%
502	Whittingham Lane WB	03:48	03:43	2.16%
601	M6 (between J31A and J33)	16:17	14:59	8.70%
602	M6 (between J31A and J33)	14:55	14:13	4.96%
701	M55 (between J32 and J3)	07:48	07:19	6.52%
702	M55 (between J32 and J3)	07:27	06:56	7.41%

Table 11-H   Comparison of Modelled Journey Time against the Observed, AM

No.	Description	Modelled time [min:sec]	Observed time [min:sec]	% Difference
101	A6 SB (through Broughton)	07:30	07:53	-4.86%
102	A6 NB (through Broughton)	07:32	07:55	-4.84%
201	Hollowforth Ln SB	09:06	10:30	-13%
202	Hollowforth Ln NB	09:10	10:17	-11%
301	Newsham Ln WB	03:07	03:35	-13%
302	Newsham Ln EB	05:05	04:36	11%
401	A6 NB (through Garstang)	:10:07	11:40	-13.26%
402	A6 SB (through Garstang)	10:09	11:37	-12.67%
501	Whittingham Lane EB	01:26	01:19	9%
502	Whittingham Lane WB	03:52	03:47	2.00%
601	M6 (between J31A and J33)	14:31	14:25	0.72%
602	M6 (between J31A and J33)	14:42	14:32	1.17%
701	M55 (between J32 and J3)	06:49	06:48	0.20%
702	M55 (between J32 and J3)	07:03	07:01	0.58%

Table 11-I   Comparison of Modelled Journey Time against the Observed, IP

No.	Description	Modelled time [min:sec]	Observed time [min:sec]	% Difference
101	A6 SB (through Broughton)	08:26	08:21	1.00%
102	A6 NB (through Broughton)	11:42	13:02	-10.23%
201	Hollowforth Ln SB	09:20	10:47	-13.45%
202	Hollowforth Ln NB	10:02	10:23	-3.37%
301	Newsham Ln WB	03:15	03:21	-2.99%
302	Newsham Ln EB	05:36	05:35	0.30%
401	A6 NB (through Garstang)	10:41	11:12	-4.63%
402	A6 SB (through Garstang)	:10:46	11:02	-2.45%
501	Whittingham Lane EB	01:26	01:26	-0.22%
502	Whittingham Lane WB	04:41	04:06	14.44%
601	M6 (between J31A and J33)	15:51	14:02	12.90%
602	M6 (between J31A and J33)	15:44	15:05	4.34%
701	M55 (between J32 and J3)	07:40	06:43	14.01%
702	M55 (between J32 and J3)	07:32	07:03	6.97%

Table 11-J   Comparison of modelled journey time against the observed, PM

In addition, Appendix E contains the journey time graphs for all routes in the model.

The above table demonstrates that the WebTAG2 criteria is met and exceeded for all but one route (route 302 in the AM peak period which marginally falls short of the criteria). It is also notable that the differences in times are not consistently positive or negative, suggesting there is no underlying bias of too quick or too slow journey times in the model. More than this however, the graphs in Appendix E show that there is also a good match in journey times along all points of the journey time route. This is particularly important for routes 101 and 102 (see Figure 5-F for route maps) which are the routes along the A6. These routes include the exact stretches of road that will be relieved by the presence of the proposed bypass. It was therefore crucial to ensure that the journey time routes on these sections showed a very good match between modelled and observed times at all points of the routes since the performance of the bypass will be directly affected by the amount of delay on the existing north/south route. As the graphs in Appendix E show, routes 101 and 102 both demonstrate a high level of correspondence between the modelled and observed times on those routes. This provides reassurance that the effects predicted by the forecast model will be underlined by a sound base year model.

12 Summary of Model Development, Standards Achieved and Fitness for Purpose

12.1 Summary of Model Development

The demand data used in the model has been collected using a mixture of observed and synthetic data, and has been constructed following guidance laid down in WebTAG. Extensive origin-destination data, collected across five roadside survey locations in and around the study area ensured that the model accurately reflected actual trip movements around the areas local to the scheme. The synthetic demand was generated using software created for the purpose; namely CTripEnd and NATCOP; using established data sources including from Census, NTS, and employment survey data.

The modelled network was created from the ITN network, a reliable data source provided by Ordnance Survey. The finer points of junction coding and link speeds and capacities were modelled with reference to Google Earth and site visits to establish the highway conditions. Link data was coded in a manner consistent with the COBA manual. Extensive checks on the coded network were conducted.

The modelled assignment satisfies the WebTAG criteria for a well converged model. Modelled flows and journey times compare very favourably to observed data, both for independent data, and data used as part of the model building process. Both flow and journey time validation in the model exceeds the criteria set out in guidance.

12.2 Summary of standards achieved

The standards to which the model aimed to conform are set out in section 3. The table below summarises how the model has actually performed against those standards:

Model aspect	Criterion	Acceptability Guideline	Actual model performance
Matrix validation	Differences between modelled flows and counts should be less than 5% of the counts	All or nearly all screenlines	Satisfied for 50% of screenlines in AM peak, 25% in IP and 25% in PM peak. Criteria is satisfied if judged on flow differences of +/- 100 on short screenlines
Matrix estimation	Matrix zonal cell values	Slope within 0.98 and 1.02 Intercept near zero R^2 in excess of 0.95	Satisfies criterion in all time periods
	Matrix zone trip ends	Slope within 0.99 and 1.01 Intercept near zero R^2 in excess of 0.98	Satisfies criterion in all time periods
	Trip length distributions	Means within 5% Standard deviations within 5%	Satisfies criterion in all time periods
	Sector to sector level matrices	Differences within 5%	Fails criterion in all time periods. No movements are fully observed however, so this is expected.
Assignment	Delta and %GAP	Less than 0.1%	Satisfied for all time periods

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convergence			
Link calibration	Individual flows within 100 veh/hr of counts for flows less than 700 veh/hr	> 85% of cases	AM peak: criteria met for car flows on 87% of links, and for total vehicles on 83% of links
	Individual flows within 15% of counts for flows from 700 veh/hr to 2,700 veh/hr	> 85% of cases	Interpeak: criteria met for car flows on 97% of links and for total vehicles on 95% of links
	Individual flows within 400 veh/hr of counts for flows more than 2,700 veh/hr	> 85% of cases	PM peak: criteria met for car flows on 84% of links and for total vehicles on 81% of links. In summary, criteria were satisfied or almost satisfied in all time periods.
	GEH < 5 for individual flows	> 85% of cases	
Link validation	Same as for link calibration, but for independent counts		AM peak: criteria met for car flows and total vehicles on 88% of links. Interpeak: criteria met for car flows and total vehicles on 100% of links. PM peak: criteria met for car flows on 88% of links and for total vehicles on 94% of links. In summary, criteria were satisfied in all time periods.
Journey times	Modelled times along routes should be within 15% of surveyed time, or 1 minute if higher	> 85% of all routes	Meets criteria for 93% of routes in the AM peak, and 100% in the interpeak and PM peak.

Table 12-A   Model performance against standards

The table demonstrates that most model standards set out in section 3 are met. Some of the criteria related to screenline validation and matrix estimation are not met, however, there are well understood reasons why that is the case and explanations have been given.

12.3   Assessment of Fitness for Purpose

The model performs very well against the model standards previously set out and this should serve to give confidence and provide reassurance that the model is representative of current conditions. However, it is acknowledged that simply meeting the validation criteria does not in of itself qualify the model to be a suitable tool for assessing the effects of Broughton Bypass. In addition to the model meeting the WebTAG criteria, further confidence in the ability of the model to represent current traffic conditions should be sought from the modelled journey times along the A6 and other roads through the study area, which demonstrate that the model reflects observed levels of congestion at all points to a high degree of accuracy. Additionally, modelled traffic flows in the vicinity of Broughton and the proposed scheme provide further evidence of the model's robustness in representing current traffic conditions to a high level of accuracy.

Given that the model has been demonstrated to have been constructed in a manner consistent with guidance, exceeds the calibration/validation criteria in a number of areas <u>and</u> is highly representative of traffic conditions in the immediate vicinity of the proposed scheme, it is expected that a high degree of confidence may be placed in the model for the purposes of scheme assessment, appraisal, economic and environmental appraisal, as described in the opening sections of this report.