Warrington Transport Model

Model Validation Report

Warrington Borough Council

Project Number: 60513762

06 December 2017

Quality information

Prepared by	**Checked by**	**Approved by**
	Frank Mohan	Frank Mohan
Laura Appleton Senior Consultant	Frank Mohan & Ian Taylor	Frank Mohan

Revision History

Revision	**Revision date**	**Details**	**Authorized**	**Name**	**Position**
1	09/02/17	Draft contents list			
2	18/04/17	1st Draft – Ch1 - 4			
3	17/10/17	1st completed Draft			
4	27/11/17	Updated Run053 results and addressing comments from WBC / WSP			
5	04/12/17	Revised Version addressing comments from WSP 30/11/17			
6	06/12/17	FINAL VERSION			
7	12/12/17	FINAL Version with final refinements to VDM Section			

Distribution List

# Hard Copies	**PDF Required**	**Association / Company Name**

Prepared for:

Warrington Borough Council

Prepared by:

Laura Appleton
Senior Consultant
T: 0161 602 7540
E: laura.appleton@aecom.com

AECOM Limited
1 New York Street
Manchester
M1 4HD
UK

T: +44 161 601 1700
aecom.com

Table of Contents

Figures

Tables

1. Introduction

1.1 Context

Warrington Borough Council (WBC) has a requirement for a highway and public transport model to help estimate and assess future year traffic conditions, inform transport related policy and scheme decision making, as well as informing wider planning decision making. AECOM were appointed by WBC to commence work on the development of the new transport model in July 2016. The model is referred to as the Warrington Multi Modal Transport Model 2016 (WMMTM16).

There are two main issues that require evidence derived from a transport model covering Warrington:

- WBC is preparing a spatial strategy for the Warrington Local Plan which is currently under review. This is expected to involve substantial development, comprising an additional 24,774 dwellings over the next 20 years. These are expected to impose significant pressure on the transport network. It will be particularly important that soundly based evidence justifies the associated transport strategy, for the final consultation of the preferred spatial strategy prior to an Examination in Public (EIP).
- The model is required to underpin the appraisal of a variety of transport proposals, notably a major western route, “Warrington Western Link”, providing access to potential development along the Manchester Ship Canal and providing improved connectivity to the west of the town centre, together with relief and resilience to the town centre road system. Evidence will be required to justify investment in this scheme; which is currently being developed.

In addition to these issues, which are fundamental to the Town’s growth strategy, there are requirements to liaise with Highways England to identify and prioritise investment in the motorway network; the operational performance of which is critical to Warrington’s own highway network. There is also a need to consider and prioritise other investments and management plans for the transport system.

1.2 Scope of this Report

This report sets out the work undertaken to develop the model and how well it performs against observed data.

1.3 Related Documents

In the context of this project, no particular scheme is being appraised but there is a need to clearly set out the context, background and technical requirements of the model to be built. Best practice is therefore to produce a Model Specification Report (MSR). For more information on the specification of the model, please refer to the AECOM report *“Warrington Transport Model: Model Specification Report (MSR), November 2016.”*

In addition to the MSR, please refer to the AECOM report *“Warrington Transport Model: Data Collection Report (MDCR), January 2017”* for more information relating to the methodology, collection and analysis of existing data and the additional data collection exercise undertaken in June/July 2016.

1.4 Report Structure

Following WebTAG guidance, Unit M3.1, this Model Validation Report (MVR) covers the following:

- Chapter 2 details the model specification and overall design of the WMMTM;
- Chapter 3 sets out the criteria and standards against which the model will be assessed;
- Chapter 4 presents a summary of the data collected, quality assessment, and how the data has been taken forward into calibration and validation;
- Chapter 5 presents the key features of the highway and public transport model networks;

- Chapter 6 describes the methodology behind the production of the highway and public transport prior matrices;
- Chapter 7 presents the results of the calibration exercise for the highway assignment;
- Chapter 8 presents the results of the calibration exercise for the public transport assignment;
- Chapter 9 presents the results of the model validation against the criteria outlined in Chapter 3;
- Chapter 10 describes the demand model process; and
- Chapter 11 presents the conclusions and recommendations.

2. Model Description & Specification

2.1 Background to the Model

This chapter covers the key features of the WMMTM16 model in terms of: scope, time periods, demand segmentation, assignment methods; generalised cost assumptions, representation of transport network capacity and the structure and interfaces of the model suite.

2.2 Model Objectives

The MSR sets out the requirements of the model. These can be summarised in terms of a need for a tool that comprises highway and public transport assignment and variable demand modelling capability, following the standard modelling structure defined in WebTAG M1.1.

There are particular pressures on the operation of the highway model reflecting the resilience of the M6, M56 and M62 around Warrington and the funnelling of north-south routes crossing the Manchester Ship Canal. Combined with the pressures to support substantial development in the borough, the model must be capable of representing the effects of these pressures on an already congested urban network as well as represent the capacity and constraints within Warrington.

The key model requirement is to support WBC’s transport strategy and Local Plan development which aims to deliver acceptable accessibility to support growth of the borough, and to help justify investment in particular schemes.

2.3 Model Scope

The model is required to be sufficiently detailed and robust to accomplish the following:

- represent the existing transport networks within Warrington and performance at present;
- understand the traffic impact of the site specific allocations of the Warrington Local Plan on the local highway network;
- develop realistic mitigation measures to support these allocations and test them to understand their benefit and their impact on traffic patterns - these results can then be fed into a transport strategy and associated infrastructure planning; and
- undertake detailed feasibility work on Warrington transport infrastructure projects such as Warrington Western Link.

2.3.1 Model Platform

The WMMTM16 has been developed using SATURN modelling software, version 11.3.12U for highway assignment modelling aspects integrated with EMME 4.29 software for public transport and demand modelling aspects.

2.3.2 Geographic Coverage

Although the purpose of the WMMTM16 is to model demand and network conditions within the boundaries of the Warrington Borough, the model itself extends outside of this area. As the distance from the borough increases, the level of spatial detail reduces.

Following WebTAG M3.1 the resultant classification of modelled area type has been considered:

- **Fully Modelled Area (FMA)**: the area over which proposed interventions have influence. This can be further subdivided as follows:
  - *Area of Detailed Modelling*. This is the area over which significant impacts of interventions are certain. Modelling detail in this area is characterised by: representation of all trip movements; small zones; very detailed networks; and junction modelling (including flow metering and blocking back).

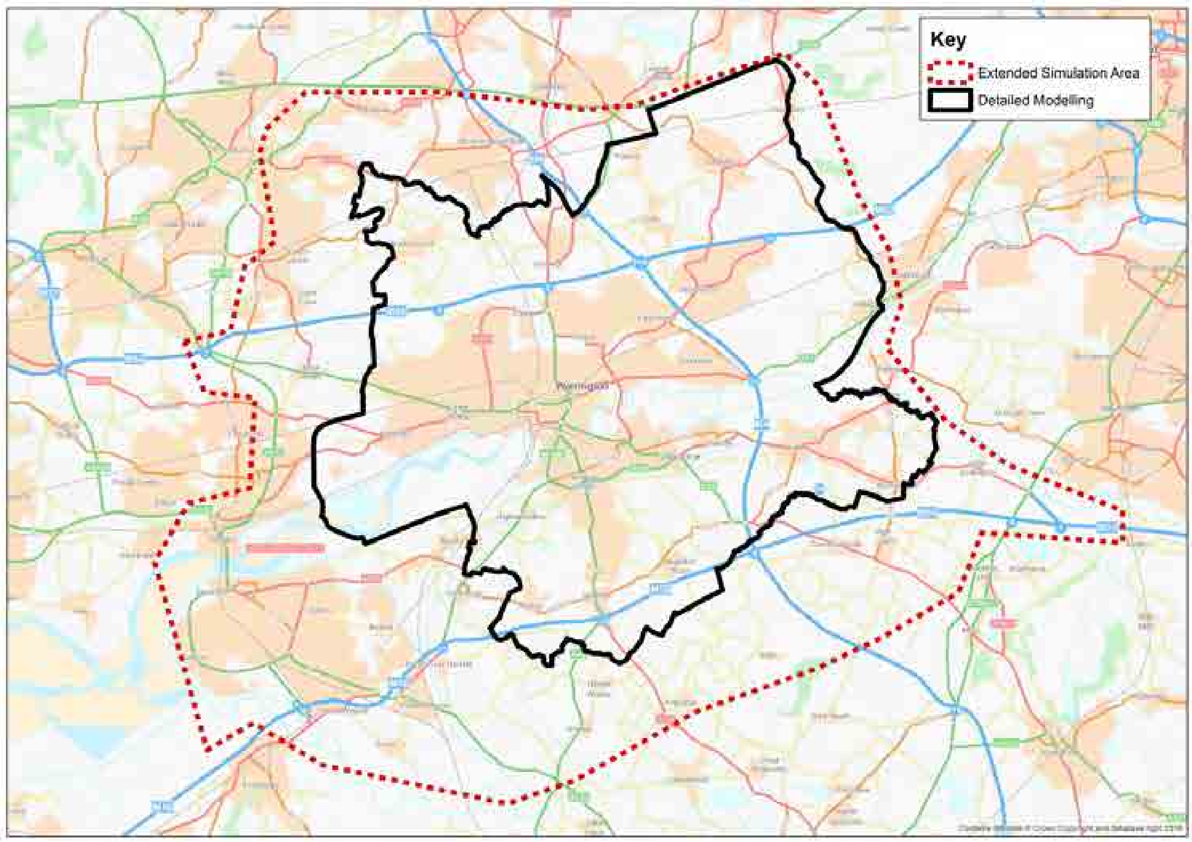
  - *Rest of the Fully Modelled Area*. This is the area over which the impacts of interventions are considered to be quite likely but relatively weak in magnitude. It is characterised by: representation of all trip movements; somewhat larger zones and less network detail than for the Area of Detailed Modelling; and speed/flow modelling (primarily link-based but also including a representation of strategically important junctions).
- **External Area**: In this area impacts of interventions would be so small as to be reasonably assumed to be negligible. It is characterised by: a network representing a large proportion of the rest of Great Britain, a limited representation of demand focused on trips to, from and across the Fully Modelled Area; large zones; skeletal networks and simple speed/flow relationships or fixed speed modelling.

The WMMTM16 consists of the three areas noted above (see Table 1 for more information)). This area of Detailed Modelling is shown in Figure 1 and covers the area within the Warrington Borough boundary.

The *Rest of the Fully Modelled Area* is the area between the Warrington Borough boundary and the dotted line on Figure 1.

The external area is the remaining area outside the dotted line on Figure 1, covering the rest of the country.

Figure 1 WMMTM16 Modelled Area



2.3.3 Highway Network structure

2.3.3.1 Buffer / simulation network

Within the FMA the model needs to be capable of modelling the choice of routes available to the driver. Therefore within this area, all motorway, A roads and B roads are included as well as a substantial number of additional minor roads where these provide a through route. Additionally, some minor roads have also been included to provide a means for trips to access the highway network from zones and to represent public transport service routeing. The external area consists of motorways and ‘A’ roads only.

The minor roads represented have been identified through an inspection of the network and an assessment of the potential to serve through movements. These definitions were then reviewed by WBC and an independent auditor to verify that the network representation included routes of local concern where ‘rat running’ was observed or the potential was judged to exist. Table 1 summarises the association between each model area and the road types included.

Table 2 provides a summary of the key network features. Figure 2 displays the extent of the model simulation area and Figure 3 shows the simulation nodes within Warrington by junction type.

Table 1 Network Density and Detail

Area	Sub – Area	Network Density	Network Detail
Fully Modelled Area	Area of Detailed Modelling	Motorway A Roads B Roads Key Minor Roads	Simulation
	Rest of Fully Modelled Area	Motorway A Roads B Roads	Simulation
External Area	External Area	Motorway Some A Roads	Buffer

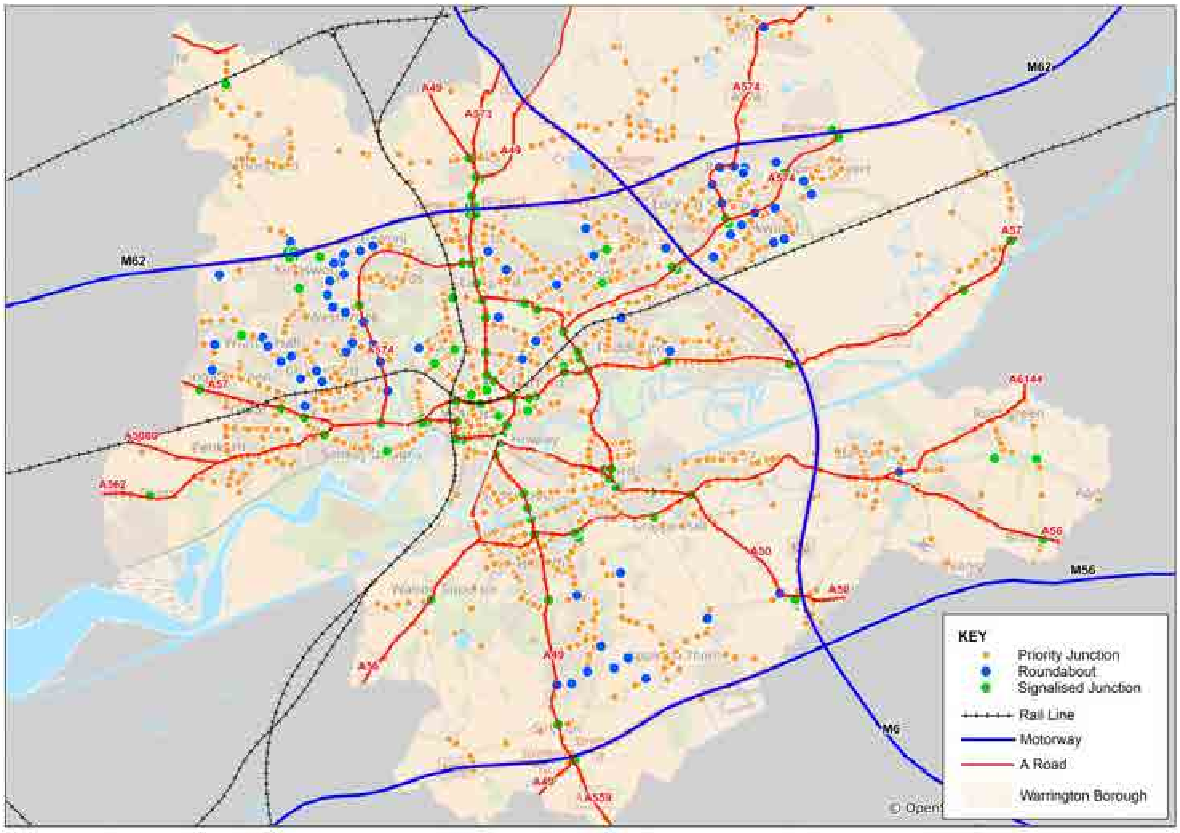
Figure 2 Extent of Model Simulation Area

Table 2 Network Summary

	Simulation	Buffer	Total
Number of Links	5,150	9,956	15,106
Number of Zones	498	88	586
No. of Zones in Borough	488	-	
Number of Nodes	2,484	6,386	8,870
Dummy	36		
Number of Junctions	2,447	-	-
External Nodes	*173*	-	-
Priority Junctions	*2,053*	-	-
Roundabouts	*87*	-	-
Signalised	*135*	-	-

SOURCE: P1X, SATLOOK, Option 7

Figure 3 Simulation Nodes in Warrington by Junction Type



2.3.4 Highway Capacity Restraint Mechanisms

2.3.4.1 Junction modelling

In the FMA, all junctions are modelled in full ‘simulation’ level detail to explicitly represent junction delays.

Section 4 of the Coding Manual (appendix E) details how the turn saturation flows can be calculated and applied for each junction included within the SATURN simulation network. Saturation flow is defined in the SATURN User Manual Section 6.4.6 as “the maximum number of pcu’s per hour which could make that particular turning movement PROVIDED there were no other vehicles on the road, no red lights to oppose it, etc.”

The calculation of the turn saturation flows is therefore based upon the physical characteristics of the junction incorporating standard attributes such as:

- Junction type – including signalised junctions, roundabout and signals.
- Major or minor arm
- No of lanes
- Lane Width
- Turning Radius
- Position of lane – nearside and offside
- Visibility; and
- Inclination (on hills).

Tables 2 to 14 in the Coding Manual (appendix E) provide details on the saturation flows applied in the model by junction type and the attributes noted above.

2.3.4.2 Speed/flow relationships

For urban links within the simulation area, cruise speeds (based on DfT Trafficmaster data) have been used on links. These have been extracted for the same time periods being modelled. This is in line with best practice where it is felt that, in urban areas, capacities on links are a function of junction operation; i.e. general activity on a link (for example parked cars, bus stops, side entrances, pedestrians crossing etc.) has the primary influence on the standard “cruise” speed as opposed to a speed/flow relationship typically used on rural links.

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

Speed-flow curves were used to represent the relationship between link flow, speed and capacity and, by defining a speed-flow relationship (or ‘curve’) enables the (observed) decrease in link speeds to be estimated as the overall link flow increases. Those used in the WMMTM16 are listed in Section 4.4 of the Coding Manual and have been derived from a technical note produced by the Highways England TAME group. Appendix C of the Coding Manual contains a copy of the technical note.

All links in the external area (i.e. outside the FMA) have been coded using fixed speeds. This is to allow more stable routeing of high volume trips between large external zones where neither capacity nor demand are fully defined at a link level. These have been derived from the Highways England Trans-Pennine South Regional Transport Model which has fixed speeds coded using observed data from Trafficmaster by time period.

Section 8 of the Coding Manual provides more details on the methodology used to derive the fixed speeds and cruise speeds used in the WMMTM16.

2.3.4.3 Specific Toll Assumptions

The following toll locations were identified and toll rates were implemented in the SATURN 44444 card:

- Mersey Tunnels (Kingsway & Queensway); and
- Warburton Bridge Rd.

For the Mersey Tunnels, tolls were derived from:

http://www.merseytunnels.co.uk/nossl/html/fees.php.

Toll Class 3 was used to represent the cost to HGVs.

For the Warburton Bridge, tolls were derived from:

http://www.ajdor.co.uk/secondary/UK_TOLL_BRIDGES.htm

In addition to the toll charges, Warburton Bridge and the Cantilever bridge crossing in Warrington also carry a weight restriction of 3T. As such, a ban on HGV movements has been applied to the model link.

A summary of the toll charges applied is shown in Table 3.

Table 3 Summary of Base Model Toll Charges Applied

Link	Car Toll (Commute)	Car Toll (Other Users)	LGV Toll	HGV Toll
Kingsway Tunnel Queensway Tunnel	£1.20[1]	£1.70	£2.90	£4.35
Warburton Bridge	£0.12	£0.12	£0.12	Banned

2.3.5 Public Transport Network

The public transport network uses the network developed for the highway model and allows bus operation and walking on each link. Additional walk only links were coded to represent pedestrian links within town centres and access to rail stations. Links were also coded to represent rail tracks and access to the rail services operating to and from Warrington.

The public transport network was coded to represent:

- All bus services operating within, to and from the borough, except privately run (i.e. non-scheduled) services and school buses; and
- All rail services stopping at stations within the borough.

The bus network was initially coded using data from two sources; Traveline's TransXchange data and Basemap's ATCO CIF data. This gave stopping sequences for most services, and allowed the model to take account of route variations through the day with different stopping patterns. Following the application of these datasets, manual headway and routing checks were conducted against timetables.

Rail station locations were mapped using the Ordnance Survey Meridian2 dataset and services were coded manually from timetables listed on the National Rail Enquiries website.

Centroid connectors were coded to link zone centres to the nearest point on the highway network to allow walk access to any routes operating through the zone. Where appropriate, multiple connectors were allowed for a single zone. It is assumed that core area centroid connectors are walk links, however for external areas additional centroid connectors were coded directly to stations as drive links with car travel times coded based on the distance from the zone centre to the station.

2.3.6 Zone Structure

The zone structure for WMMTM16 was developed specifically for this model in line with the guidance in WebTAG M3.1, Section 2.3 and WebTAG M3.2, Section 1.5. This suggests a balance between the size of the zones and the precision/accuracy of the model. The number of zones also has a significant influence on model run times.

The same zone system has been used within all three elements (highway, public transport and demand) of the overall model suite. The zones within the borough are disaggregated from Office of

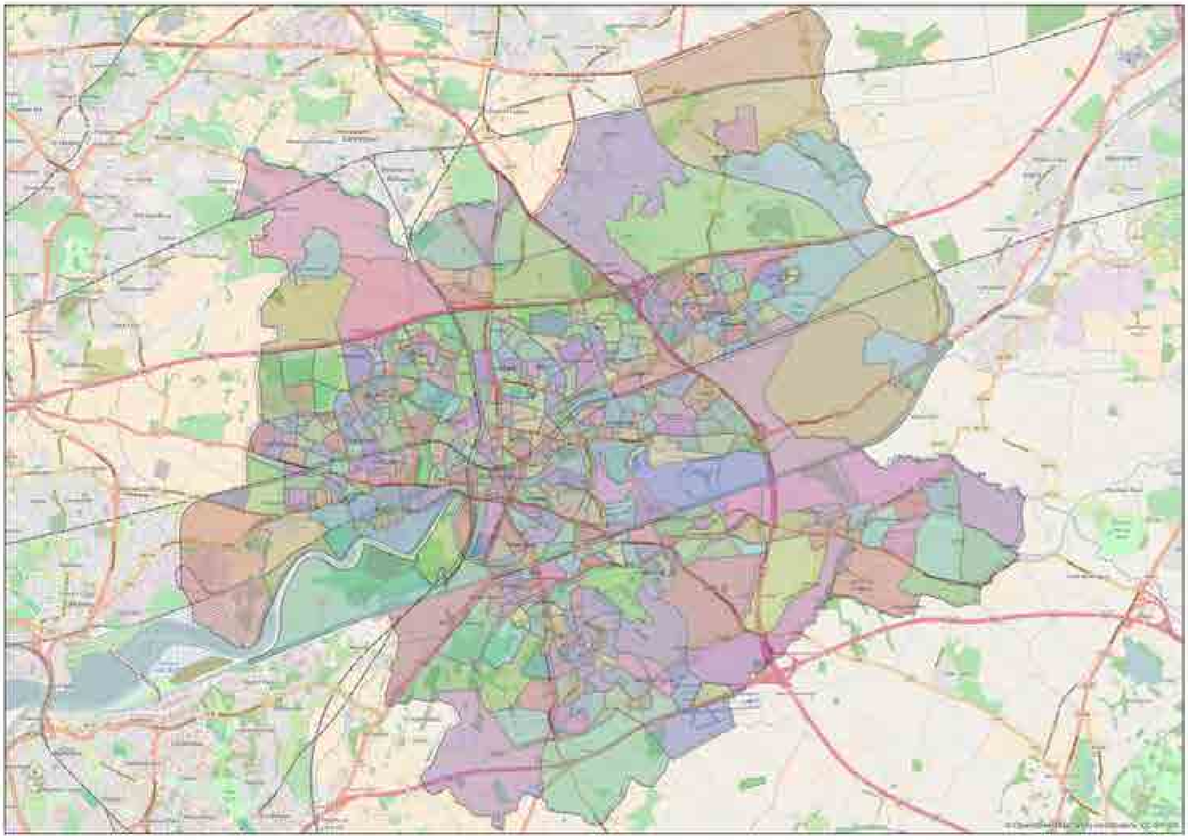
---

[1] It was assumed that commutes would be regular users of the tunnels and were therefore more likely to have a 'fast tag' thereby having access to discounted charges.

National Statistics (ONS) MSOA[2] Census boundaries to reflect proximity to bus stops and stations and access to the modelled road network as well as natural boundaries (rivers, rail infrastructure, highway network, etc.). Population and employment data was used alongside WebTAG recommendation that specifies internal zones should contain around 200-300 highway trips per hour) to estimate trip ends.

Outside the borough the zone system extends across the entire country with zones increasing in size as distance from Warrington increases, formed by aggregating MSOAs for the rest of the country. Once a set of highway zones were created to satisfy these highway access and natural boundary criteria, they were further disaggregated to fit with the requirements of the public transport model (linked to the walking catchment areas around stops and stations). These additional changes were then applied back to the highway model zone system for consistency. The Warrington borough zone structure and the zones covering the immediate areas surrounding Warrington are illustrated in Figure 4 and Figure 5.

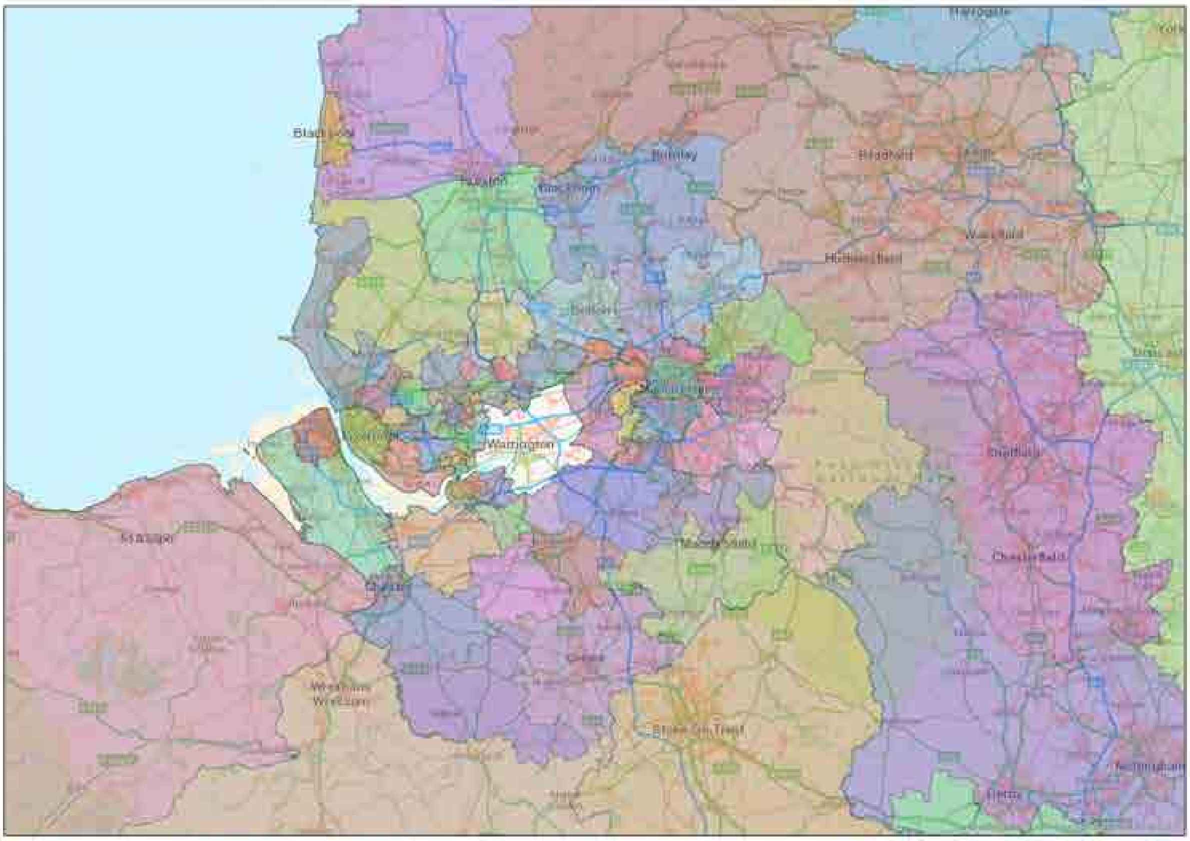
Figure 4 Zones within Warrington Borough



---

[2] Middle Super Output Areas (MSOAs) are one level of a geographical hierarchy used by the ONS designed to assist in the consistent reporting of Census area statistics in England and Wales. The minimum population size for an MSOA is 5,000, the average is approximately 7,200.

Figure 5 North West Zone Structure



2.3.7 Model Time Periods

The base year for the model is 2016 and represents an average neutral “weekday” in June. It has also been assumed that the swing bridges are not in operation and are open to traffic throughout the modelled time period.

Analysis of ATC data collected for the purposes of model development and Google Live Traffic display has revealed the peak hours for highway movements. These have been applied to the WMMTM16 and are shown in Table 4.

Please refer to the AECOM report *“Warrington Transport Model: Model Specification Report (MSR), November 2016”* for more details.

Table 4 Modelled Time Periods

Period Name	Model Time Period	Average Modelled Hour
AM Peak Period	07:45 – 09:15	Average hourly
Inter-peak Period	10:00 – 16:00	
PM Peak Period	16:30 – 18:00	

The Public Transport (PT) survey data was categorised within the AM, Inter-peak and PM peak periods of 07:00-10:00, 10:00-16:00 and 16:00-19:00. The PT model time takes an average of these time periods to represent average time period hours, so as to enable use of all available survey data.

2.3.8 Segmentation

The demand model is more-heavily segmented than the supply models. It considers five modes of travel:

- Car;
- Rail;
- Bus and coach,
- Freight (Light Goods Vehicles, LGV, and Heavy Goods Vehicles, HGV) and
- Active modes (walk, cycle)

It models two person types based on categories of car-availability (car available / no-car available) and five travel purposes:

- Home-based commuting
- Home-based employer’s business;
- Home-based other;
- Non-home-based employer’s business; and
- Non-home-based other.

The highway model assigns the demand across five user classes:

- Car (commuting);
- Car (business);
- Car (other purposes);
- LGV; and
- HGV.

Table 5 lists the Passenger Car Unit (PCU) parameter values that have been used in the highway model to convert vehicles to SATURN PCUs.

Table 5 PCU Factors Used

Vehicle Type	PCU Factors	Source
Car	1.0	*WebTAG M3.1, paragraph D7.2*
LGV	1.0	
HGV	2.0	
Bus	2.5	

The PT model represents bus and rail modes only (no split between fare/non-fare paying has been used). As specified, the model does not include school buses, or coach services.

Surveys were conducted at each of the rail stations within the model simulation area, generating a sample of boarders relating to any train operators.

Bus surveys were conducted on a selection of Network Warrington, Arriva and First operated services. Other relevant bus operator services were included, but accounted for a small percentage of demand.

The surveys were used to generate purpose specific PT matrices in line with the equivalent highway purpose definitions. These were combined for assignment of a single PT demand matrix.

2.3.9 Assignment Costs

2.3.9.1 Highway

The assignment generalised cost formulations (expressed as PPM and PPK – pence per minute and pence per kilometre) were derived using WebTAG’s data book as published in March 2017. The parameters PPM and PPK vary with each user class and time period and these are shown in Table 6.

HGV values are twice as high as those originally quoted in the WebTAG data book Unit A1.3. This is in accordance with WebTAG Section 3.1, paragraph 2.8.8 which states *"…the value of time given in TAG Unit A1.3 for HGVs relates to the driver's time and does not take account of the influence of owners on the routeing of these vehicles. On these grounds, it may be considered to be more appropriate to use a value of time around twice the TAG Unit A1.3 values."*

Table 6 User Classes and Value of Time/Distance 2016 (perceived values)

		AM		Inter Peak		PM	
User Class	**Class Name**	**Value of Time (PPM)**	**Value of Distance (PPK)**	**Value of Time (PPM)**	**Value of Distance (PPK)**	**Value of Time (PPM)**	**Value of Distance (PPK)**
1	Car Commute	20.2	6.12	20.56	6.12	20.38	6.12
2	Car Business	30.17	13.45	30.97	13.45	30.71	13.45
3	Car Other	13.95	6.12	14.85	6.12	14.6	6.12
4	LGV	21.1	13.1	21.1	13.1	21.1	13.1
5	HGV	50.16	46.53	50.16	46.53	50.16	46.53

SOURCE: WebTAG Data Book, March 2017

During model calibration it was found that HGV routing was favouring cross town routes rather than more realistic motorway routes. To encourage HGVs to travel on motorways where this was a more realistic route, reductions of 10p per kilometre were made to HGV operating costs on motorway links as suggested in WebTAG Module M3.1, paragraph 7.2.3. The value was adjusted until realistic cross town routes were observed.

2.3.9.2 PT – Route choice parameters

The model assignment is carried out within EMME. The model includes a representation of the sub mode choice between bus and rail. Route choice is based on a weighted sum of the various elements of journey time, as shown in the formula below, which are refined during the calibration process.

As identified in the MSR, the model uses a standard cost function of the form;

$$Boarding\ penalty\ +\ in\ vehicle\ time\ +(a\ *\ wait\ time)+\big(b\ *(access\ +\ egress\ time)\big)\\ +(c\ *\ interchanges)+\left(\frac{fare}{VOT}\right)$$

Where:

- *A, b and c are constants;*
- *VOT is the value of time; and*
- *Boarding penalty is a mode specific constant*

Access Time

Walk access has been included within the model, allowing travel along the highway network for walk trips. Also walk journeys use the zone centroid connectors. During the network build, the need for additional walk-only links has been considered, covering additional walkway links, connections between the bus and rail networks and zone centroids. This had led to a small number of additional walk-only links being added to ensure an appropriate representation of access to, and connection between, the public transport networks.

In addition, it was necessary to disaggregate the rail demand into car and non-car access, given the relatively even split, and significant difference in access options / times. Car-rail, zone-to-station access link connectors were included and made available to be used by this part of the demand.

No similar disaggregation was required for the bus demand as the survey results showed very few car-bus trips.

All walk link speeds within the model are based on an assumed walk speed of 5kph (WebTAG Unit A5.1, 2014).

Standard zone connectors have been assigned a speed of 25kph and car-rail access connectors have been assigned a speed of 50kph.

A cost perception factor ranging from 1.4 to 1.65 was applied to the access time across the time periods, accounting for the inherent physical inconvenience for walking, and congestion / parking costs associated with access by car. The upper value was used in the IP period to account for the greater degree of concessionary pass users, with an associated greater degree of reduced physical mobility.

Wait Time

To represent wait time, there are two approaches which can be adopted within EMME, these are:

- Schedule based, which are derived from actual service timings; and
- Frequency based, which are based on service headways.

WebTAG M3.2 provides advice and recommendations on each of the two approaches. For the purpose of this project, a headway based representation of wait time has been used in the model. This was selected based on the review of WebTAG guidance presented in Table 7.

Table 7 Frequency-based Wait Times Rationale

Descriptor		Schedule (S) / Frequency (F) Based	Comments
Service Frequency	High	Either	Varies substantially, but many services in the peak periods in particular are relatively frequent.
	Low	S	
Passenger Information & Service Punctuality	High	S	Limited punctuality information. Though passengers have access to full timetables there are questions of reliability at peak times in particular.
	Low	F	
Transfer choice-making by travellers	Pre-trip	S	Given extent of network most trips are likely to be planned in advance, but extent of interchange is also expected to be relatively small.
	En-route	F	
Regular schedule	Yes	Either	Services generally follow a regular schedule.
	No	S	
Crowding / congestion	Yes	S	Crowding is not considered to be significant for most services.
	No	Either	
Capacity problems	Yes	S	Not aware of significant capacity problems.
	No	Either	
Scale of network	Large	F	Fully Modelled Area is relatively large, covering the Borough area.
	Small	Either	
Day by day variations	Yes	S	Service schedules are regular on weekdays
	No	Either	
Significant dispersion of behaviour	Yes	Either	Analysed at a sector level.
	No	Either	

Table 7 suggests a frequency based approached is more appropriate. Taking into consideration the additional time to generate a timetabled representation and added complexities of maintenance with respect to timetable changes and practicalities of use in forecasting scenarios, a frequency approach was adopted.

Given the relatively high frequency of many bus services a flat headway factor was applied, depending on access type. This is incorporated within the model by using a wait time factor of 0.35 for non-car-rail users and 0.25 for car-rail users. This identifies that for most passengers there is a degree of planning and they don't arrive randomly at the station, as would be implied by a factor of 0.5. The car-rail travellers have a lower factor to represent the fact that they are making journeys which typically are planned with the more reliable scheduling and lower frequencies for long distance journeys.

A wait time perception factor of 1.85 was applied to the general PT users, to represent the fact that people dislike waiting at bus stops and train platforms. For car-rail users a factor of 1 was used, given the reduced headway factor and fact that people can remain in their cars should they wish to.

In Vehicle Time

To represent bus journey times, two approaches were considered. These are the representation of bus journey times extracted from the highway network link speeds, or a timetable based approach based on bus operator timetables. A timetable based representation of in vehicle time has been derived to inform the base model. This approach was selected to allow for a dynamic link between highway and bus link times. In forecasting, outputs from the highway model will be considered to judge whether changes in bus in vehicle time should be represented.

Fare

A distance-based fare structure for bus trips has been derived for inclusion in the model. Bus fares are calculated for single fare journeys by distance, which is calculated from data obtained from Network Warrington. The average fares account for seasons, day, and concession fare types. Survey responses and published fare data has been analysed. The model represents average fares and takes into account concessionary users. Fares were converted to generalised cost minutes by applying a value of time (V.O.T.) based on Office for National Statistics (ONS) data.

For bus users the fare applied, converted to generalised cost mins is:

- 6.6 + 0.6 mins / km

For rail users the equivalent is:

- 8.8 + 0.5 mins / km

Boarding/Interchange Penalty

Boarding penalties have been applied on a mode basis. These, along with walk access links have been used to represent the cost associated with accessing services within the study area of interest. At external stations where the model structure is more aggregated, a combination of node connectors and interchange penalties (ranging from 10-15 minutes) have been applied to calibrate access.

Egress Times

Egress times have been calculated in line with access time discussed above for access time.

Calibration of wait time factors, maximum wait times, and boarding penalties during the model and matrix calibration are described further in Section 8.5.1.

2.3.10 Relationships with Demand Model and Assignment Models

2.3.10.1 Relationships with Demand Model and Highway Assignment Models

The highway model provides costs of zone to zone travel in each of four times period (AM Peak, Inter Peak, PM Peak and Off Peak[3]) for the demand model. Cost skims are carried out on each iteration of the demand model to extract zone to zone:

- Travel times;
- Travel distances; and
- Tolls incurred on tolled routes.

The demand model provides trip demand matrices for highway model assignment. The highway model also provides changes in link travel times for the Public Transport model.

2.3.10.2 Relationships with Demand Model and Public Transport Assignment Models

There are two sets of data transferred between the demand model and the public transport model. These are transferred in the format of zone-to-zone matrices for each element. The public transport model is used to supply travel costs to the demand model. These are derived from the assignment process and the following elements of cost are calculated separately and provided in terms of minutes (except 'fare') without any generalised cost weights:

- In vehicle travel time;
- Access/egress time;
- Wait time;
- Transfer time; and
- Fare.

The demand model provides trip demand matrices to be used for public transport assignment.

---

[3] Off-Peak matrices were received from Telefonica in the same raw format as the other time periods. As such, the same process was applied to remove freight and rail, apply the bias factors, and infill short distance trips. However, the trip length distributions have not been adjusted for the Off-peak. Off peak costs were derived from assigning an average off peak hour matrix to the inter peak network. The off peak assignment was not validated, as the matrix was used only to derive an estimate of off peak travel costs.

3. Model Standards

3.1 Introduction

This section discusses the following topics:

- Details on the verification criteria and standards used to check the quality of the data collected and the mobile phone matrix;
- Validation criteria and acceptability guidelines; and
- Convergence measures and acceptable values.

3.2 Count Data Verification Standards

The development of the WMMTM16 required the use of a substantial dataset for network and matrix production, as well as traffic counts and journey time data for model calibration and validation. The standards and checks applied below considered the suitability of different data sources and outlines the approach used to process the count data and the vehicle classifications required for the model.

A comprehensive data collection exercise has been undertaken for the development of the base year highway and PT models. Please refer to the AECOM report *"Warrington Transport Model: Data Collection Report (MDCR), January 2017"* for more information relating to the methodology, collection and analysis of existing data and the additional data collection exercise undertaken in June/July 2016. In summary, data was collected for:

- Mobile phone data for the borough and surrounding area;
- 459 highway count sites;
- Trafficmaster data coverage for the whole borough to facilitate the analysis of 38 journey time routes;
- 23 RSI surveys;
- 10 parking surveys;
- 8 specialised goods vehicle surveys and 19 freight operator interviews;
- Bus ticket data for Network Warrington services alongside 22 bus passenger surveys and rail access interviews at each station in the borough; and
- Traffic signal data for 80 signalised junctions in the borough.

Each of these datasets has been checked and any anomalies found were removed where necessary or corrected as appropriate as per the standards and processes described in this chapter.

3.2.1 Quality Assurance

Post data collection (which is described in more detail in Chapter 4), the data has gone through a three-stage quality assurance process:

- Internal sense / logic checks conducted by the survey company;
- Analysis of the data by AECOM on a day by day variance basis;
- Cross-checking of nearby count sites. For the highway counts, this focused on checking the automatic traffic counters (ATCs) against the manual classified counts (MCCs) and adjacent site MCCs. Given that most locations had at least one or more roads in between them, no generalised acceptance rules were adopted, but instead a logic check carried out on a site by site basis to determine whether any differences in the flows were plausible. This included a sense check on the ratios between car / LGV / HGV;
- For the Public Transport (PT) model, services and routes were reviewed against timetables and visual checks of the route followed by each coded service in the model were undertaken to ensure that it reflected the existing public transport network as outlined in Section 5.4. Service

headway by bus and rail service was also benchmarked against the timetables and survey data to ensure consistency and prevent potential demand routing issues; and

- Reviews of model the zone connectors, public transport links and walk routes used by passengers to access the transit network were also undertaken to ensure that the access to the model network was adequate for a PT model. The model links have also been reviewed to prevent excessively long walking distances on the network, as well as any missing walk links from the Highway Model.

This process did not highlight any obvious anomalies at this stage. 338 ATC/MCC counts were initially taken forward into the calibration dashboard where they have undergone further review against the modelled outputs, with 280 remaining by the end of the calibration exercise. An additional 109 Junction Turning Link counts were added later during calibration to supplement the core dataset. Further details on this can be found in Section 4.

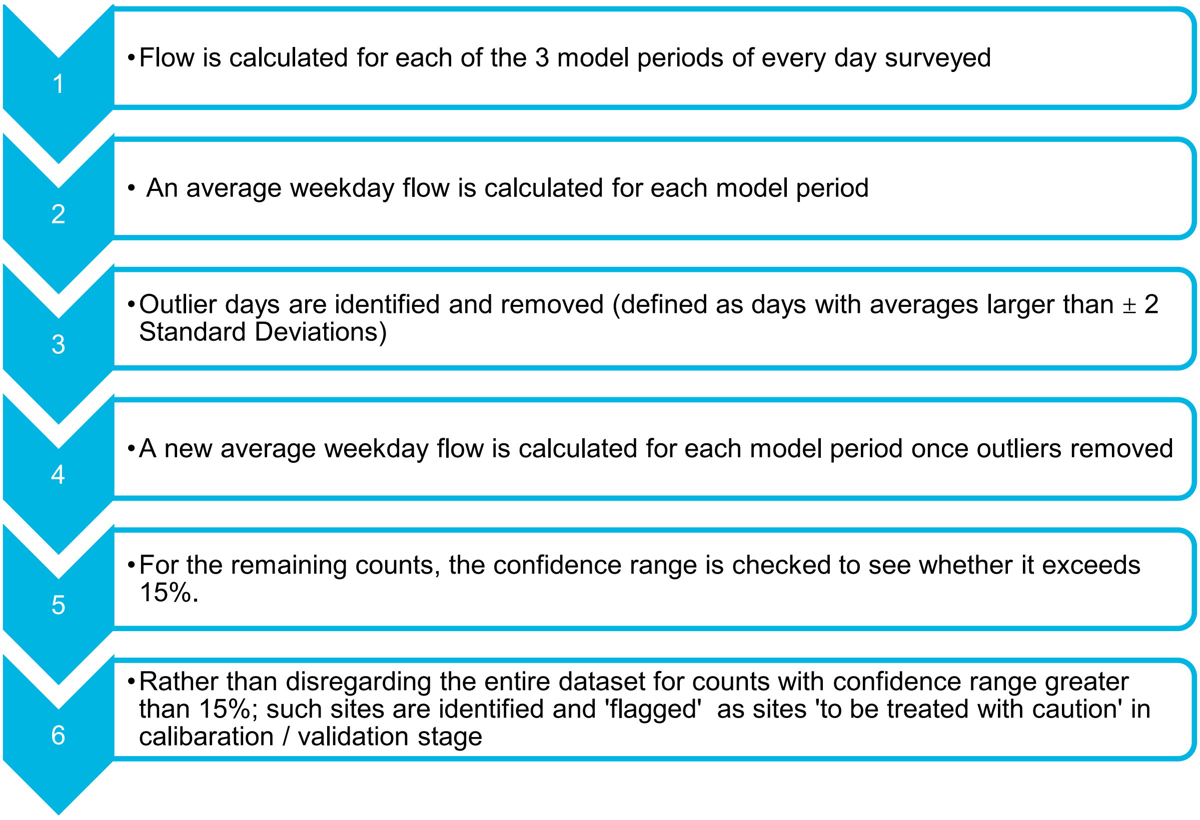
3.2.2 Data Cleaning and Outliers Checks

In the case of ATCs, where data were collected across multiple days, the variance across those days was analysed by each model period. Where the flow for a given period for a given day was identified as being 2 standard deviations or more outside of the respective period average day, the flow for this period was removed from the dataset and the mean for the site recalculated.

This 'outlier's removal' process follows both the WebTAG guidance of unit M1.2, 3.3.37 (the removal of outliers that arise from unusual events) and the Highways England TAME ACO Note V05 on *'Data Requirements for Traffic Models and Economic Review'* and is shown in Figure 6.

The outputs from this process are discussed in more detail in Chapter 4.

Figure 6 Outliers Removal Process



1. Flow is calculated for each of the 3 model periods of every day surveyed
2. An average weekday flow is calculated for each model period
3. Outlier days are identified and removed (defined as days with averages larger than ± 2 Standard Deviations)
4. A new average weekday flow is calculated for each model period once outliers removed
5. For the remaining counts, the confidence range is checked to see whether it exceeds 15%.
6. Rather than disregarding the entire dataset for counts with confidence range greater than 15%; such sites are identified and 'flagged' as sites 'to be treated with caution' in calibaration / validation stage

3.2.3 Vehicle Classification Processing

The proportion of each vehicle class was calculated for each model time period and for the entire day for sites where MCC data or classified ATC data were available. Table 8 sets out the approach adopted for classifying different types of counts.

Table 8 Classifying Counts

Vehicle Class	Data Source		
	TRADS Data[4]	DfT Count Data	ATC (No Vehicle Splits)
HGVs	> 6.6m length	Total HGV classification	Use local splits (by road type etc.) obtained from MCC or DfT data
Lights (Cars and LGV)	< 6.6m length	n/a	If no data available, use the national default data by road type
Cars	Use local MCC splits (e.g. DfT data) to split between cars and LGVs	Car classification	
LGVs		LGV classification	

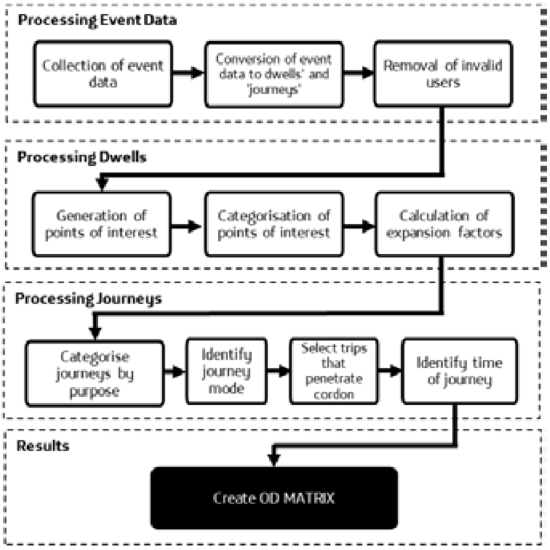
Where there were no local data available to split the counts by vehicle class, regional factors (DfT Traffic Forecasts of 2015) have been used.

3.3 Matrix Verification Standards

Mobile phone data (MPD) was required as the primary component for the generation of the highway demand matrices. MPD has been used as it provides a larger dataset in terms of geographic coverage and timeframe compared to using automatic number plate recognition (ANPR) or RSIs in isolation.

MPD was received directly from one of the main operators – Telefonica, the parent company of O2. Figure 7 shows the methodology used by Telefonica, to develop their mobile phone based origin-destination trip data.

Figure 7 Telefonica Methodology for Producing Mobile Phone-Based Matrices



---

1 As well as TRADS sites, any other sources of data that use vehicle lengths as the basis for their classification system will use this guidance

3.3.1 Verification Checks

The collection and use of MPD is a new technology and area of analysis and as such there is no existing guideline at this stage on how to use mobile phone data to produce OD matrices. In fact there is little guidance in WebTAG on matrix building and the merging of different data sources.

In addition to the checks undertaken by Telefonica on the MPD noted above, an approach has been developed to use existing data sources to test and seek to establish at which resolution level (both spatially and demand segments) the mobile phone data set should be used and then from there to make use of other data sets to refine and disaggregate from this point.

A set of verification standards was developed, and the following key aspects of the MPD were reviewed and verified through comparisons with independent data sources (see Table 9).

Table 9 Mobile Phone Data Verification Tests

Test ID	Demand Indicator	Data Check / Comparison	Indicative criteria	Purpose of Test
A	Trip-ends	All day from-home trip origins and to-home trip destinations vs. Census population	Regression Analysis R2 ≥ 0.90	Verify usability of the data Spatial accuracy of trip allocation to MSOAs
		All day HBW from-home origins and to- home destinations vs. Census JTW 'home' locations		
		All day HBW from-home destinations and to- home origins vs. Census JTW 'work' locations		
	Symmetry	From-home vs. to-home (all day, all purposes)	Regression Analysis R2 ≥ 0.95	Inform defining mobile data sectors as aggregations of MSOAs.
		From-home vs. to-home (all day, HBW)		
		All origins vs. all destinations (all day, all purposes)		
B	Trip Rates	All day from-home trip rates vs. NTS	Review against 95% CI of NTS data	Verify overall expansion of data
		All day internal distribution of from-home trip rates	No criteria, logic check	Identify any localised expansion issue
C	Trip Distribution	HBW from-home (all day) vs. census JTW (district level)	Regression Analysis R2 ≥ 0.95	Verify trip pattern Investigate inclusion of any rail trip
D	Trip Length Profile	HBW all day from-home vs. JTW data	Review against 95% CI of observed data, CI ≥ 0.7	Verify trip length distribution
		All day (all purposes, HBW, HBO) vs. RSI data		
E	Trip Purpose	HBW/HBO/NHB split vs. NTS	No criteria, logic check	Verify purpose split Investigate inclusion of HBEB in HBW matrices

Test ID	Demand Indicator	Data Check / Comparison	Indicative criteria	Purpose of Test
F	Daily Profile Check	Daily profile of trips for AM, IP and PM periods (all purposes, from-home) vs. NTS	No criteria, comparison only	Verify daily profile
G	Vehicle Flows	Assigned flows vs. counts across screenlines (all day level)	Differences ≤ ±20% of observed flows at individual screenlines and ±5% of observed flows across all screenlines	Verify flow pattern and expansion

3.4 Calibration & Validation Criteria

The validation criteria and acceptability guidelines for highway assignment models are set out in Table 10.

Table 10 Validation Criteria and Acceptability Guidelines for Transport Models

Model	Indicator	Criteria	Acceptability Guideline
Highway*	Screenline Flows (1)	Differences between modelled and observed values should be less than 5%	All or nearly all of the screenlines
	Link Flows (2)	Individual flows within 100 veh/hr of counts for flows less than 700 veh/hr Individual flows within 15% of counts for flows between 700 and 2,700 veh/hr Individual flows within 400 veh/hr of counts for flows more than 2,700 veh/hr	>85% of cases
		GEH <5 for individual flows	>85% of cases
	Journey Times (3)	Modelled times along routes should be within 15% of surveyed times (or 1 minute, of higher than 15%)	>85% of cases
Change between prior and post matrix estimation – highway model	Matrix zonal cell values	Slope within 0.98 and 1.02 Intercept near zero R2 in excess of 0.95	
	Matrix zonal trip-ends	Slope within 0.99 and 1.01 Intercept near zero R2 in excess of 0.98	
	Trip length distributions	Means within 5% Standard deviations within 5%	
	Sector to sector level matrices	Differences within 5%	
Public Transport**	Screenline flows	Differences between modelled and observed values should be less than 15%	All or nearly all of the screenlines
	Link flows	Individual flows within 25% counts except where observed hourly flows are less than 150 passengers per hour	

**SOURCE: WebTAG M3.1, Section 3.2, Tables 1, 2, & 3*

***SOURCE: WebTAG M3.2, Section 7, Paragraph 7.1.6*

3.5 Assignment Convergence Criteria

Before the results of any traffic assignment are used to influence decision making, the stability (or degree of convergence) of the assignment model must be confirmed at the appropriate level. The importance of achieving an appropriate level of convergence is driven by the need to provide stable, consistent and robust model results.

The WebTAG convergence criteria and acceptability guidelines are set out in Table 11. It is acknowledged that to achieve a level of convergence which is sufficient to ensure that any scheme benefits can be estimated robustly, a lower value of %GAP than the guidelines below may need to be sought. Additionally, more iteration in the forecast years may be required to account for the higher levels of demand and congestion.

Table 11 WebTAG Convergence Criteria and Acceptability Guidelines

Model	Indicator	Criteria	Acceptability Guideline
Highway Convergence	% Gap	< 0.1%	For final 4 assignment iterations
	Link Flows	% links changing by < 1%	> 98% of cases in final 4 assignment iterations

SOURCE: WebTAG M3.1, Section 3.3, Table 4

3.6 Demand Model Realism Testing & Convergence Criteria

Demand model performance criteria are as set out in WebTAG M2:

- Fuel cost elasticity between -0.25 and -0.35 (WebTAG M2 para 6.4.14);
- Car travel time elasticity less than -2.0 (WebTAG M2 para 6.4.28)
- Public transport fare elasticity between -0.2 and -0.9 (WebTAG M2 para 6.4.21); and
- Convergence gap of less than -0.1% (WebTAG M2 para 6.3.8).

4. Summary of Data Collection

4.1 Context

Please refer to the AECOM report "*Warrington Transport Model: Data Collection Report (MDCR), January 2017*" for more detailed information relating to the methodology, collection and analysis of existing data and the additional data collection exercise undertaken in June/July 2016.

This chapter presents a summary of the MDCR and a review of the data quality. As noted in Chapter 3, a comprehensive data collection exercise has been undertaken for the development of the base year highway and PT models. Data was collected for:

- Mobile phone data for the borough and surrounding area (please see Chapter 6, section 6.2 for more information on this dataset);
- 459 highway count sites;
- Trafficmaster data coverage for the whole borough to facilitate the analysis of 38 journey time routes;
- 23 RSI surveys;
- 10 parking surveys;
- 8 specialised goods vehicle surveys and 19 freight operator interviews;
- Bus ticket data for Network Warrington services alongside 22 bus passenger surveys and rail access interviews at each station in the borough; and
- Traffic signal data for 80 signalised junctions in the borough (please see section 4.3.1.3 for more details on this dataset).

The remainder of this chapter presents a summary of the count data collected (section 4.2), whist section 4.3 presents a summary of the additional data collected to support the highway and PT network development.

4.2 Summary of MDCR Findings

4.2.1 Data Quality / Accuracy

As noted in Section 3.2, the data processing has gone through a three-stage quality assurance process including internal sense checks by the survey company in addition to checks and cross analysis of data by AECOM, all of which presented no major anomalies. Upon completion of these initial checks, the data underwent a final review; an outlier removal process, (as defined earlier in Figure 6, Section 3.2.2) to ensure robust and valid data was used in the subsequent stages of calibration and validation.

4.2.2 Traffic Count Data

The cleaned and processed data collected from traffic count sites was used in WMMTM16 for the following purposes:

- Expanding roadside interviews;
- Calibrating trip matrices by means of matrix estimation; and
- Validating the model.

Table 12 presents a comparison between the count sites (by type) taken forward from the data collection cleaning stage into calibration against the final set of count sites used to calibrate/validate the base model . The table shows that whilst a number of counts were removed during calibration as a result of further detailed checking and verification, the final total used on calibration overall has increased from the first assignment. Each of these count types are discussed in more detail in the remainder of this chapter.

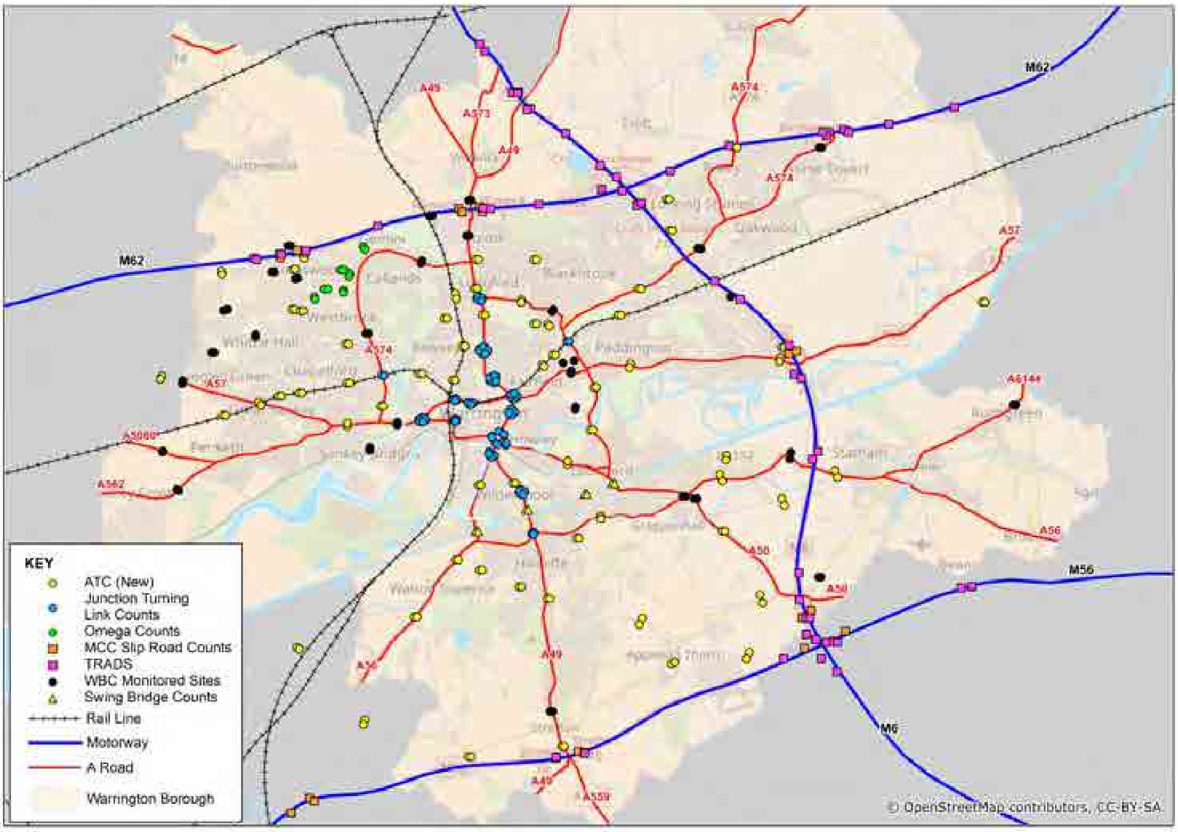
Table 12 Summary of Counts used in the Calibration / Validation Dashboard (by Type)

Count Type	Data Collected (no. sites)	First Dashboard / Initial Cal & Val	Final Dashboard / Final Cal & Val
ATC (New)	134	132	130
WBC Monitored Sites ('Golden River' GR)	92	92	72
*Extra Swing Bridge Surveys**	*0*	*0*	*4*
TRADS	88	88	58
MCC Slip Road Counts	24	24	18
Junction Turning Link Counts	109	0	109
Supplementary Omega Survey Data	12	12	12
TOTAL	**459**	**342**	**389**

* See Section 4.2.2.2 for more details on this dataset

Despite reducing the number of sites used in calibration and validation by 15%, the use of 389 count sites for the calibration and validation of the WMMTM16 provides significant coverage across Warrington (as shown in Figure 8).

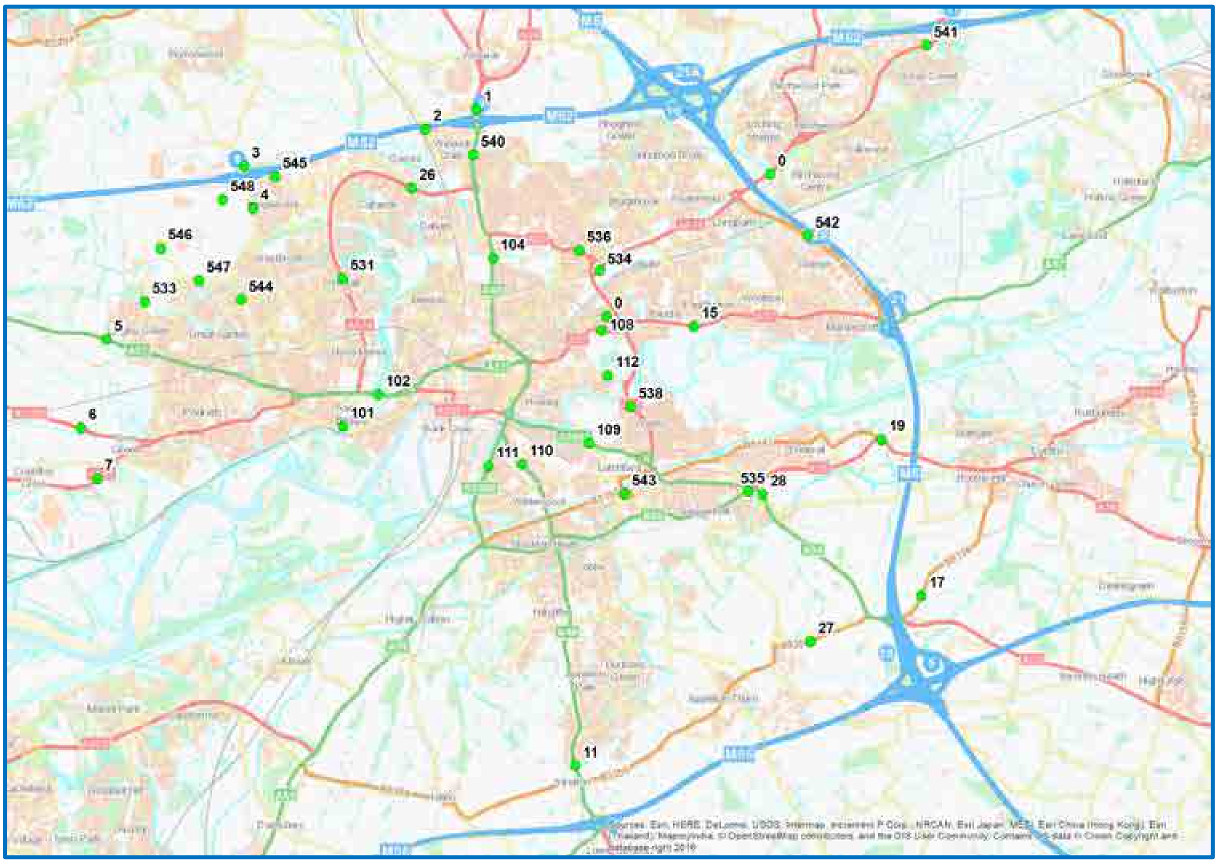
Figure 8 Count Data Coverage by Type - Final Dashboard



4.2.2.1 ATCs – New and Existing

Data was collected for 226 ATC sites (2-way); 92 existing from WBCs continuous monitoring sites and 134 new sites surveyed specifically for this project. Their locations are shown in Figure 9 and Figure 10 respectively.

Figure 9 Existing WBC 'Golden River' ATC Sites



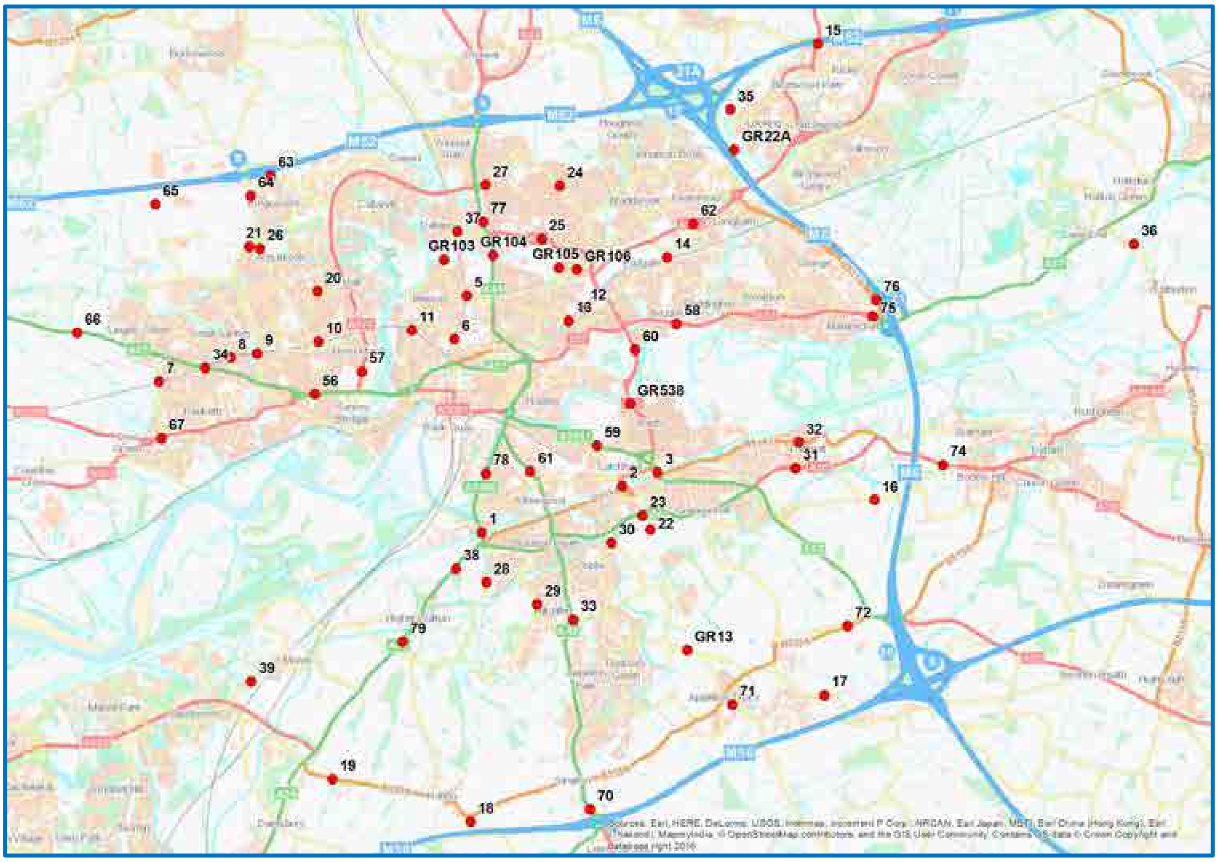
Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community, Contains OS data © Crown Copyright and database right 2016

20 sites from WBCs continuous monitoring collection were removed from calibration:

- 4 in the initial checking stage due to errors found in the processing of the data in the calibration dashboard;
- 6 sites were found to be covering cycle ways and therefore not relevant for use in the model, and
- The remaining 10 have been removed either because they are duplication of another data site, or where the counts provided appeared questionable relative to nearby sites. Some examples include:
  - GR539 – no eastings/northings provided so could not be allocated to a model link;
  - GR104, 105, & 109 – initially discarded from analysis as duplication with WMMTM16 commissioned ATC surveys;
  - GR108, 535 & 540 – issues identified which are believed to be due to an error of original entry in the data set in regard to entering the Motor Cycle and Cars & Light Vans in the wrong columns; and
  - GR111A, 110A & 110B - discarded from analysis as duplication of count sites along the same section of road. Contradictory flows found.

In the case of sites GR108, 535 and 540, it was identified that the car records had been allocated to the motorcycle column in error. We have corrected each of these sites rather than remove them from subsequent analysis as the locations are important in infilling a number of gaps to create a 'watertight' outer cordon. These sites have been retained and were flagged for 'cautionary use' within calibration.

Figure 10 WMMTM16 Commissioned ATC Surveys



Only 2 ATC sites were removed prior to the start of the calibration exercise (Site 22 Stockton Lane) as this was not surveyed on the correct road by the survey company and also not represented in the model.

For the remaining ATCs, sites were checked for exclusion from the calibration and a small number of corrections were made:

- Some instances of low counts on unrepresentative days were identified and excluded as part of the outlier checking and data processing/cleaning;
- Checks made against close proximity sites with contradictory flows; default decision was to remove WBC ‘Golden River’ sites rather than the commissioned surveys (noted above);
- Dashboard corrections made where wrong sites allocated to incorrect screenline; and
- Checks and clarifications made on site descriptions and direction.

Within Appendix A of the MDCR is a summary table of the variation and ‘dispersal index’ for each site, before and after outliers removed. Within this table, ‘N’ identifies the number of days of used data. Typically this is 8, representing two weeks of Monday to Thursday day (Fridays and weekends excluded for each site).

It is noted that of the sites where only one week of data (N = 4) is present, only site 16 has a notably variable dataset across the days. This site is for Weaste Lane, which has a very low flow and is unlikely to generate issues as a result. This site has been flagged for ‘cautionary use’ within calibration.

Table 13 provides a summary of the average weekday flow totals for all the ATC sites (67 locations, 134 sites) over 12-hours and 24-hours periods; as it can be observed the average flows are consistent in either direction of travel and provides no evidence of consistent bias for the ATCs.

Table 13 ATC Sites Summary

Period Analysed	Direction	LV	HV	Total	LV/HV	% Diff LV	% Diff HV	% Diff Total
12 Hr Totals	A (NB / EB)	323,17	7,831	330,946	2.4%	3.0%	6.2%	3.1%
	B (SB / WB)	332,821	8,313	341,132	2.5%			
24 Hr Totals	A (NB / EB)	400,374	9,831	410,203	2.5%	2.7%	5.4%	2.8%
	B (SB / WB)	411,279	10,359	421,621	2.5%			

Figure 11 to Figure 13 show summaries of the observed flows for each of the 3 modelled time periods for count sites used in either calibration or validation.

Figure 11 AM Observed Flow Summary

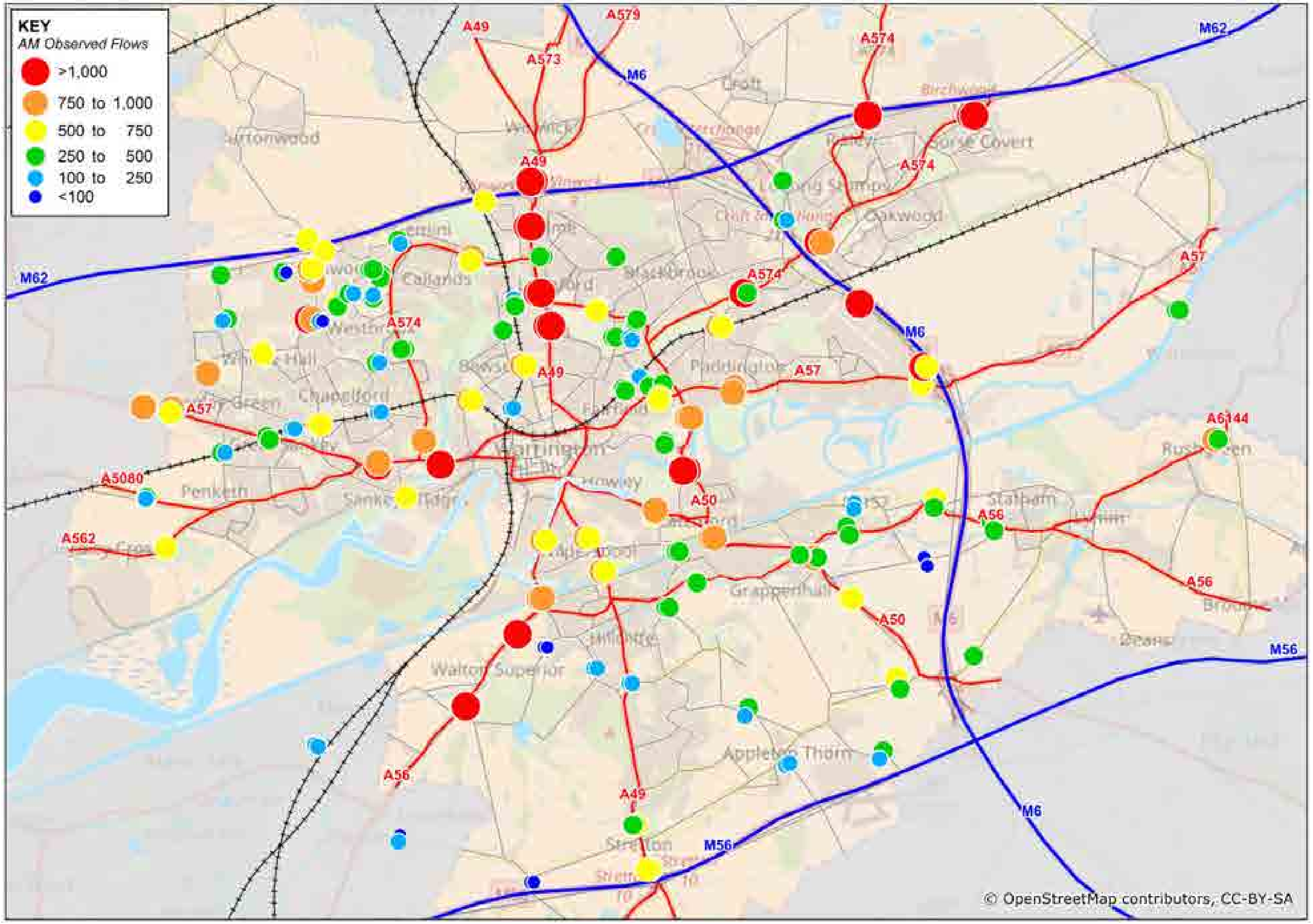
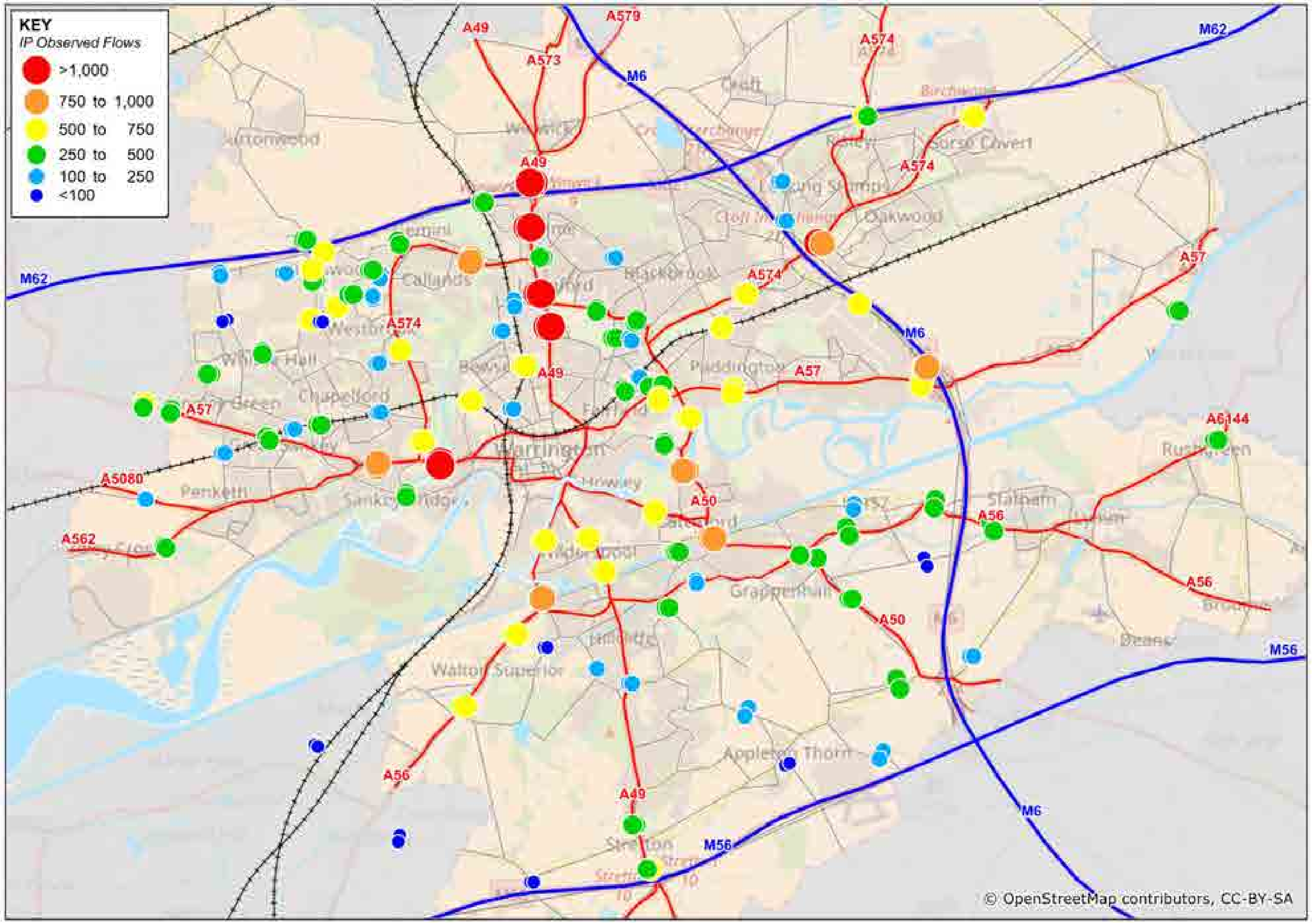
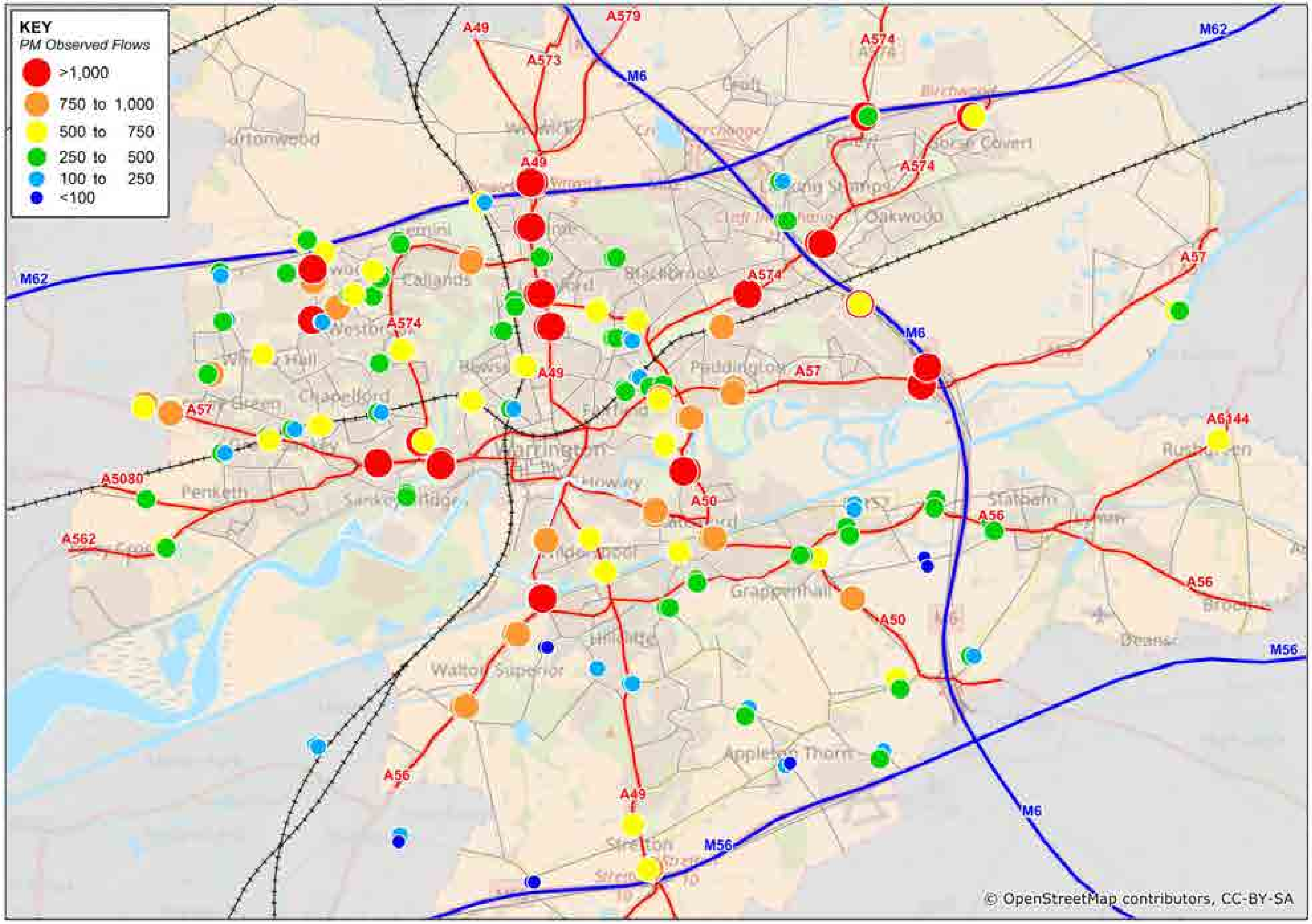


Figure 12 IP Observed Flow Summary



© OpenStreetMap contributors, CC-BY-SA

Figure 13 PM Observed Flow Summary



© OpenStreetMap contributors, CC-BY-SA

4.2.2.2 Additional Swing Bridge Surveys

During the review of the ATC data a gap was identified as a result of removing an ATC count site from the A49 London Road Bridge as it found to be surveying a cycleway rather than the highway bridge crossing. In order to ensure a 'watertight' Manchester Ship Canal screenline (see section 4.2.5 for more information on counts allocated to screenlines and cordons), a second survey was undertaken in May 2017. For completeness, all 4 Manchester Ship Canal crossings were re-surveyed in the event of any incidents on the network that might have impacted movements across the borough.

No incidents were reported in the collection of the data. But due to the timing of the surveys with local school holidays, only one week of data was collected.

These counts underwent the same cleaning and checking process used previously and no issues have been reported. A comparison of the new survey results against the existing datasets are shown in Table 14 and Table 15. The variability in flow at the Ackers Road count site is due to some uncertainty over the precise location of the existing dataset. With this in mind, the final count sites taken forward for use in calibration of the Canal Screenline were as follows:

- Existing 'Original' sites for Chester Road, Knutsford Road, Ackers Road, and Warburton Bridge; and
- New count data for London Road.

A comparison of the total flows for this screenline is shown in Table 16. For full details on all screenlines and cordons used in the calibration and validation of the model, please see section 4.2.5.

Table 14 Comparison of Observed Bridge Crossing Flows - Northbound

Crossing	Direction	Original Dataset			May 2017 Counts			% Diff AM	% Diff IP	% Diff PM
		AM	IP	PM	AM	IP	PM			
Chester Road	NB	908	680	883	986	689	773	8.59%	1.39%	12.42%
Ackers Road	NB	451	262	404	625	340	592	38.51%	29.72%	46.53%
Knutsford Road	NB	967	814	914	1,023	862	1,044	5.76%	5.90%	14.22%
London Road	NB	-	-	-	931	639	598	-	-	-
Warburton Bridge	NB	348	276	551	-	-	-	-	-	-

Table 15 Comparison of Observed Bridge Crossing Flows - Southbound

Crossing	Direction	Original Dataset			May 2017 Counts			% Diff AM	% Diff IP	% Diff PM
		AM	IP	PM	AM	IP	PM			
Chester Road	SB	944	888	1,058	966	788	1,106	2.33%	11.31%	4.54%
Ackers Road	SB	428	370	573	555	411	672	29.75%	11.00%	17.28%
Knutsford Road	SB	856	774	868	879	762	907	2.73%	1.53%	4.53%
London Road	SB	-	-	-	541	586	641	-	-	-
Warburton Bridge	SB	446	287	495	-	-	-	-	-	-

Table 16 Canal Screenline Totals - Observed

Direction	AM	IP	PM
Northbound*	3,605	2,671	3,350
Southbound*	3,215	2,905	3,635

* Flows based on combined flows of 4 original bridge data plus newly surveyed London Road Site

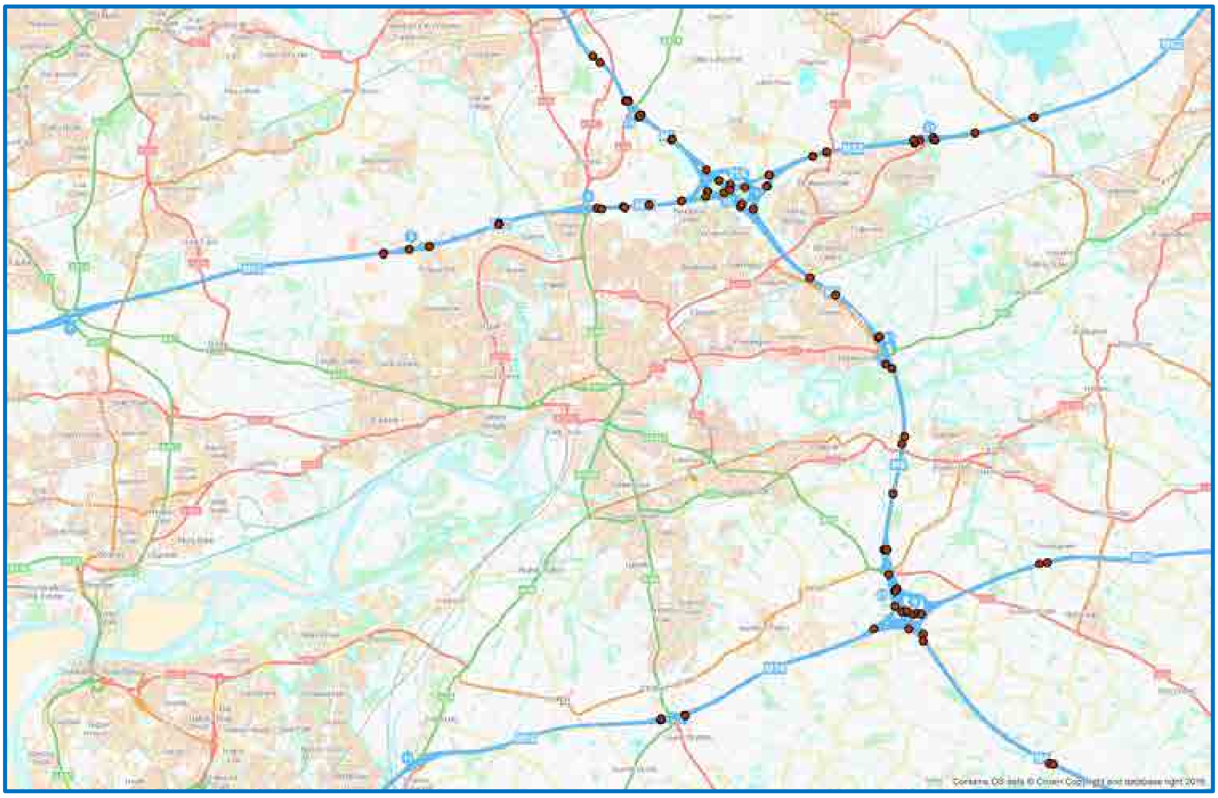
4.2.2.3 TRADS

Data was downloaded for 88 Highways England TRADS sites;

- 10 sites along the M56 between Junctions 11 and 7;
- 50 sites along the M6 between Junctions 19 and 23; and
- 28 sites along the M62 between Junctions 7 and 12.

These are shown in Figure 14.

Figure 14 Highways England TRADS Sites



Contains OS data © Crown Copyright and database right 2016

Data for each TRADS site was downloaded using the following specification and then underwent the same outlier’s removal process as outlined earlier:

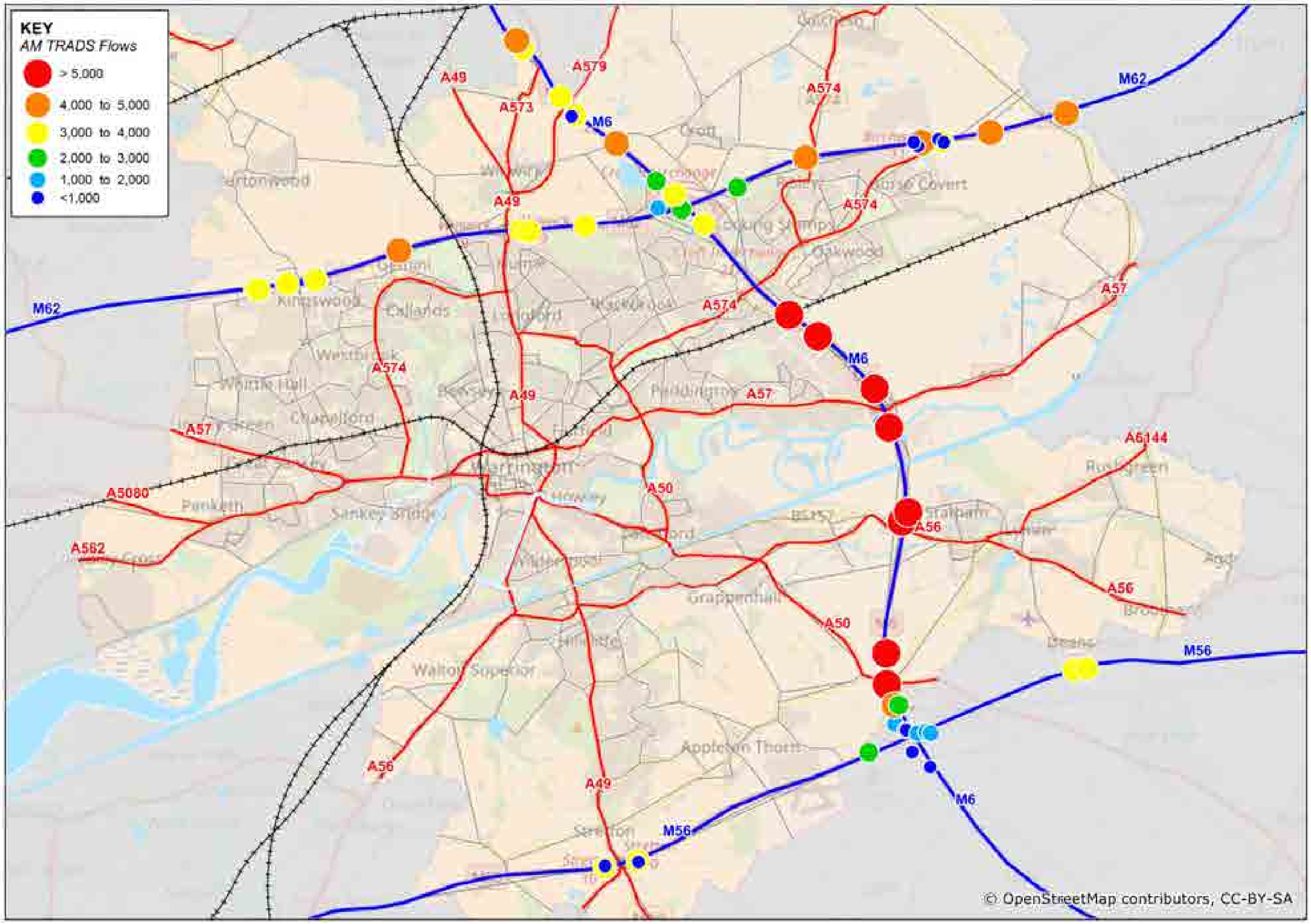
- Daily report format;
- June 2016 (March, June or September 2015 if 2016 data not available);
- Flow by 15 minute intervals; and
- Flow split by vehicle classification.

30 TRADS sites have been removed from the calibration due to questions over the quality of the data downloaded or the close proximity to another site:

- 11 sites were deemed duplicates of other sites;
- 5 sites returned low or unrepresentative flows, for example TRADS_044 returned a flow of less than 500 vehicles for the AM peak along the M62 westbound.
- The remaining 14 sites have been removed during the calibration process once additional checks were undertaken and data quality reviewed:
    - 7 of the sites were located on the Croft Junction. It was deemed that due to the unique nature of delay-response movements between Croft, and junctions 9 of the M62 and 22 of the M6 it was not possible to accurately reflect these movement responses in the model. A sensitivity test which assigned these count sites to matrix estimation demonstrated no improvement in flow through these sites as a result of inclusion in matrix estimation.
    - 4 of the sites were located at the Lymm Interchange. Each were deemed to have low unrepresentative flow relative to their location and in comparison to an upstream/downstream count.
    - The remaining 3 sites were removed as they had not previously been allocated to calibration or validation and deemed surplus to requirements.

Figure 15 to Figure 17 show summaries of the observed flows for each of the 3 modelled time periods.

Figure 15 AM Observed Flows - TRADS Sites



© OpenStreetMap contributors, CC-BY-SA

Figure 16 IP Observed Flows - TRADS Sites

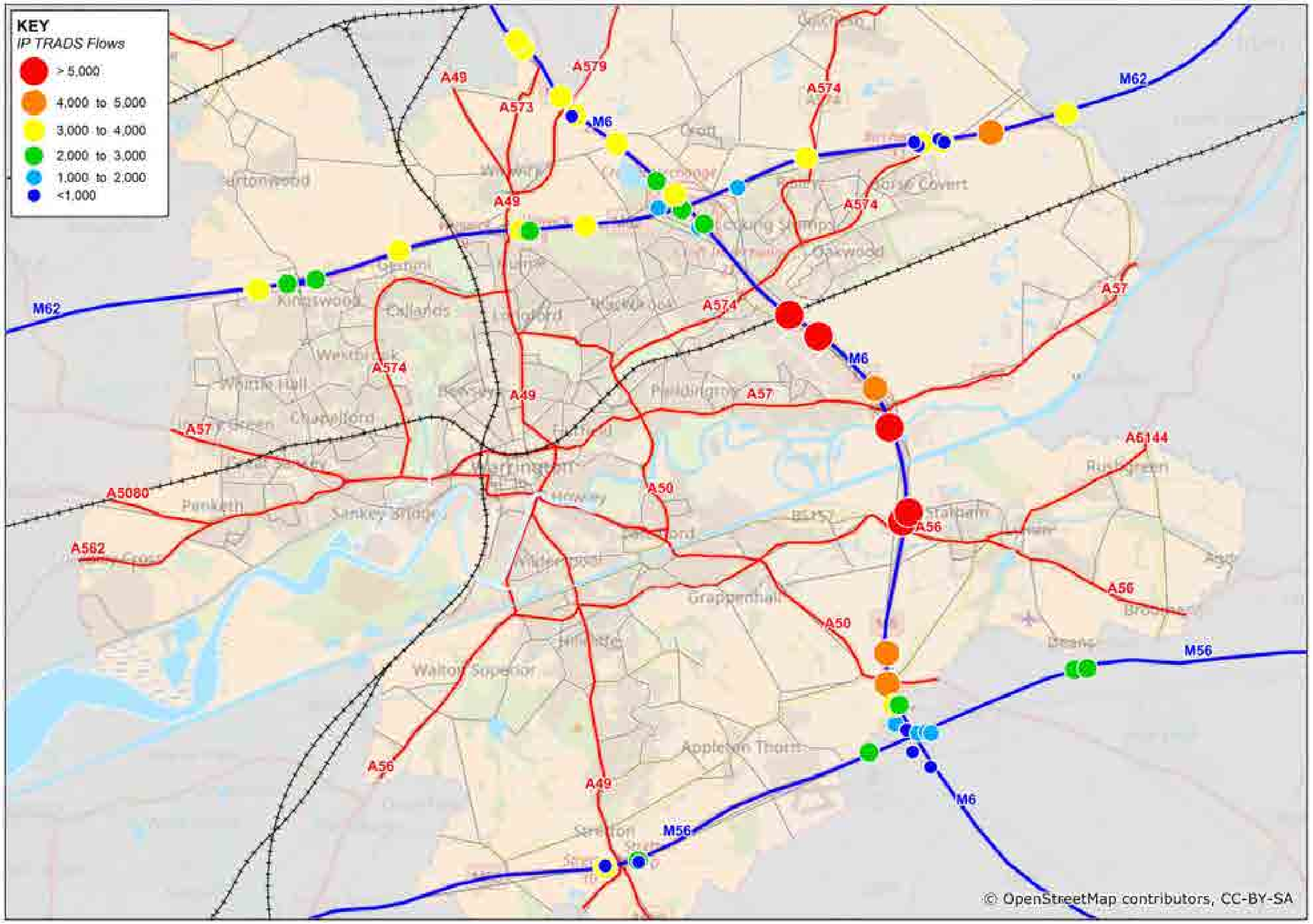
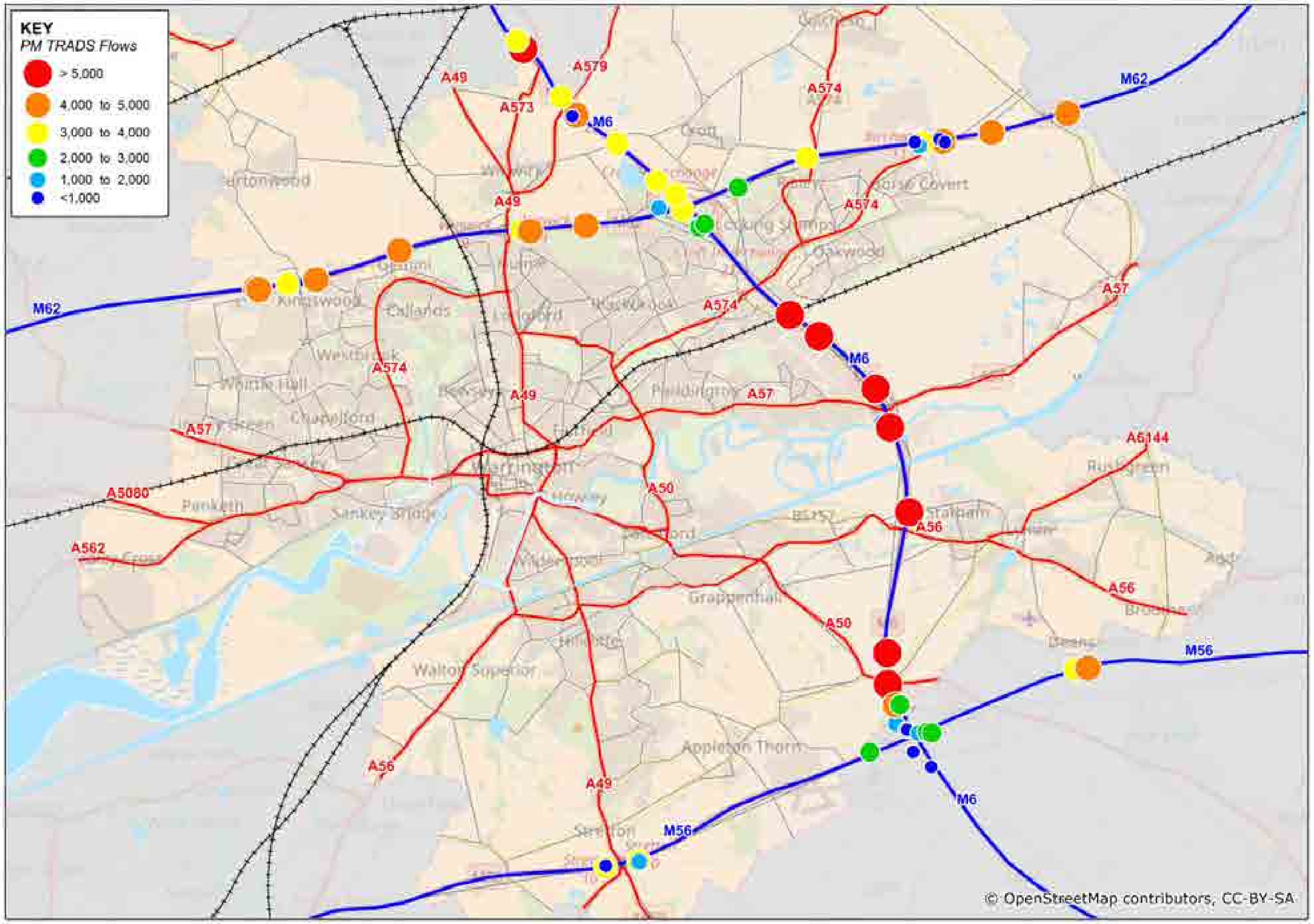


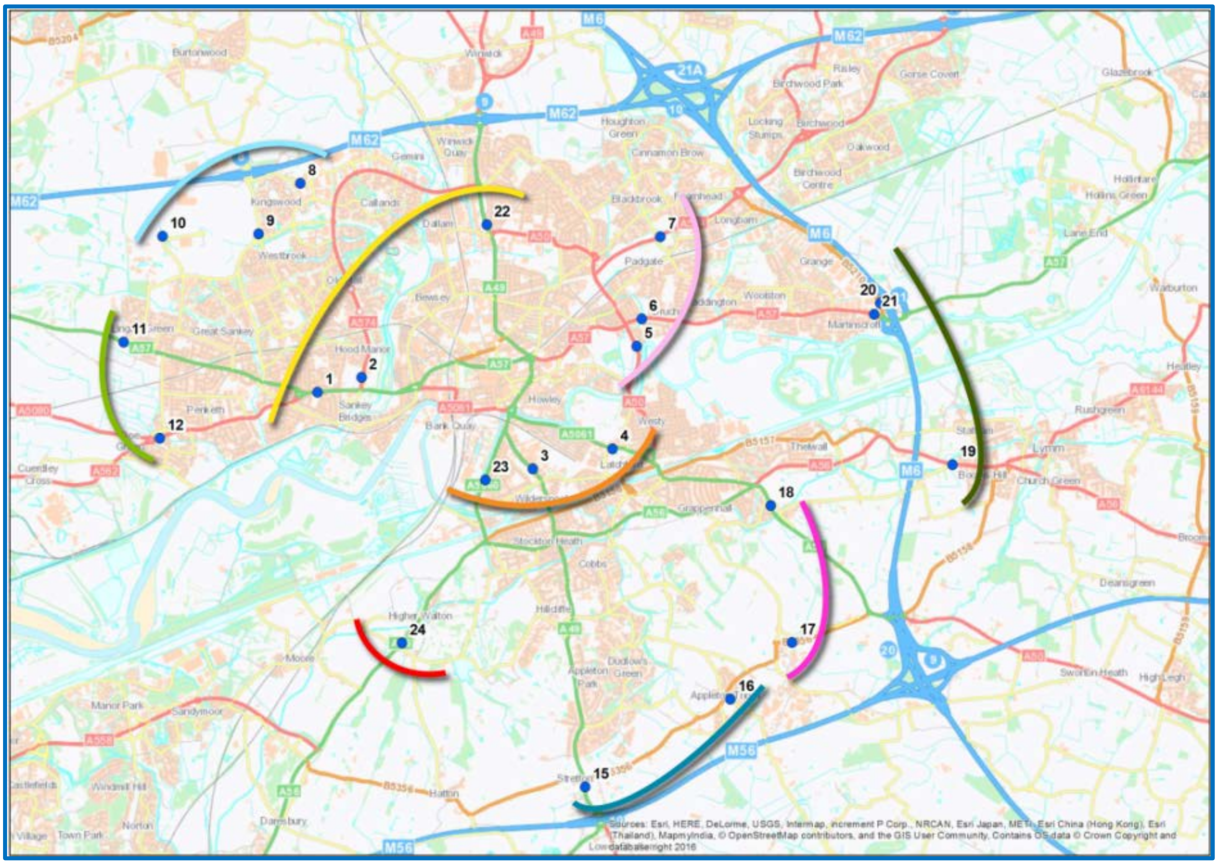
Figure 17 PM Observed Flows - TRADS Sites



4.2.3 Roadside Interviews

23 roadside interview (RSI) sites were originally identified for survey during the specification stage. During the final specification discussions with the survey company, 2 sites were moved closer to Warrington and combined (site 24 on Figure 18) and a total of 22 RSI sites were surveyed.

Figure 18 WMMTM16 Commissioned RSI Surveys



The following validation checks were conducted by the survey company:

Table 17 Nationwide Data Collection RSI Data Validation Checks

Data	Check Undertaken
Logic	Origin and destination postcodes are checked in relation to the geographical location of the site. Any illogical or invalid trips are checked and removed from the clean data set.
Serial Number	All data should be numeric only.
Interview Number	Face to Face Interview number on the sheet (maximum 2 surveys per sheet).
Interview Date	All records should have the correct date for the site number.
Interview Time	All data should be in the range 07:00 to 19:00, in 15-minute intervals.
Vehicle Type	1 to 3 only (Car, LGV, Van), as per the interview form.
Occupancy	1 to 14+ only, as per the interview form. No value greater than 7 in a car, no value greater than 3 in an LGV or OGV.
Origin Postcode	All postcodes should be full and valid.
Postcode Validity	The number of characters from the left which are valid. Generated by MapInfo - 0 for invalid, 7 for full postcodes.
Origin Purpose	1 to 10 only, as per the interview form. No 'Home' to 'Home' or 'Work' to 'Work' trips are allowed
Destination Postcode	All postcodes should be full and valid. Cannot be the same as the origin.
Postcode Validity	The number of characters from the left which are valid. Generated by MapInfo - 0 for invalid, 7 for full postcodes.
Destination Purpose	1 to 10 only, as per the interview form. No 'Home' to 'Home' or 'Work' to 'Work' trips are allowed.
Two-Way Trip	Time in hh:mm for any two-way trips.

As part of the NDC highway RSI data collection / processing, grid reference co-ordinates were generated and origin-destination relative to the RSI site sense checks conducted.

Initially, an RSI screenline was developed to assess the calibration of these count sites. However, this was not a 'watertight' screenline but an accumulation of 9 smaller screenlines this screenline was deemed unnecessary. Of the 26 count sites on the original screenline:

- 2 sites were removed due to quality concerns;
- 18 of the locations were duplications of sections on both the inner and outer cordon, these sites were retained and analysed as part of the cordon calibration;
- The remaining 6 sites were allocated to independent validation.

4.2.3.1 MCC & Junction Turning Counts

Manual classified counts were conducted at:

- The same 22 RSI locations referred to in Figure 18 (one-day);
- 12 additional 'one-day' junction turning count surveys, and 4 'one-day' link counts as shown in Figure 19; and
- 24 motorway slip roads (five-day counts), shown in Figure 20.

Figure 19 WMMTM16 Commissioned MCC Surveys - Junctions (yellow), Links (purple)

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community. Contains OS data © Crown Copyright and database right 2016

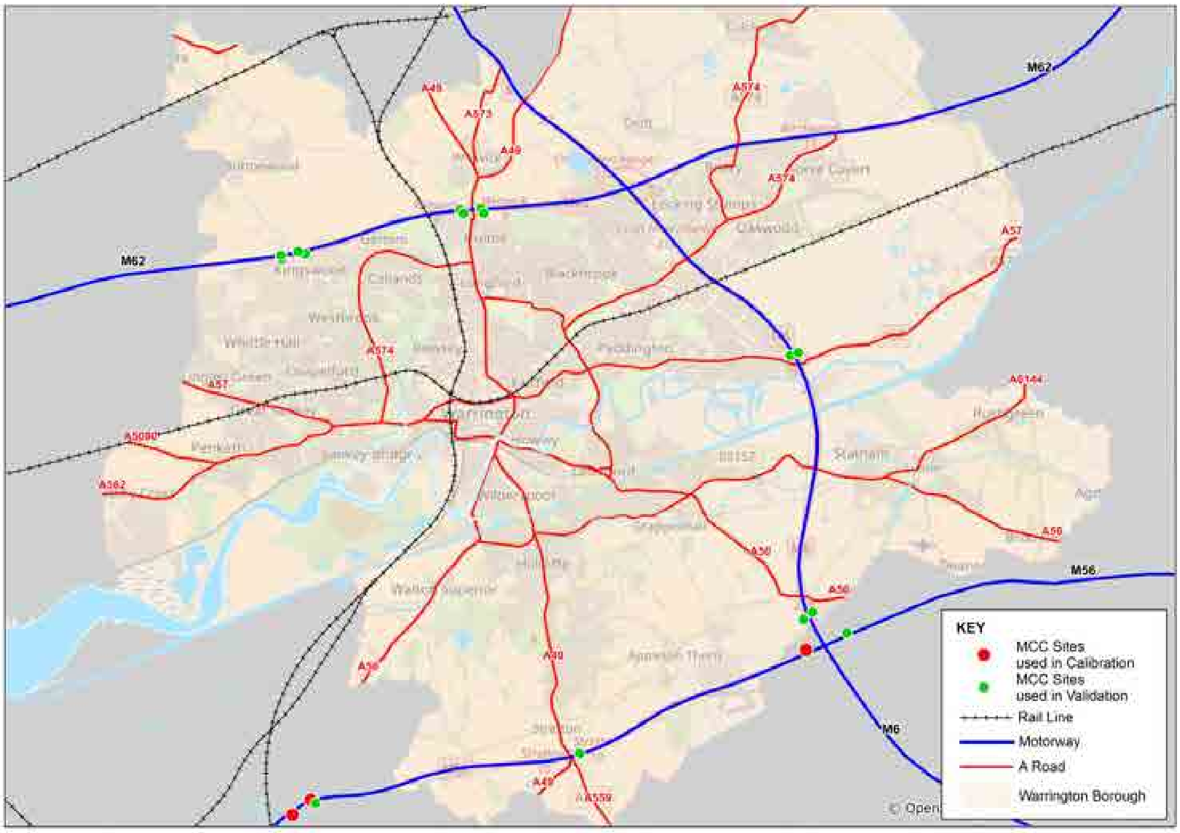
Figure 20 WMMTM16 Commissioned MCC Motorway Slip-Road Surveys

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community. Contains OS data © Crown Copyright and database right 2016

The 22 RSI MCCs were not used in calibration. These counts were instead used to calculate vehicle type proportions and applied to the count data where this information was missing.

18 of the 24 MCC slip road counts were used in calibration and validation of the model. 3 of these sites (M56 J11 on-slips) were allocated to matrix estimation and the remaining 15 were used for independent validation (Figure 21). 6 sites were removed from the analysis as they were either a duplication of an ATC count or the flow calculated was unrepresentative relative to the direction being reported.

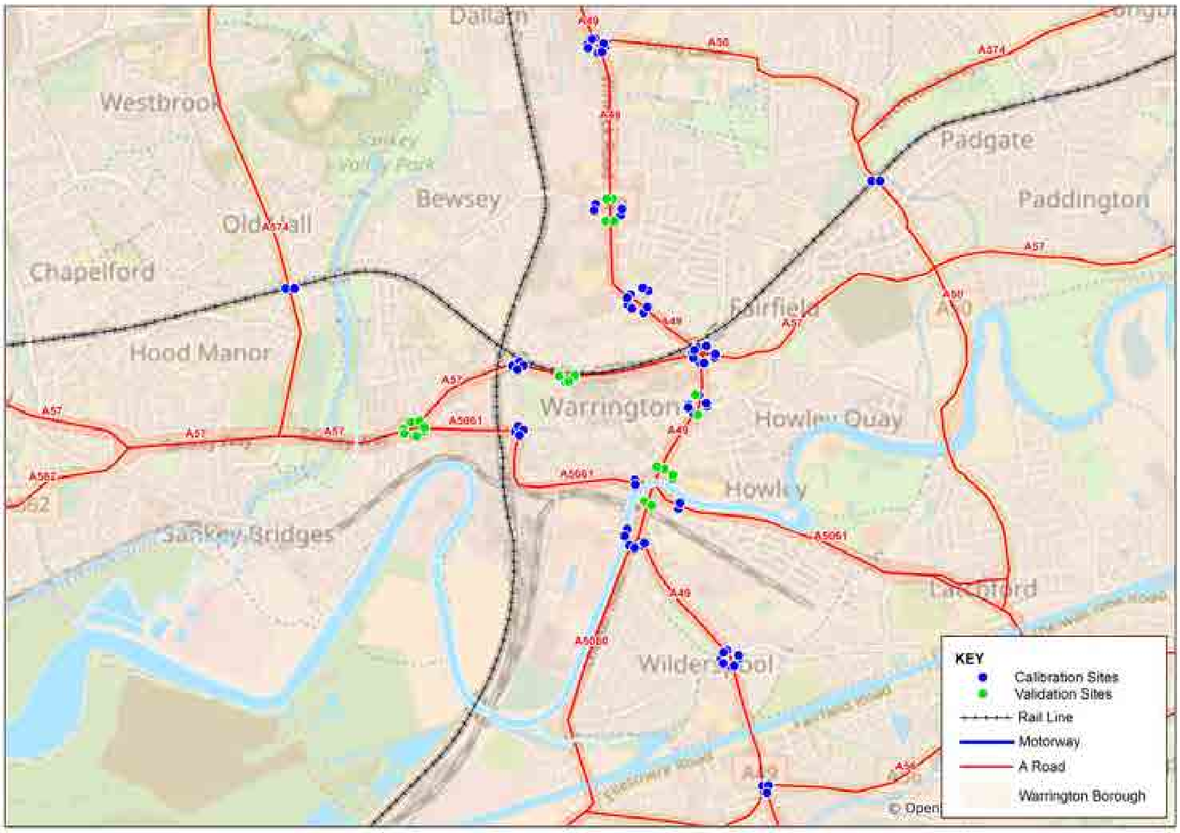
Figure 21 Location of MCCs Used in Validation



12 ‘one-day’ junction turning count surveys and 4 ‘one-day’ link counts were undertaken as part of the data collection exercise. These turning movements have been converted to entry/exit link counts and used in the model calibration. A total of 109 sites have been analysed; 81 for calibration, 28 for validation (Figure 22);

- 24 of the 28 validation sites were allocated to validation of individual links. The remaining 4 sites were used on the validation screenlines.
- 44 of the 81 calibration sites were used in matrix estimation. The remaining 37 were used to create 2 new screenlines running parallel to the A49 to analyse movements east/west across the A49.

Figure 22 Junction Turning Link Counts Used in Calibration and Validation



4.2.4 Comparisons with ATC & MCC

For MCCs no significant anomalies were identified. A comparison has been made between MCCs (Link counts), MCCs (Junction turning counts) and ATCs where appropriate (without roads in-between) in terms of total flow and heavy vehicle percentage. The comparison tables can be found in Appendix A of the MDCR, and show that there is a close correlation overall in terms of total vehicles across the total sites.

MCCs and ATCs corresponding to RSI survey sites were also compared and as shown in Table 18 and Table 19, there is no evidence of a consistent significant bias for the sites surveyed that could affect the flows identified. A more detailed analysis table for each site can be found in Appendix A of the MDCR.

Table 18 RSI MCC - ATC 12-Hour Comparison

Period Analysed	Direction	LV	HV	Total	LV/HV	LV	HV	Total	LV/HV
		MCC Sites				ATC Sites			
12 Hour Totals	Interview	106 ,074	5,366	111,440	5.1%	108,599	3,035	111,634	2.8%
	Non-interview	107,476	5,499	112,975	5.1%	106,550	3,397	109,947	3.2%

Table 19 RSI MCC - ATC Directional Comparison

Period Analysed	Type	% Diff LV	% Diff HV	% Diff Total
12 Hour Totals	MCC	4.4%	3.8%	4.4%
	ATC	-1.9%	11.9%	-1.5%

Whilst not directly comparable, given the close proximity of the junction turning link count sites on the two A49 screenlines, there is little variation between the junction turning link counts on West of A49 screenline and the East of A49 screenline.

Table 20 Comparison of Junction Turning Link Counts on A49 Screenlines - EB Direction

Screenline	AM Flow (obs)				IP Flow (obs)				PM Flow (obs)			
	Car	LGV	HGV	Total	Car	LGV	HGV	Total	Car	LGV	HGV	Total
West of A49: Entry EB	2,873	485	177	3,535	2,229	346	140	2,715	4,435	299	68	4,802
East of A49: Exit EB	2,929	444	154	3,527	2,148	300	111	2,559	4,336	312	62	4,710
Absolute Difference	56	41	23	8	81	46	29	156	99	13	6	92

Table 21 Comparison of Junction Turning Link Counts on A49 Screenlines - WB Direction

Screenline	AM				IP				PM			
	Car	LGV	HGV	Total	Car	LGV	HGV	Total	Car	LGV	HGV	Total
West of A49: Exit WB	4,005	434	160	4,599	2,286	311	129	2,726	3,159	295	67	3,521
East of A49: Entry WB	4,225	460	141	4,826	2,324	301	110	2,735	3,560	328	50	3,938
Absolute Difference	220	26	19	227	38	10	19	9	401	33	17	417

While it was envisaged that all the ATC sites corresponding to RSI survey locations will include the RSI day of the survey in their 2-weeks coverage, a limited number of sites did not fulfil this criteria due to either damages to tubes or equipment failure on the particular day.

These sites were then omitted from the above comparative analysis; a total of five such sites were identified as outlined in Table 22.

Table 22 RSI ATC Sites Omitted

RSI ID	ATC ID	Comments
4	59	Day not surveyed in ATC surveys
7	62	Day not surveyed in ATC surveys
20	75	Day not surveyed in ATC surveys
22	77	Day not surveyed in ATC surveys
11	66	RSI survey day omitted as ATC surveys provide incomplete flows during the day

A detailed table of comparison for each site can be found in Appendix A of the MDCR where the total volume over 12-hours for each MCC sites was compared to the corresponding ATC survey day total volume. The comparative analysis showed no major anomalies.

While light vehicles could be surveyed as normal for each site, operational constraints and the quality of responses meant that HGV clean survey quantities were low overall. For RSIs, the overall quantum of interviews was in line with expectations. During the surveys it was noted that there was no significant traffic incidents on the network. The overall quality of the highway data collection process was therefore above expectations and judged acceptable for its designed purpose.

For HGVs it is acknowledged that sample rates are relatively low, but the reasons for this and acknowledgement that the surveys were conducted satisfactorily, have been accepted by WBC. With the RSI data available global checks on HGV trip length distribution have been conducted in addition to the RSI analysis, this along with extensive count data coverage and qualitative and quantitative supporting information from the freight operator interviews is judged acceptable overall.

Table 23 displays the RSI to MCC sample rates for each RSI site and the ATC factors to convert the RSI day to an average day total.

Table 23 RSI Data Sample Rates

Site ID	Name	Day/ Date	LV Interview Total	LV MCC	LV Sample	HV Interview total	HV MCC	HV Sample
1	A57 SANKEY WAY	29/06	1,138	12,452	9.1%	4	421	1.0%
2	A574 CROMWELL AVENUE	29/06	735	8,576	8.6%	2	145	1.4%
3	A49 RIVER ROAD	28/06	682	6,800	10.0%	9	205	4.4%
4	A5061 KNUTSFORD ROAD	28/06	992	7,663	12.9%	6	314	1.9%
5	A50 KINGSWAY NORTH	27/06	890	7,631	11.7%	5	230	2.2%
6	A57 MANCHESTER ROAD	27/06	1,012	8,518	11.9%	11	331	3.3%
7	Birchwood way	20/06	955	5,509	17.3%	8	134	6.0%
8	CHARON WAY	22/06	871	5,866	14.8%	19	192	9.9%
9	BURTONWOOD ROAD	22/06	918	6,296	14.6%	24	262	9.2%
10	OMEGA	22/06	493	1,674	29.5%	14	74	18.9%
11	A57 WARRINGTON ROAD	21/06	792	5,810	13.6%	10	194	5.2%
12	A562 WARRINGTON ROAD	21/06	1,124	6,322	17.8%	22	403	5.5%
15	A49 TARPORLEY ROAD	15/06	1,126	6,267	18.0%	0*	210	0.0%
16	ARLEY ROAD	15/06	523	998	52.4%	10	32	31.3%
17	B5356 GRAPPENHALL	14/06	731	3,289	22.2%	102	927	11.0%
18	A50 KNUTSFORD ROAD	14/06	651	4,965	13.1%	64	323	19.8%
19	A56 STOCKPORT ROAD	30/06	804	3,102	25.9%	14	100	14.0%
20	A57 MANCHESTER ROAD	30/06	956	6,993	13.7%	2	396	0.5%
21	B5210 WOOLSTON GRANGE AVENUE	30/06	1,118	9,152	12.2%	34	766	4.4%
22	WINWICK ROAD	29/06	1,702	13,461	12.6%	31	1,079	2.9%
23	A5060 CHESTER ROAD	28/06	943	6,429	14.7%	0*	329	0.0%
24	A56 CHESTER ROAD	20/06	830	7,737	10.7%	38	416	9.1%
		TOTAL	**19,986**	**145,510**	**13.7%**	**429**	**7,483**	**5.7%**

** No HGV interviews undertaken at this location due to site constraints*

Table 24 displays the results of the RSI data cleaning process. An overall percentage of 20% for light vehicles and 11% for heavy vehicles, is within expectations. The lower HV rate is considered to be as a result of increased driver knowledge of end points.

Table 24 RSI Data Cleaning

Site ID	Name	Day/ Date	LV Interview Total	LV Cleaned Surveys	LV % Remove	HV Interview total	HV Cleaned Surveys	HV % Remove
1	A57 SANKEY WAY	29/06	1,138	973	14%	4	4	0%
2	A574 CROMWELL AVENUE	29/06	735	595	19%	2	2	0%
3	A49 RIVER ROAD	28/06	682	565	17%	9	9	0%
4	A5061 KNUTSFORD ROAD	28/06	992	739	26%	6	5	17%
5	A50 KINGSWAY NORTH	27/06	890	696	22%	5	5	0%
6	A57 MANCHESTER ROAD	27/06	1,012	824	19%	11	7	36%
7	Birchwood way	20/06	955	728	24%	8	8	0%
8	CHARON WAY	22/06	871	739	15%	19	18	5%
9	BURTONWOOD ROAD	22/06	918	702	24%	24	15	38%
10	OMEGA	22/06	493	422	14%	14	14	0%
11	A57 WARRINGTON ROAD	21/06	792	685	14%	10	10	0%
12	A562 WARRINGTON ROAD	21/06	1,124	953	15%	22	22	0%
15	A49 TARPORLEY ROAD	15/06	1,126	983	13%	0	0	0%
16	ARLEY ROAD	15/06	523	418	20%	10	9	10%
17	B5356 GRAPPENHALL	14/06	731	489	33%	102	90	12%
18	A50 KNUTSFORD ROAD	14/06	651	484	26%	64	60	6%
19	A56 STOCKPORT ROAD	30/06	804	681	15%	14	12	14%
20	A57 MANCHESTER ROAD	30/06	956	707	26%	2	1	50%
21	B5210 WOOLSTON GRANGE AVENUE	30/06	1,118	747	33%	34	34	0%
22	WINWICK ROAD	29/06	1,702	1,402	18%	31	31	0%
23	A5060 CHESTER ROAD	28/06	943	781	17%	0	0	0%
24	A56 CHESTER ROAD	20/06	830	638	23%	38	27	29%
		TOTAL	**19,986**	**15,951**	**20%**	**429**	**383**	**11%**

4.2.4.1 RSI Expansion

As the RSI surveys will not capture an adequate sample of travel patterns, the MCC's and ATC's corresponding to the 24 RSI sites were used to expand the flows generated by the RSI surveys. Table 25 shows the correspondence list of RSI/MCC/ATC sites.

For Sites 15 and 23, where no HV interviews were captured, the intention was to use either similar/adjacent roads levels or the respective LGV levels for the same sites as HV. However, due to poor sample rates for LGVs at the same sites and the absence of similar/adjacent roads providing reliable HV sample rates, both approaches were not appropriate and these two sites discounted from use.

Table 25 RSI/MCC - ATC Sites Correspondence

Site ID	Name	Day/ Date	RSI/MCC Direction	ATC ID	ATC Direction
1	A57 SANKEY WAY	29/06	EB	56	EB
2	A574 CROMWELL AVENUE	29/06	EB	57	SB
3	A49 RIVER ROAD	28/06	EB	61	NB
4	A5061 KNUTSFORD ROAD	28/06	EB	59	NB
5	A50 KINGSWAY NORTH	27/06	NB	60	NB
6	A57 MANCHESTER ROAD	27/06	WB	58	WB
7	Birchwood way	20/06	SWB	62	WB
8	CHARON WAY	22/06	SB	63	EB
9	BURTONWOOD ROAD	22/06	SB	64	SB
10	OMEGA	22/06	SB	65	WB
11	A57 WARRINGTON ROAD	21/06	EB	66	EB
12	A562 WARRINGTON ROAD	21/06	EB	67	EB
15	A49 TARPORLEY ROAD	15/06	EB	70	NB
16	ARLEY ROAD	15/06	NWB	71	NB
17	B5356 GRAPPENHALL	14/06	WB	72	WB
18	A50 KNUTSFORD ROAD	14/06	NWB	73	WB
19	A56 STOCKPORT ROAD	30/06	WB	74	WB
20	A57 MANCHESTER ROAD	30/06	EB	75	EB
21	B5210 WOOLSTON GRANGE AVENUE	30/06	EB	76	SB
22	WINWICK ROAD	29/06	SB	77	SB
23	A5060 CHESTER ROAD	28/06	NB	78	NB
24	A56 CHESTER ROAD	20/06	SB	79	SB

The RSI flows expansion process includes the following steps and criteria:

- First the RSI flows are expanded using the ratio of the MCC flows to the RSI flows for each site (MCC Expansion Factor).
- A second expansion factor (ATC Expansion Factor) is applied using the ratio of the ATC average representative weekday flows to the ATC flows of the RSI survey day.
- Both expansion factors are calculated for each site covering a specific hour and/or time period as well as a vehicle class.
- The MCC and ATC Expansion Factors used for the LGV and HGV category were a representative average time period factors (AM, IP or PM) rather than hourly factors.
- For any site that exhibits an hourly MCC expansion factor for Cars category greater than 15, the respective time period factors (MCC and ATC) are rather used; otherwise hourly factors were used.
- The representative average time period expansion factors were calculated to account for high hourly factors. However in some instances, due to poor sample rates and site conditions, these time period factors were still high and in the absence of better survey data they were used, with caution, in subsequent analysis and matrix building.

Table 26 shows an example of the Light Vehicles (LV) RSI Expansion factors calculations for site 1, while Appendix A provides both the LV and HV expansion factor calculations for all sites.

Table 26 Site 1 RSI Expansion Factors Calculations

				RSI Interviews			MCC					ATC		
										Expansion Factor		Survey Day	AVG Day	Exp Factor
RSI/MCC ID	ATC Site ID	St. HR	Time	Car	LGV	LV	Car	LGV	LV	Car	LGV	LV	LV	LV
Site 1	Site 56	7	07:00-08:00	180	3	183	1456	135	1591	8.09	45.00	1283	1450	1.13
Site 1	Site 56	8	08:00-09:00	154	2	156	1293	97	1390	8.40	48.50	826	1312	1.59
Site 1	Site 56	9	09:00-10:00	102	1	103	1175	110	1285	11.52	110.00	902	1044	1.16
Site 1	Site 56	10	10:00-11:00	88	3	91	760	110	870	8.64	36.67	800	796	1.00
Site 1	Site 56	11	11:00-12:00	64	2	66	765	111	876	11.95	55.50	789	779	0.99
Site 1	Site 56	12	12:00-13:00	60	1	61	700	83	783	11.67	83.00	727	780	1.07
Site 1	Site 56	13	13:00-14:00	55	1	56	797	76	873	14.49	76.00	788	808	1.03
Site 1	Site 56	14	14:00-15:00	50	3	53	825	93	918	16.50	31.00	837	828	0.99
Site 1	Site 56	15	15:00-16:00	43	4	47	865	79	944	20.12	19.75	866	876	1.01
Site 1	Site 56	16	16:00-17:00	74	0	74	843	89	932	11.39		817	893	1.09
Site 1	Site 56	17	17:00-18:00	39	2	41	908	58	966	23.28	29.00	893	925	1.04
Site 1	Site 56	18	18:00-19:00	41	1	42	963	61	1024	23.49	61.00	922	891	0.97
Site 1	Site 56	AM	07:00-10:00	436	6	442	3924	342	4266	9.00	57.00	3011	3807	1.26
Site 1	Site 56	IP	10:00-16:00	360	14	374	4712	552	5264	13.09	39.43	4807	4867	1.01
Site 1	Site 56	PM	16:00-19:00	154	3	157	2714	208	2922	17.62	69.33	2632	2709	1.03

The expanded RSI data has been used to supplement the mobile phone data and comparisons made between respective trip length distributions; for more details regarding the use of RSI data in matrices building refer to Chapter 6.

4.2.5 Screenlines and Cordons

The 389 sites used in calibration and validation of the model have been analysed in a number of ways:

- 277 sites used for calibration, 112 for validation (a 71% versus. 29% split), as shown in Figure 23;
- 216 of the 389 sites have been assigned to ether a screenline or cordon (55%) as shown in Figure 24 to Figure 26;
- 103 sites as shown in Figure 27 have been used in matrix estimation (26%) and 4 sites are individual calibration link counts not assigned to a screenline or cordon; and
- 66 sites used for independent validation sites (Figure 28) in addition to the 46 assigned to a validation screenline (Figure 26).

Figure 23 Final Set of Count Sites Taken Forward into Calibration / Validation

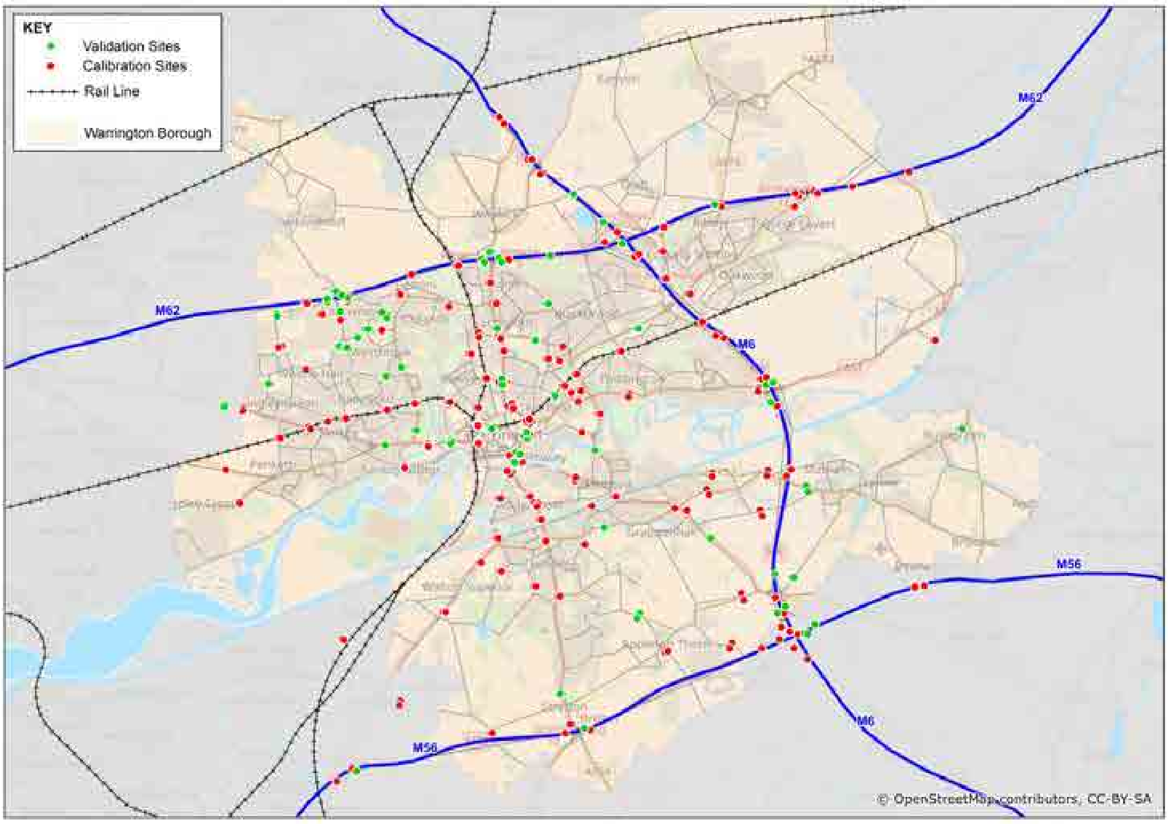
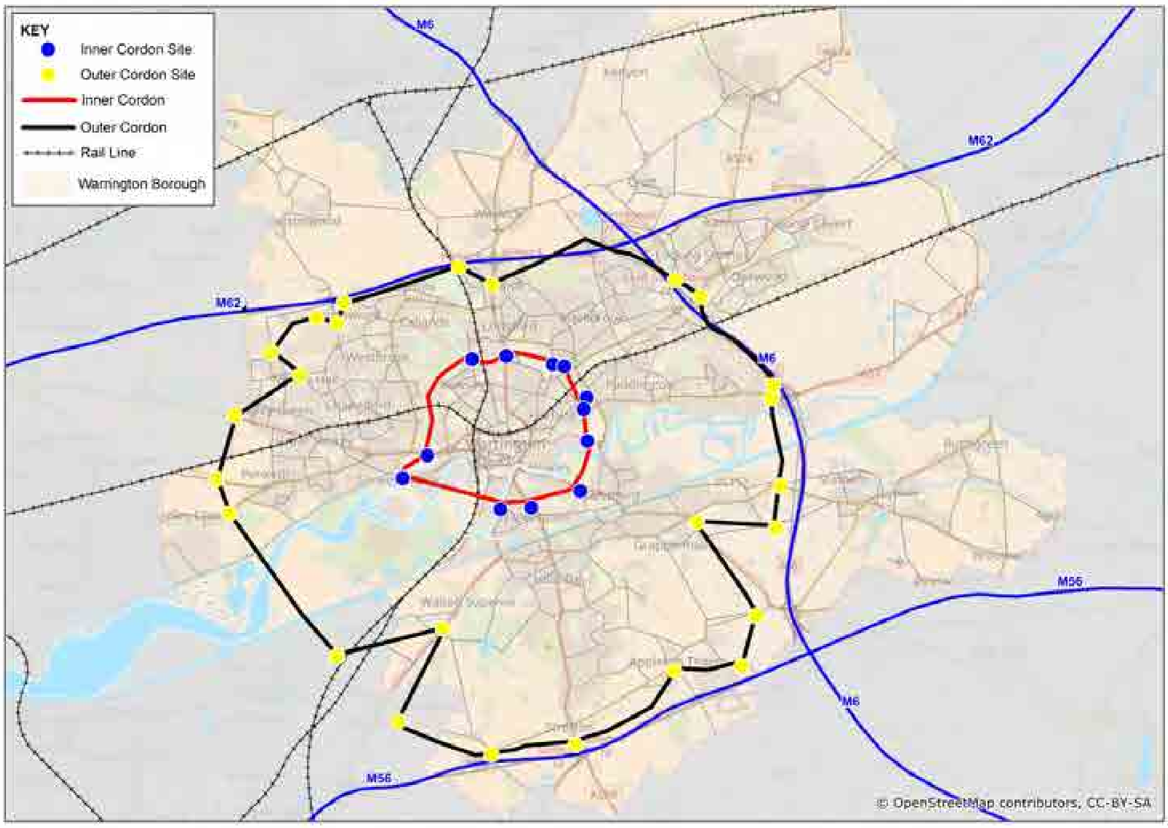
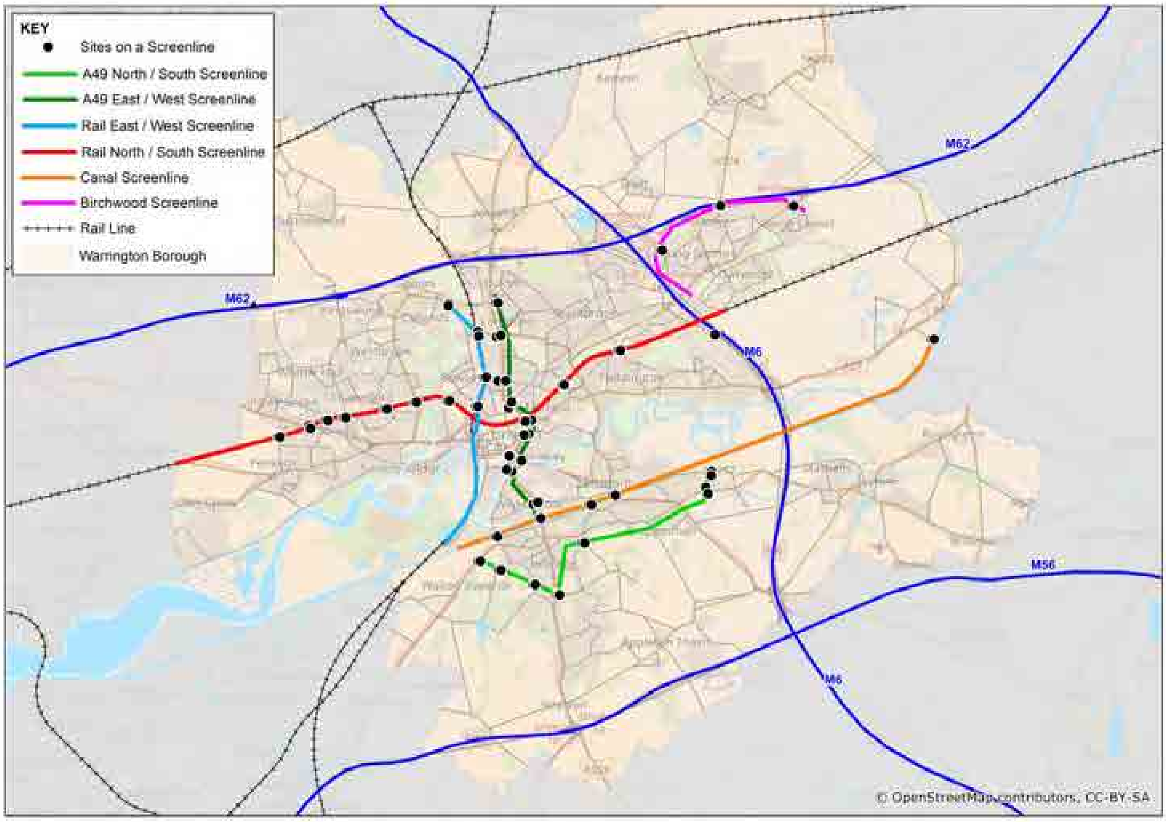


Figure 24 Sites on a Cordon



© OpenStreetMap contributors, CC-BY-SA

Figure 25 Sites on a Calibration Screenline



© OpenStreetMap contributors, CC-BY-SA

Figure 26 Sites on a Validation Screenline

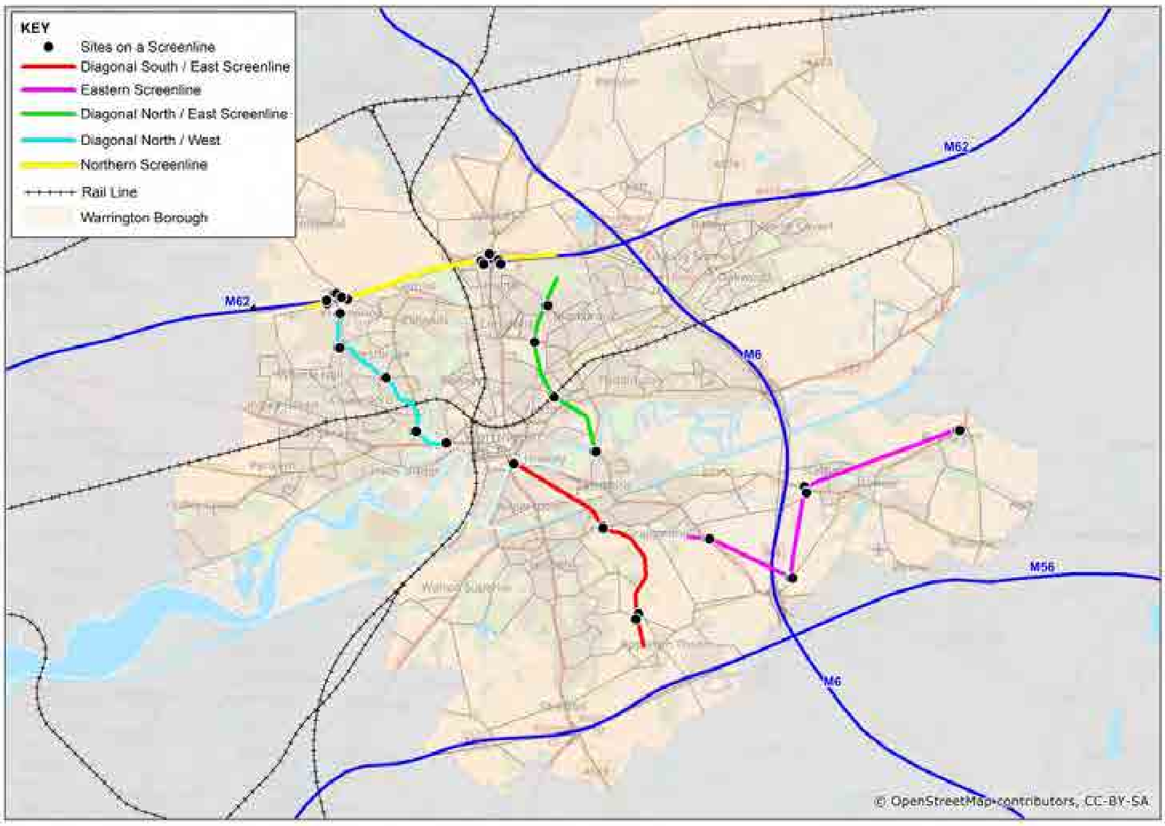


Figure 27 Sites used in Matrix Estimation

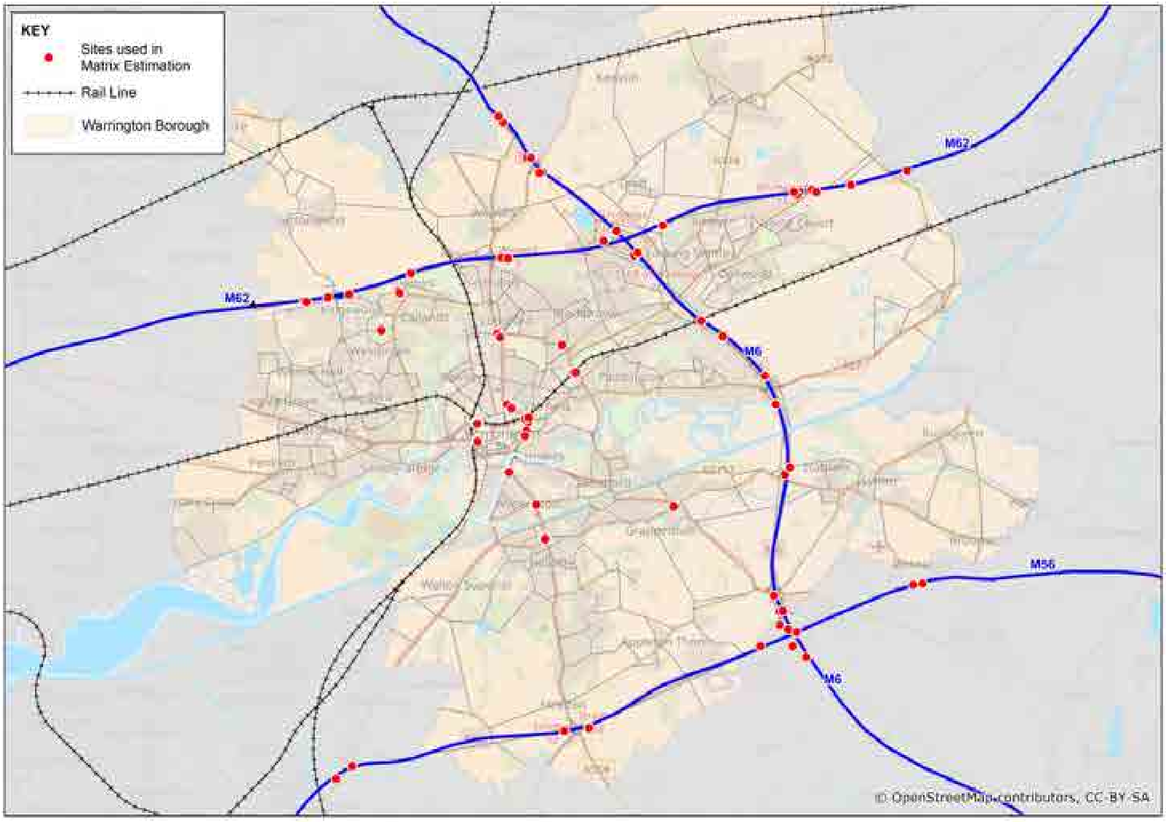
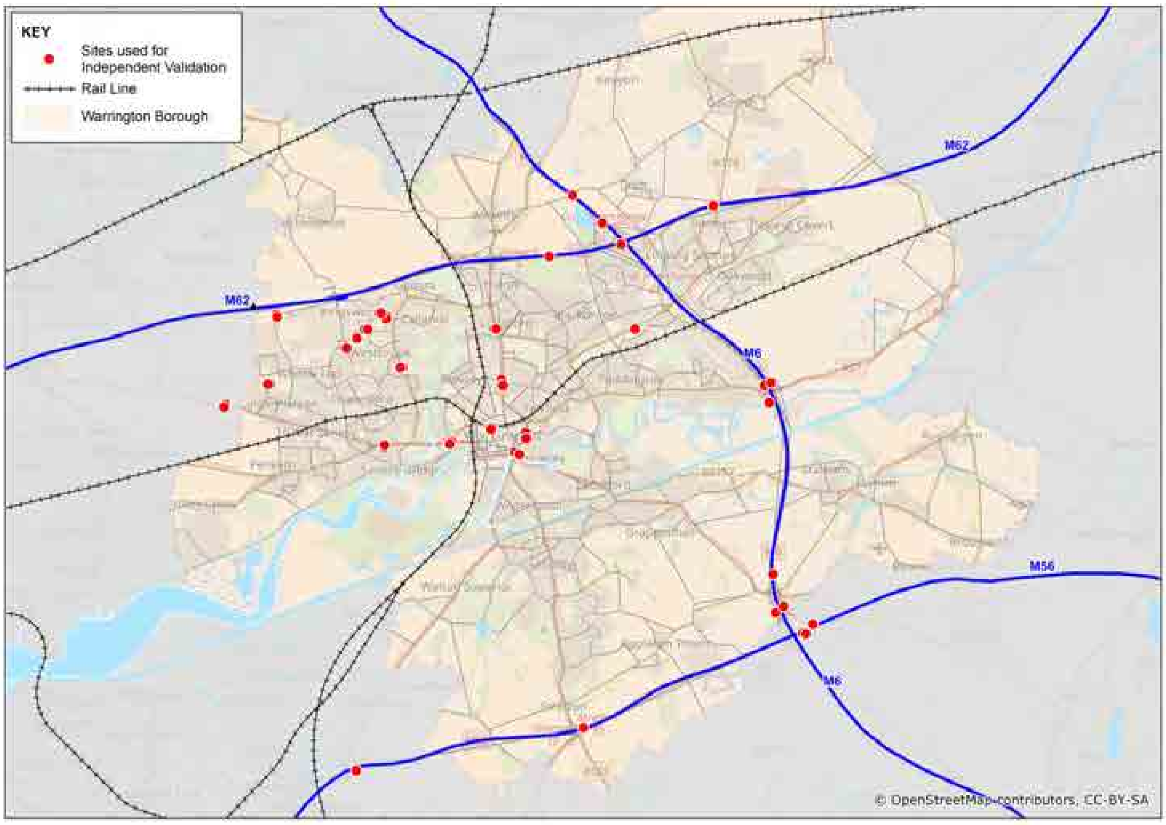


Figure 28 Sites used for Independent Validation



4.2.5.1 Cordon Summary

Of the 389 sites used in the calibration and validation of the model, 74 sites are on 2 cordons; 24 on the inner cordon (2-way), 50 on the outer cordon (2-way). Figure 24 displays the location of the count sites on each cordon. Figure 29 to Figure 34 show the summaries of the observed flows for each of the 3 modelled time periods by direction for the inner cordon, Figure 35 to Figure 40 show the observed summaries for the outer cordon.

Figure 29 Summary of Observed Flows - Inner Cordon, Inbound Direction - AM

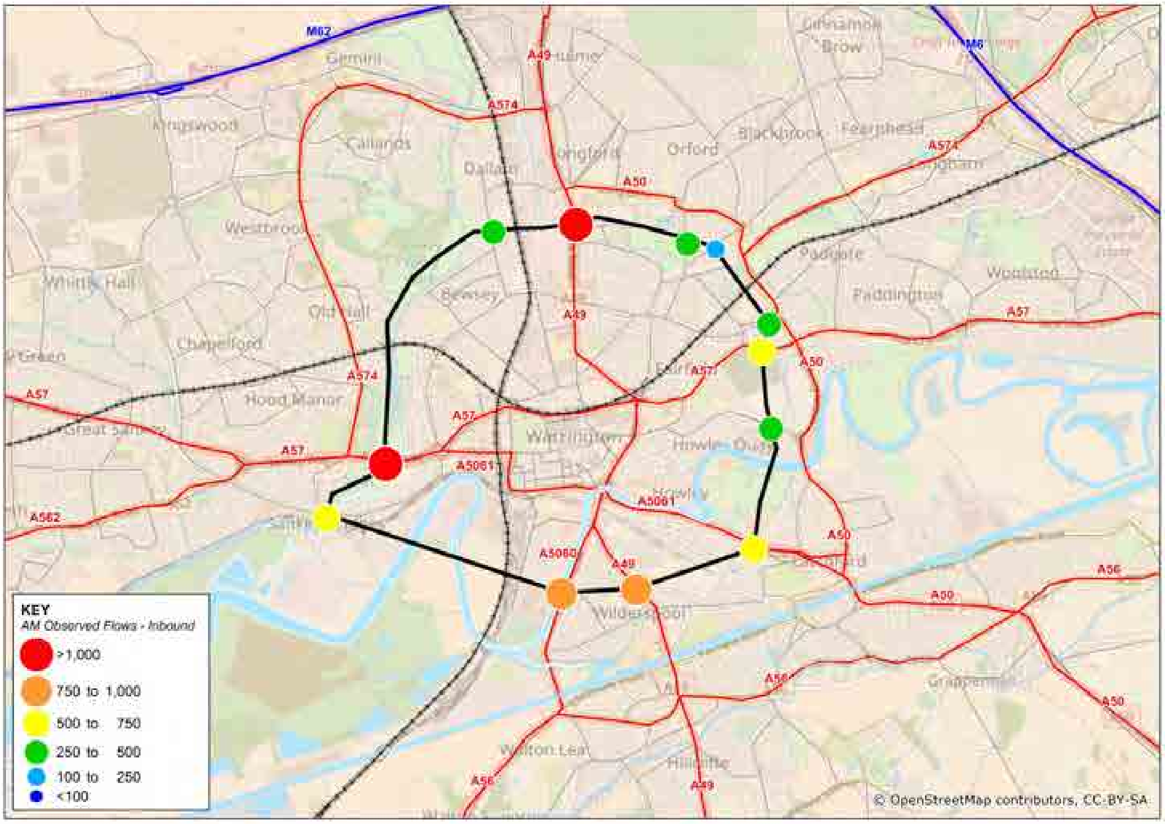


Figure 30 Summary of Observed Flows - Inner Cordon, Outbound Direction - AM

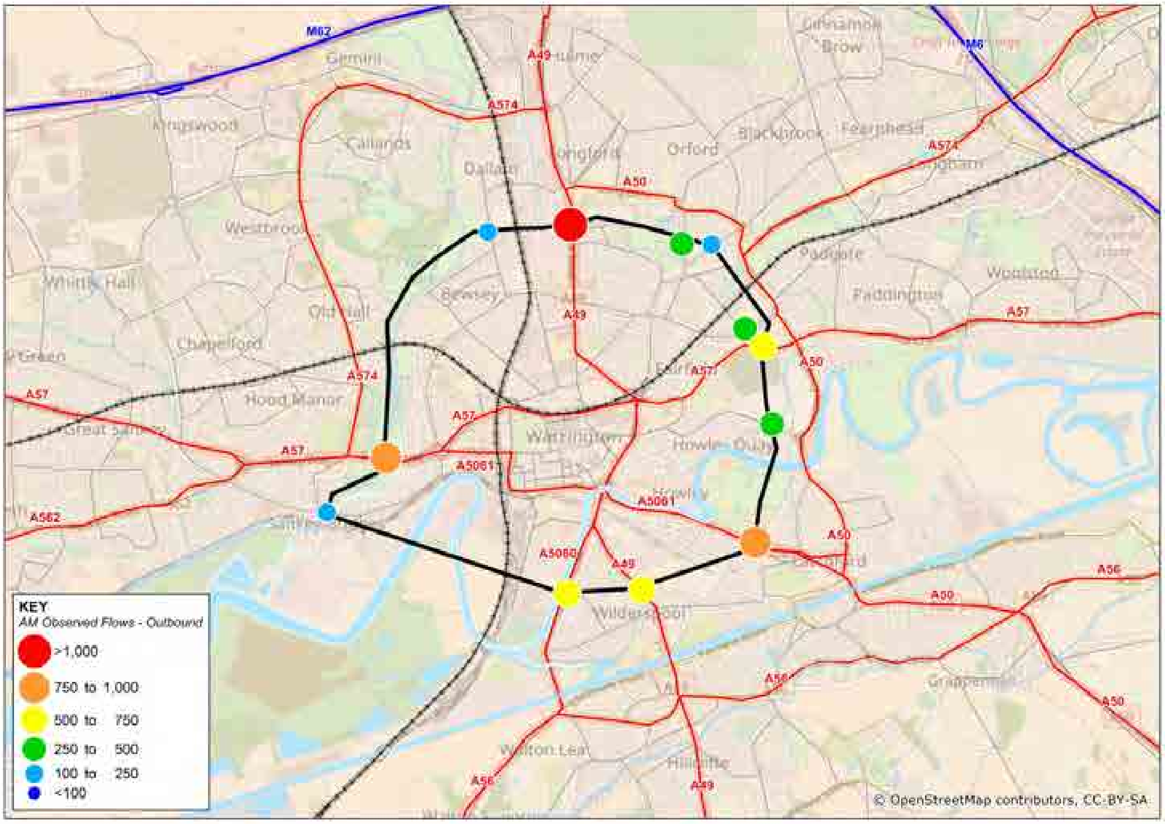


Figure 31 Summary of Observed Flows - Inner Cordon, Inbound Direction - IP

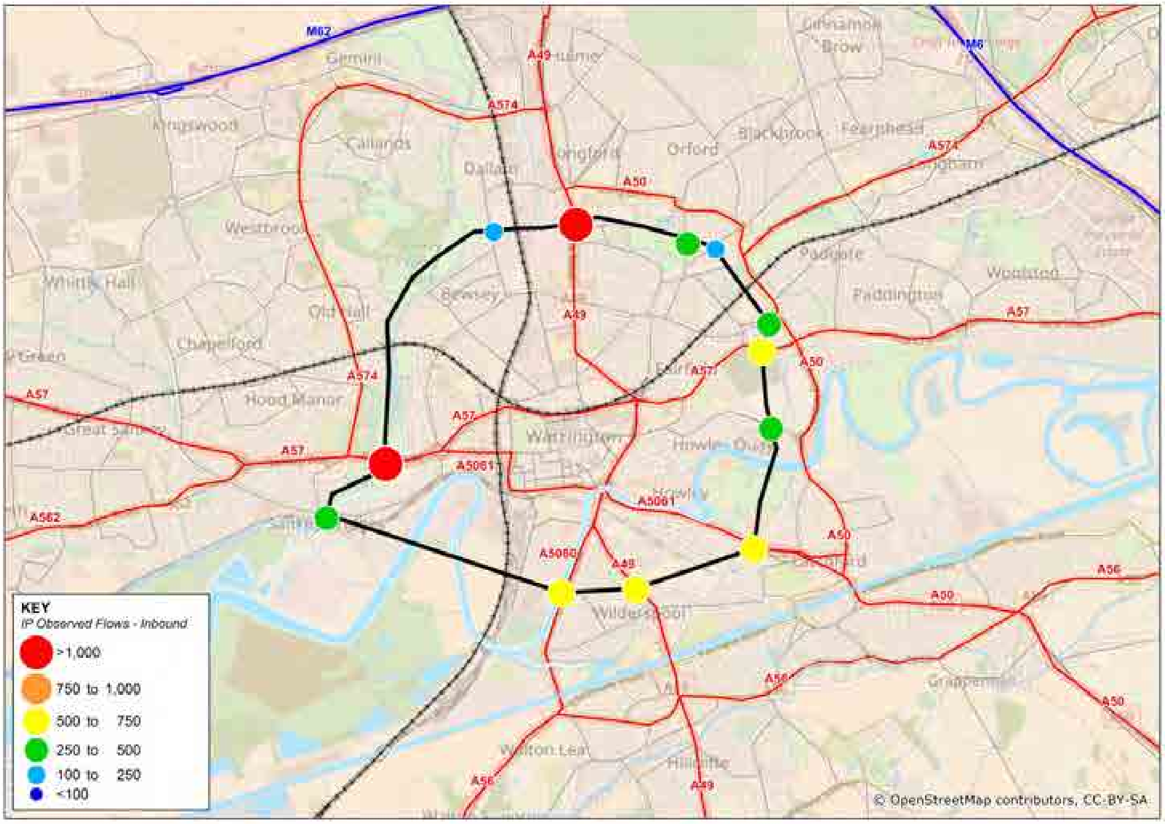


Figure 32 Summary of Observed Flows - Inner Cordon, Outbound Direction - IP

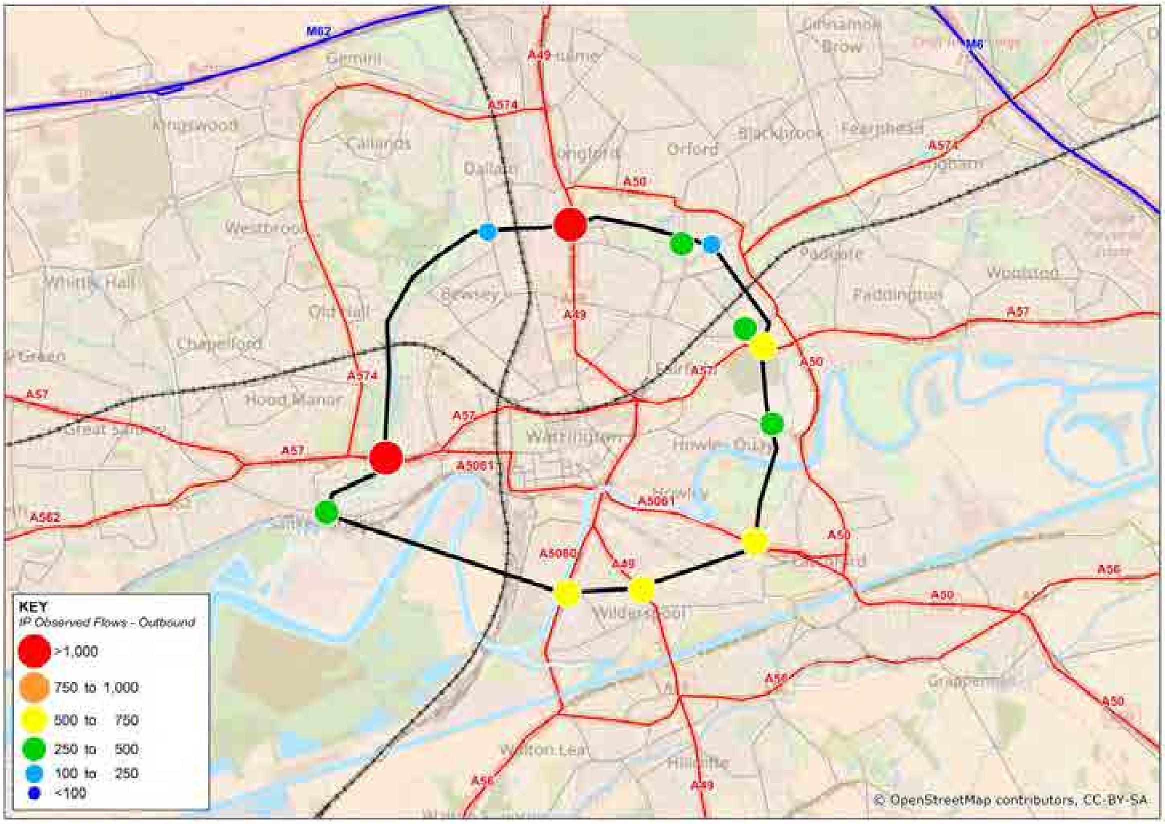


Figure 33 Summary of Observed Flows - Inner Cordon, Inbound Direction - PM

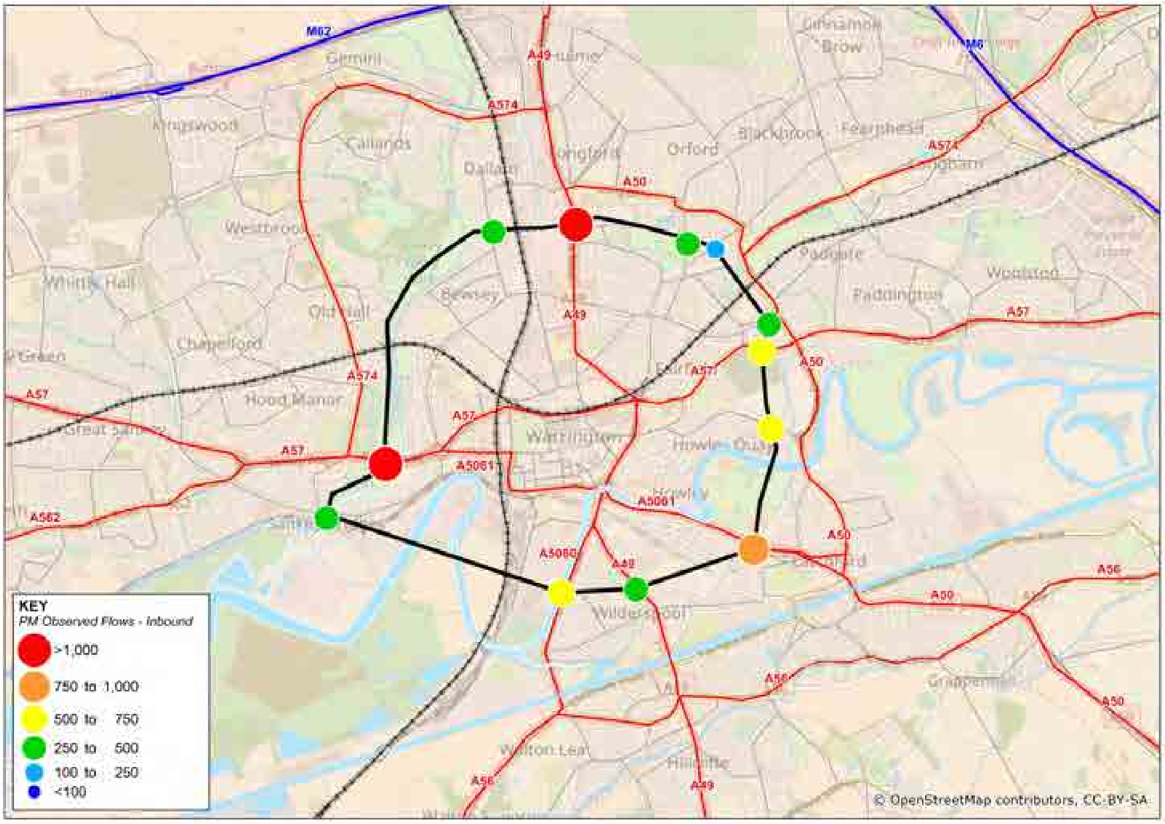


Figure 34 Summary of Observed Flows - Inner Cordon, Outbound Direction - PM

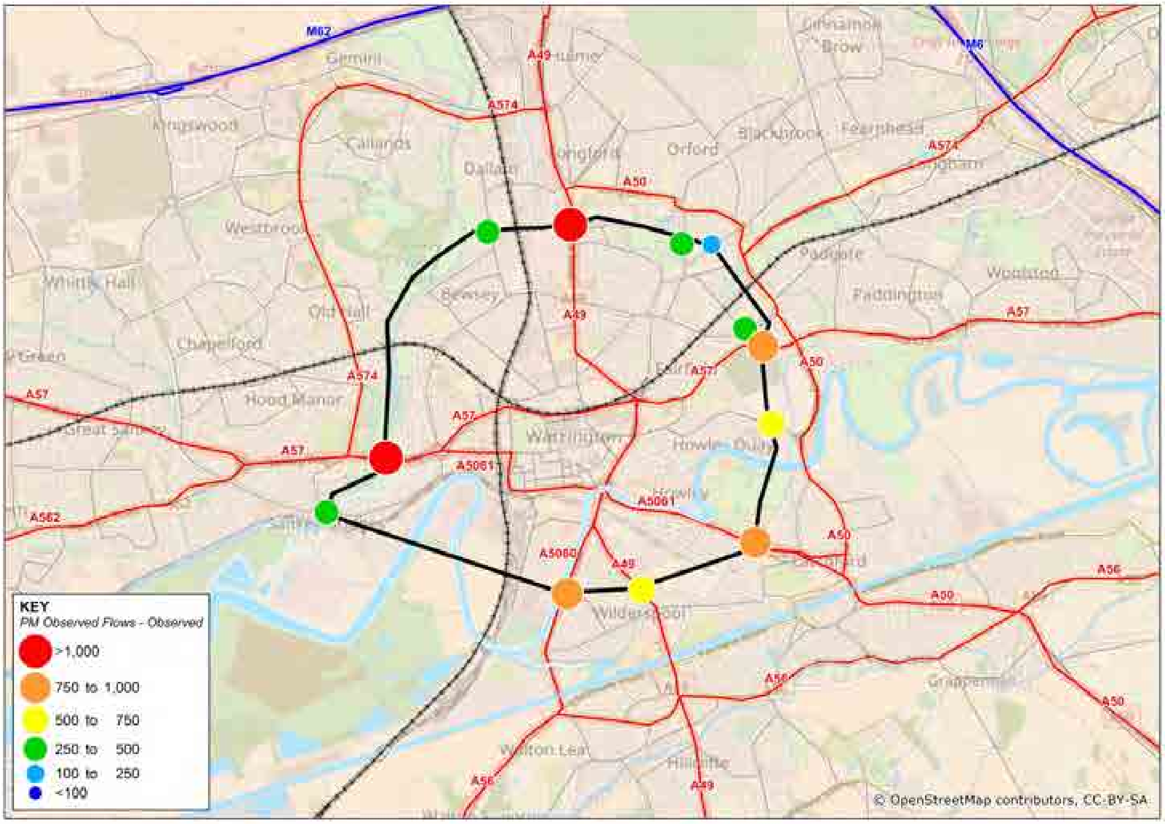


Figure 35 Summary of Observed Flows - Outer Cordon, Inbound Direction - AM

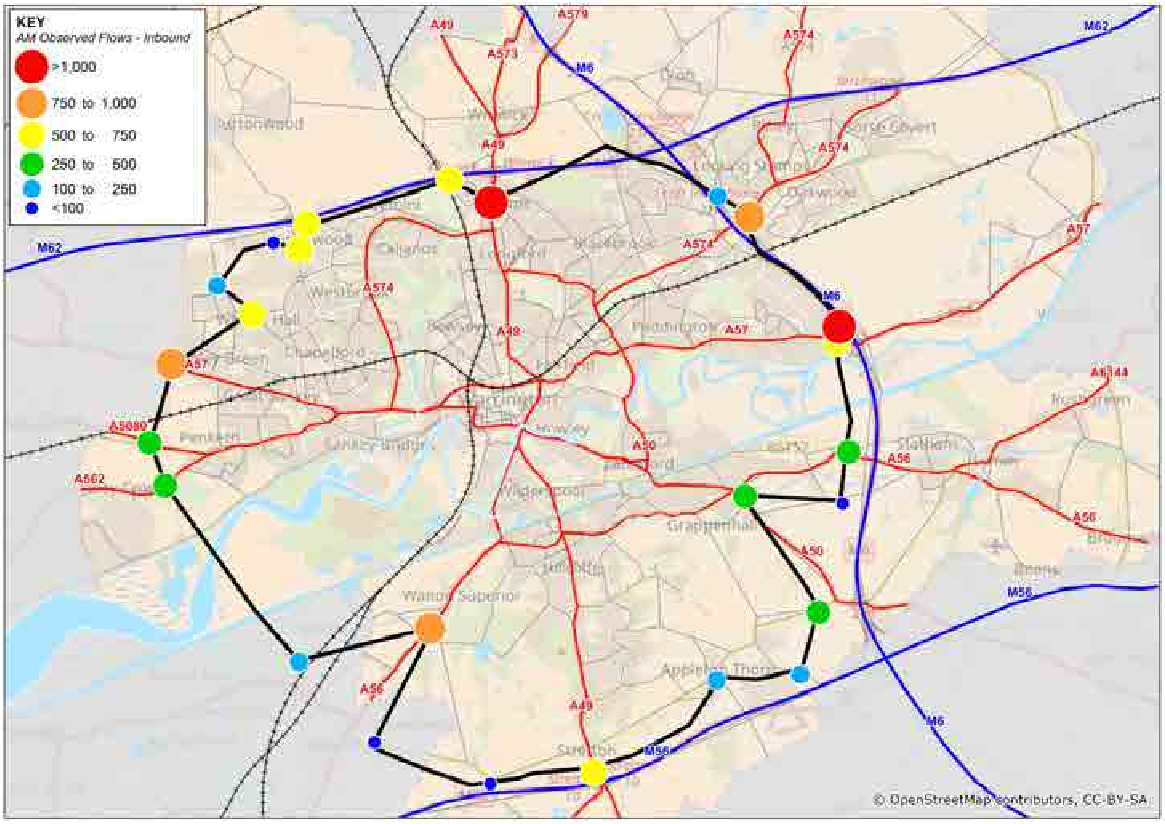


Figure 36 Summary of Observed Flows - Outer Cordon, Outbound Direction - AM

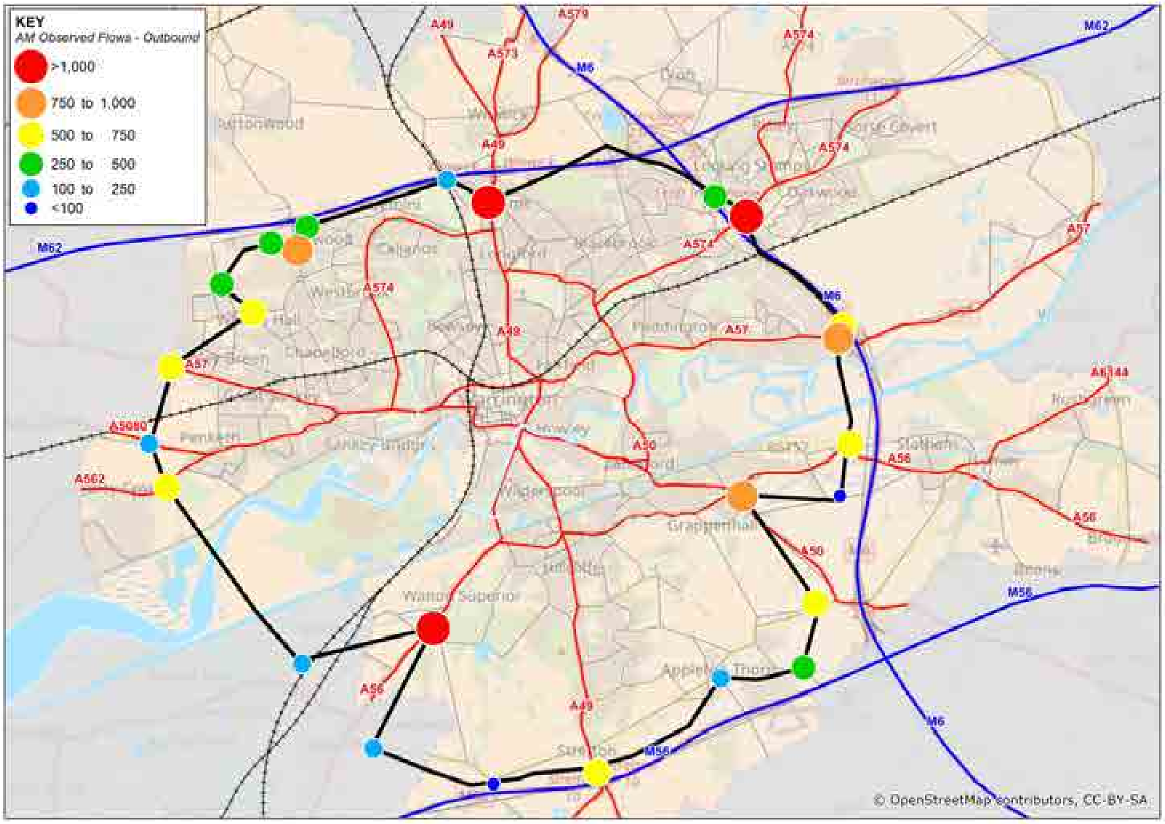


Figure 37 Summary of Observed Flows - Outer Cordon, Inbound Direction - IP

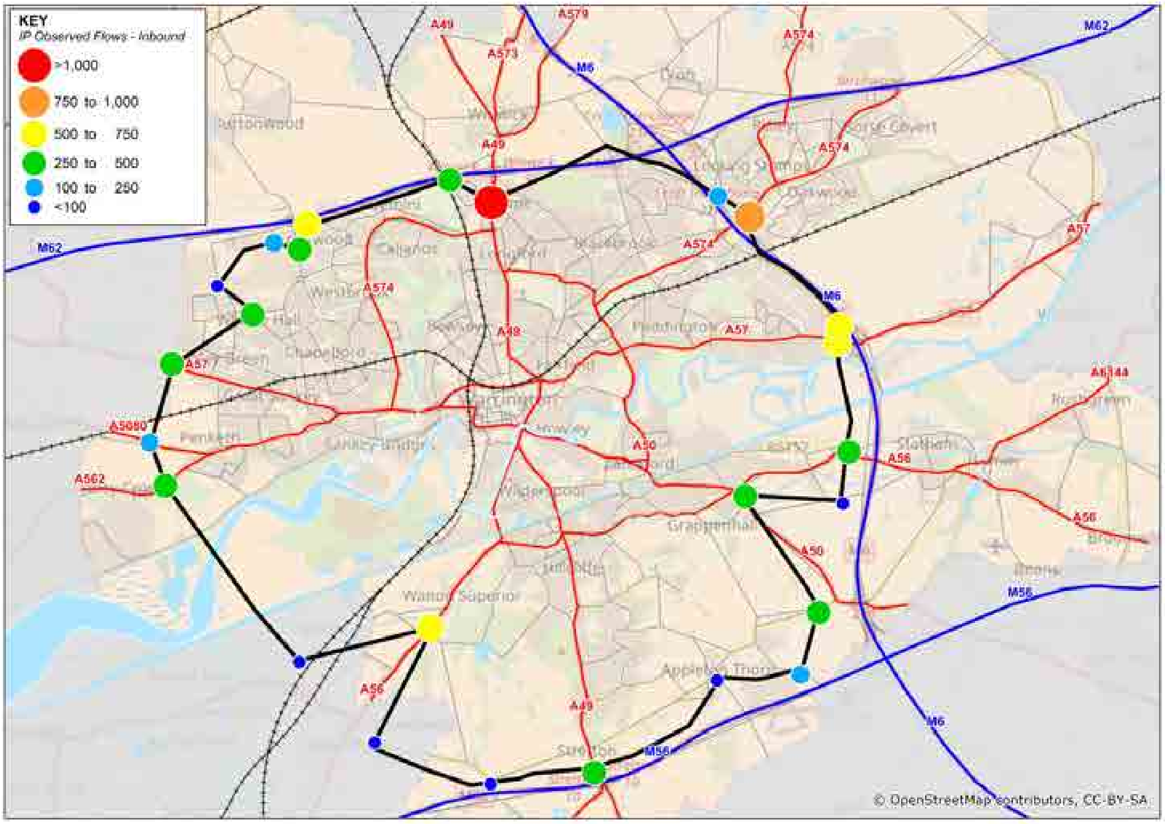


Figure 38 Summary of Observed Flows - Outer Cordon, Outbound Direction - IP

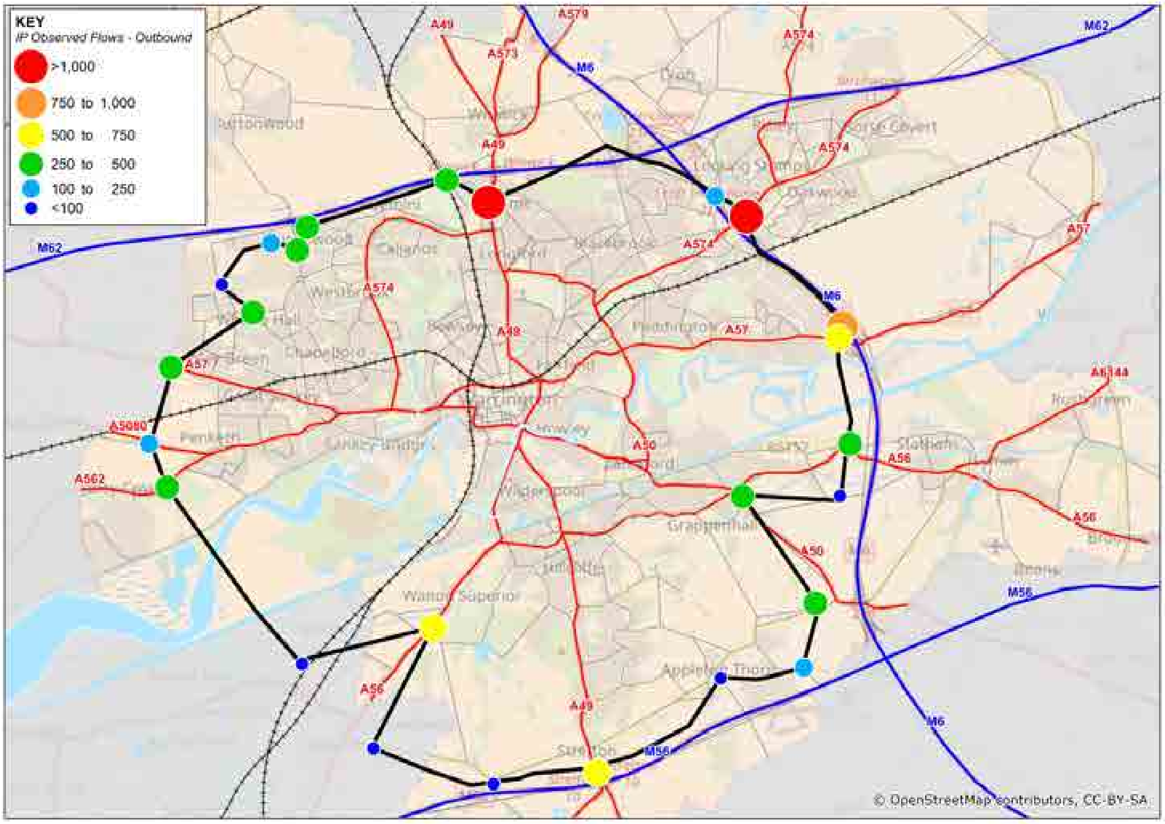


Figure 39 Summary of Observed Flows - Outer Cordon, Inbound Direction - PM

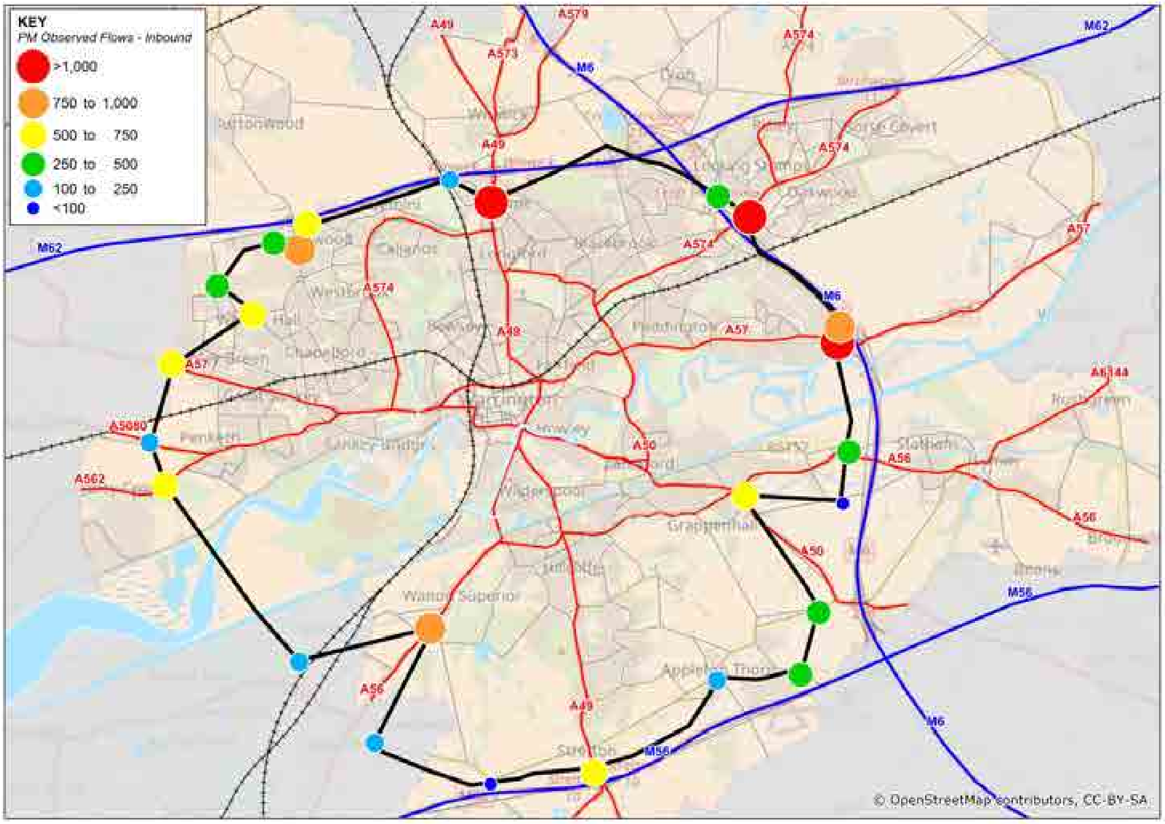
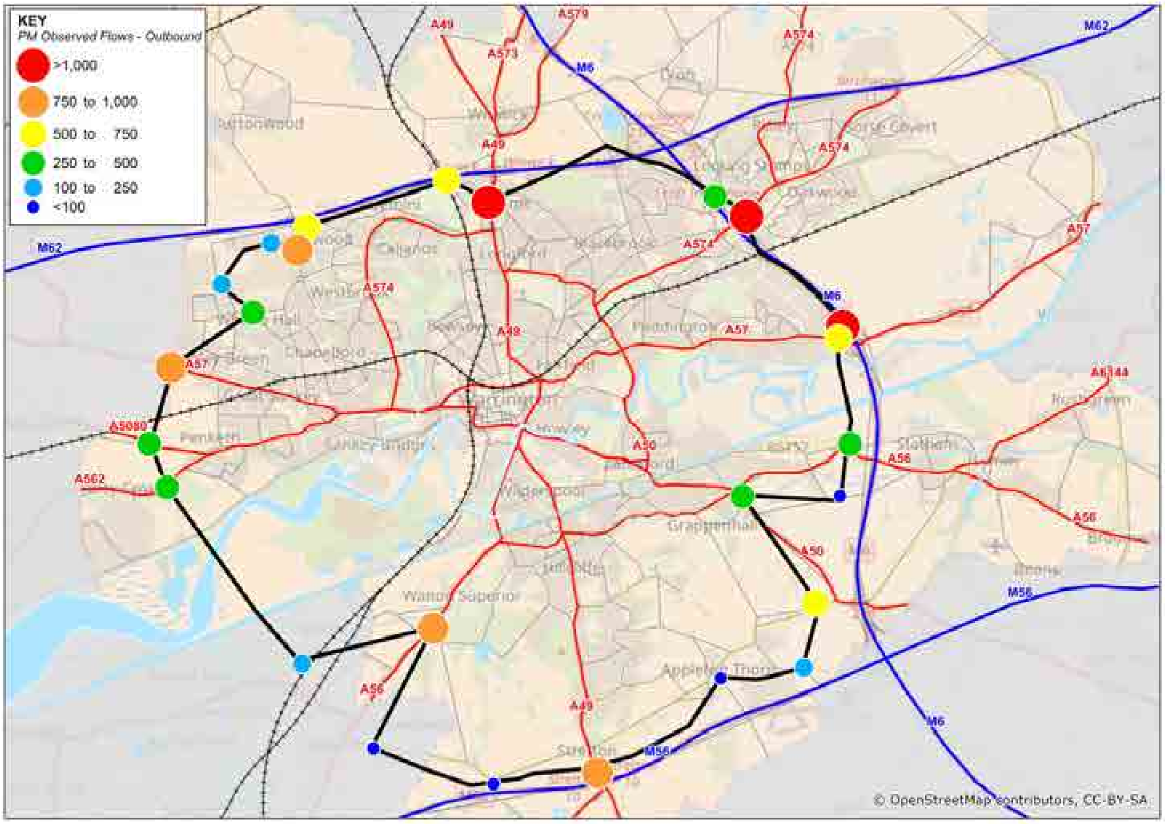


Figure 40 Summary of Observed Flows - Outer Cordon, Outbound Direction - PM



4.2.6 Journey Time Data

Journey time data is required to calibrate the highway network. It is used for two main purposes:

1. By processing the data in such a manner as to extract the upper end of the range of vehicle speeds, the 'cruise' speeds has been estimated; and
2. By processing the data so as to estimate 'average' speeds during specified peak and inter-peak model time periods, it provides a benchmark dataset to compare the model performance against.

For the purpose of the WMMTM16 model development, the journey time data is sourced via Trafficmaster, which provides a large dataset across a large number of the links and is therefore more statistically robust than traditional moving observer methods.

AECOM and WBC have entered into a licence agreement whereby AECOM analyse the Trafficmaster data on behalf of the Council using Basemap's 'Highway Analyst' programme. This is a cloud-based platform where users can quickly analyse, interrogate and download Trafficmaster data.

The model calibration / validation requires specific routes to be assessed. 19 journey time routes (each route analysed by direction) have been identified and agreed with WBC; these are shown in Figure 41 (non-motorway) and Figure 42 (motorway) below:

- 3 routes covering the 3 motorways surrounding Warrington;
- 4 'cross-town' routes covering the key A roads across Warrington and motorway-to-motorway connections; and
- 12 local routes covering other key movements in and around the town.

Figure 41 WMMTM16 Journey Time Routes (Non-Motorway)

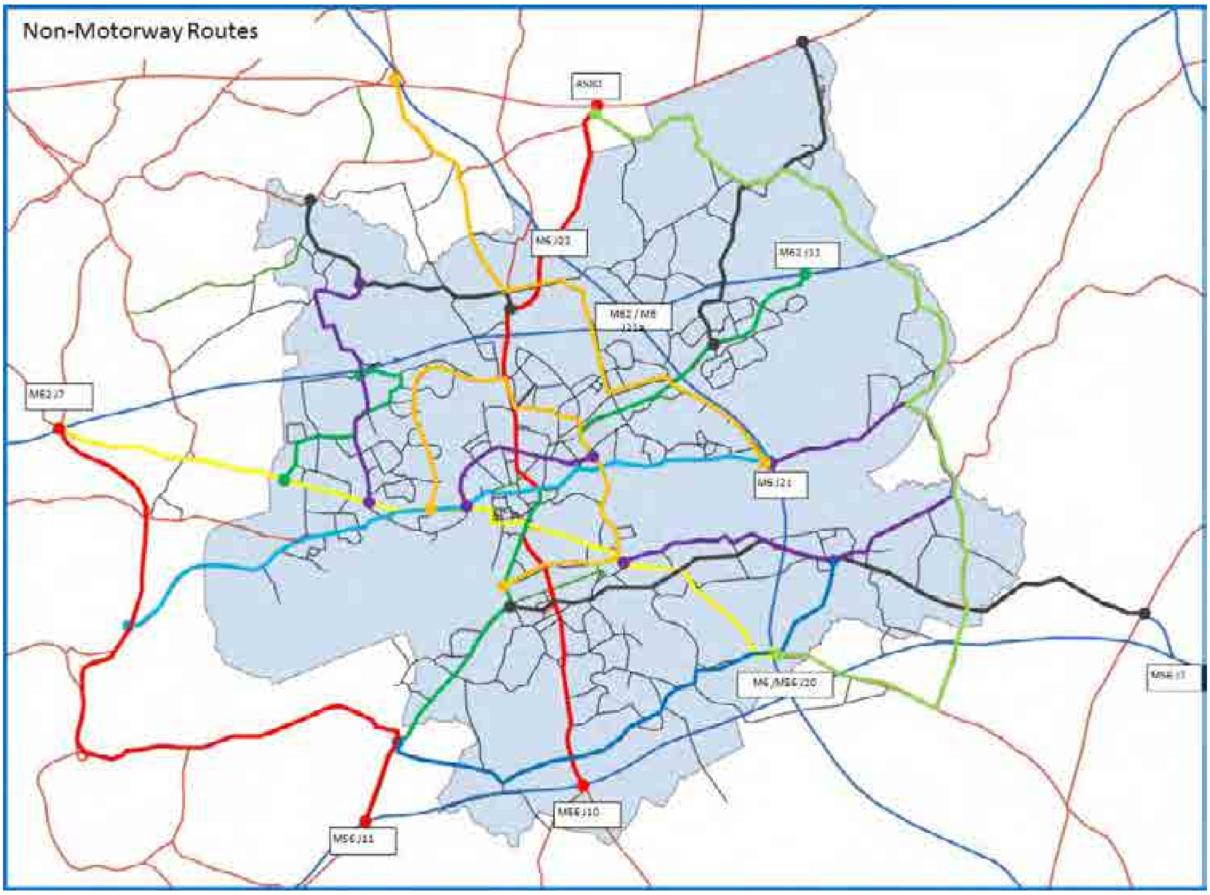
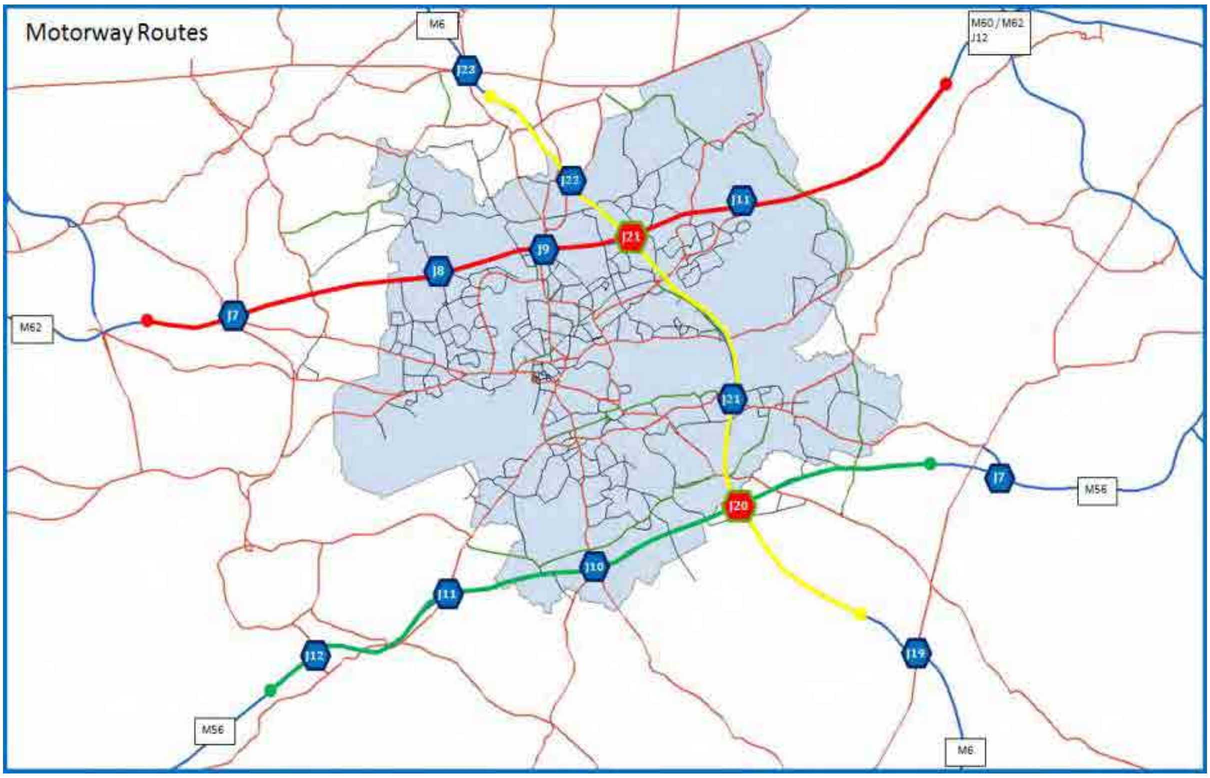


Figure 42 WMMTM16 Journey Time Routes (Motorway)



Data has been downloaded from Basemap under the following parameters:

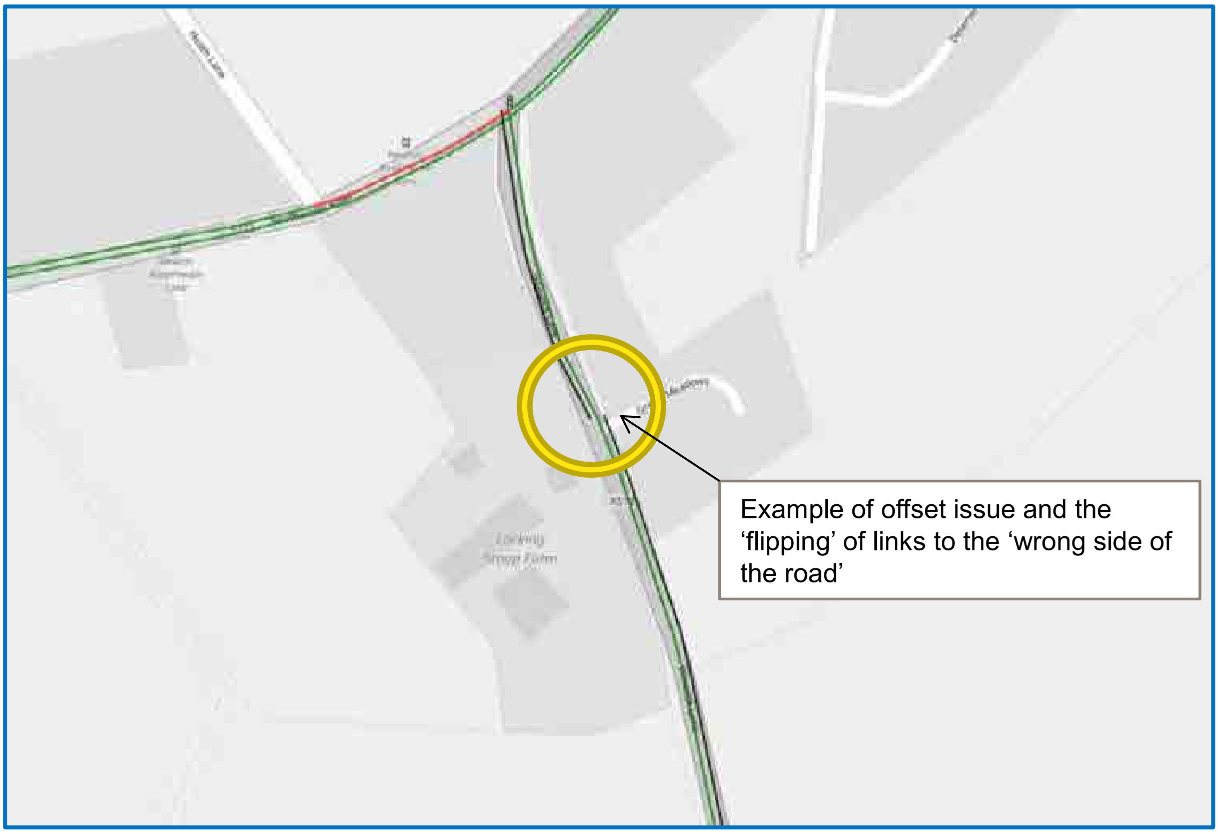
- Data for all roads in the borough and a minimum 5km buffer around, ensuring all routes into Warrington are covered. This included link data for the Runcorn Bridge.
- Data for the average month of June 2015 (corresponding June 2016 data was not as yet available and delaying processing until it might be would unacceptably impact on the model development). This was downloaded for both Mon-Fri and Mon-Thu average so analysis could be undertaken on the potential impact of 'peak-specific' traffic.
- Average Journey times and speeds for the 3 model time periods:
  - AM 07:45 to 09:15;
  - IP 10:00 to 16:00; and
  - PM 16:30 to 1800.
- Data for all vehicles, and all road types.
- Data for average speed, free-flow (uncongested) speed, maximum and minimum recorded speed and the standard deviation of the recorded time.
- Data was extracted for links that had a minimum of 10 observations recorded.
- Data was exported for the following percentile ranges so that analysis could be undertaken on the variability of speeds, removal of extreme outliers, and any impact of the swing bridges on speeds on the approaching links:
  - Zero percentile;
  - Second percentile;
  - Fifth percentile; and
  - Tenth percentile.

To mitigate against any potential biases in the calculations, these percentile ranges have been analysed to understand the variability of the data. A percentile is the value below which a percentage of data falls. For example, if the user specifies a percentile value of 5, this means that if the counts for a road link (number of speeds counted on a road link) were ordered from lowest to highest, the lowest 5% of the data and the highest 5% of the data will be removed from the analysis. This feature is used to remove extreme speed values. By removing these ‘extreme’ fastest / slowest times from the dataset the expectation is that this will address any possible swing bridge effects and abnormal records.

Whilst the use of the Basemap platform provided a quick method of analysing and extracting journey time information compared to the ‘traditional’ methods of processing the data when it was provided directly by the DfT, a number of issues arose during the processing stage which has affected the quality of the output:

- An issue was found in determining the direction of any given Trafficmaster link based on its visual representation on the Basemap platform and GIS shapefile export.
- As there is only one GIS polyline to represent the DfT’s ITN layer, Basemap ‘offset’ the display of these links based on a formula provided by the DfT so that visually the lines appear on the appropriate side of the carriageway thereby inferring a specific direction of travel.
- However, as Figure 43 illustrates, this offset does not always work perfectly where the link is at a specific angle. This issue is then brought across on export of the data from the Basemap platform to the GIS shapefile.

Figure 43 Example of Trafficmaster Issue Found

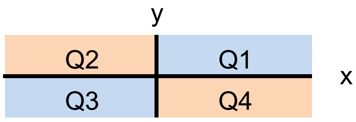


- Whilst this issue is purely a visual problem and the correct times and speeds appear on the correct links via the A/B direction allocation, this makes defining a route (by direction) impossible from the visual appearance and direct Basemap reporting as the A/B direction allocation within the Trafficmaster data is inconsistent with respect to being specific to a particular direction. For example, links along the same stretch of road that travel north-south or south-north can both be assigned the ‘A’ direction. The A/B direction allocation is purely a means to differentiate one direction from the other not to assign the actual direction of travel, as presented in the Basemap outputs.

As a result of this visual inconsistency, an alternate approach was developed to assign the Trafficmaster links to the correct direction, the appropriate SATURN network link, and calculation of the respective journey times for the routes defined in Figure 41 and Figure 42 above.

The revised methodology for assigning the Trafficmaster times and speeds to the SATURN network was as follows:

1. Extract the ‘first’ and ‘last’ co-ordinates for each link’s start and end node;
2. Transpose[5] first/last co-ordinates if direction = ‘B’ to correct start/end nodes;
3. Calculate the difference between co-ordinates of start/end nodes;
4. Using trigonometry function $\tan^{-1}$ calculate tangent of link;
5. Convert tangent to angle degrees and assign to quadrant of direction (north, south, east, west);



6. Correct for negative results by adding degrees based on quadrant assignment;
   - 0 for Q1
   - 180 for Q2 and Q3
   - 360 for Q4
7. Repeat steps 1, 3-6 to each SATURN link; and
8. Using correspondence between SATURN link ID and Trafficmaster link ID from initial GIS buffer query, allocate Trafficmaster data to SATURN links by direction using difference between SATURN link angle and Trafficmaster link angle based on criteria (<90 degrees or >270 degrees).

Table 27 and Table 28 present the results of steps 1-8; observed journey time routes for both the Motorway and Non-Motorway routes respectively.

Table 27 shows that in across all time periods, the M62 is the slowest of the 3 motorways, and the M56 is the quickest.

Table 27 Observed Journey Times for Motorway Routes

ID	Route	Direction	Length (km)	AM Time (mins)	IP Time (mins)	PM Time (mins)
MR 1	M6 – Between Junction 19 and 23	NB	23.3	14.6	13.7	27.0
		SB	24.5	17.9	14.0	15.7
MR 2	M62 – Between Junction 6 and 12	EB	28.6	22.3	17.4	25.2
		WB	30.4	17.8	17.6	22.2
MR 3	M56 – Between Junction 7 and 12	EB	22.3	13.6	12.5	14.1
		WB	21.6	12.2	12.0	12.9

---

[5] Step applies to Trafficmaster links only, not necessary to apply correction to SATURN links

Table 28 Observed Journey Times for Non-Motorway Routes

ID	Route	Direction	Length (km)	AM Time (mins)	IP Time (mins)	PM Time (mins)
XT 1	Cross Town – Via A49	NB	16.5	23.3	23.2	28.3
		SB	16.2	28.6	19.0	26.1
XT 2	Cross Town – Via A57/A50	EB	17.8	30.9	27.0	32.3
		WB	17.5	31.3	25.1	35.0
XT 3	Cross Town – Widnes / M6	EB	12.9	15.4	14.1	16.2
		WB	12.7	15.3	13.2	15.5
XT 4	Cross Town – M56 to M62	NB	15.9	25.7	22.2	27.5
		SB	16.7	26.2	21.2	31.4
Wton 1	M56 J11 – Runcorn Bridge – M62 J7	NB	18.5	18.8	18.1	24.4
		SB	18.5	18.5	15.7	16.2
Wton 2	Cromwell Avenue to Chester Road	CW	13.5	31.6	24.9	31.6
		ACW	13.7	31.5	28.2	34.7
Wton 3	M6 J21 to M6 J23 via local route	NB	13.3	22.8	17.4	20.1
		SB	13.6	19.7	17.2	20.3
Wton 4	Burtonwood to Winwick	SB	5.8	7.2	6.5	6.8
		NB	5.8	8.6	7.3	8.7
Wton 5	A580 to Birchwood	SB	8.3	13.6	11.7	17.6
		NB	8.3	13.9	11.5	14.0
Wton 6	A56 to M56 J7	EB	16.1	21.4	19.1	20.0
		WB	16.1	24.8	25.6	27.2
Wton 7	Burtonwood to Whittle Ave	SB	7.0	11.6	10.6	11.2
		NB	7.0	10.2	10.0	10.4
Wton 8	Lovely Lane to Marsh House Lane	EB	3.5	8.2	8.1	9.3
		WB	3.5	9.6	8.7	11.8
Wton 9	M6 J21 to Thellwall New Road	CW	13.7	23.1	19.5	21.5
		ACW	13.7	19.7	18.7	23.9
Wton 10	Lymm to Daresbury	WB	10.4	16.8	13.9	17.2
		EB	10.3	14.1	12.4	14.0
Wton 11	A580 to M6 J20	SB	24.2	32.7	30.0	34.8
		NB	24.2	32.4	30.0	41.5
Wton 12	Charon Way to Lingley Green	SB	4.9	7.6	7.7	8.1
		NB	5.0	7.9	8.1	10.0

4.2.7 Public Transport Surveys

4.2.7.1 Bus Counts

Two types of bus passenger count data were collected:

- Individual bus boarding / alighting counts; and
- Cordon point bus occupancy counts.

The bus boarding and alighting counts are used for the expansion of the survey data sample and for the calibration of the boarding and alighting of passengers in the WMMTM16.

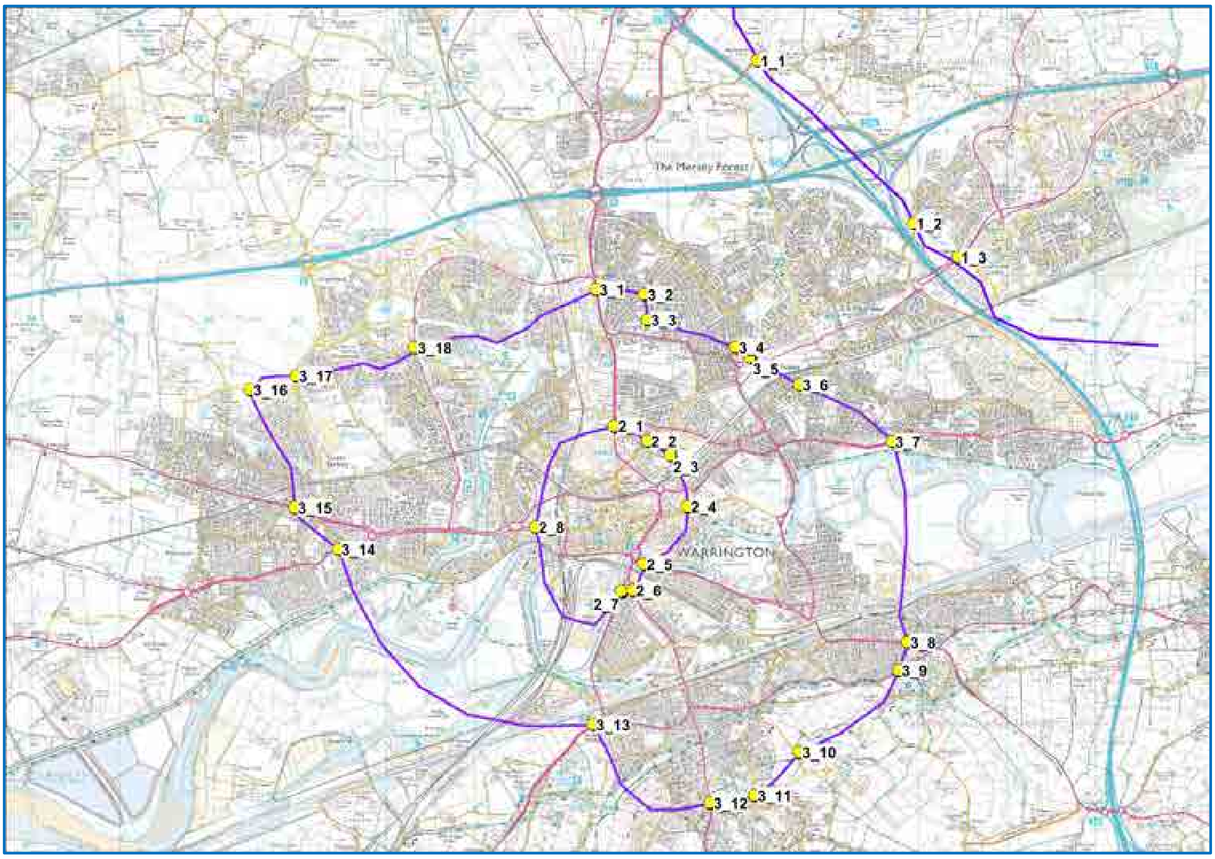
No technical issues were identified with respect to the execution and delivery of these counts.

Bus occupancy counts are used as an independent validation dataset for the assignment of bus passengers through the WMMTM16. Three set of cordons were generated as identified in Figure 44:

- A north-eastern screenline, focusing on the movements on the edge of Birchwood; an adjacent key employment area;
- An inner town centre cordon; and
- An outer town cordon.

No technical issues were identified with respect to the execution and delivery out of these counts.

Figure 44 Bus Occupancy Cordon Boundaries (purple) and Points (yellow)



4.2.7.2 Bus Surveys

Bus passenger surveys, along with bus ticketing data, provide the foundation for the bus passenger origin-destination, prior demand matrix. The surveys are not as robust as the ticketing data in terms of duration, being conducted over multiple days rather than weeks and for a sample of services, but provide information on passengers origin and destination (as opposed to boarding and alighting stage) and on travel purpose.

The passenger surveys were conducted for 22 service routes, and a target of 5,000 surveys in total. In total, including postcards sent back by passengers, 5,580 interviewed records were generated by TRACSIS. Of these approximately 1,300 related to interviewees refusing the survey part way through, or the surveyor encountering a technical problem with their device, requiring restarting the survey on the tablet or paper copy and therefore unusable. The 1,300 figure is above expectations, but given the device restart related component and with a focus on the end sample rate, it is judged acceptable.

In addition to the face-face interviews, 1,683 interview forms were handed out on bus routes (where passenger quantities were such that interviewers could not speak with everyone) and 395 returned, raising the total sample to 4,353 or 36%.

Table 29 Bus Passenger Survey Sample Rates

Route	Total Count	Total Face-face Interviews	Total Paper Questionnaires Returned	Total Interviews Conducted	Total Interviews to Count Sample %
All Routes	12,100	3,958	395	4,353	36%

Following the cleaning process by TRACSIS and AECOM, 2,866 bus passenger surveys were taken forward to be used. The proportion of discarded surveys is above expectations, but the end sample rate total; 24% of the total passenger count is accepted for the designed purpose, which is to be used to add further passenger information to the larger bus ticket dataset.

The public transport data has gone through an extensive processing and cleaning process, with the majority of this cleaning being done by AECOM rather than the survey company in this case, so as to make best use of the data captured.

The passenger traveller survey data is more prone to potential error than the corresponding RSI data, as passengers also have to identify their start and end bus stops / train stations. Further, the train surveys are simpler than bus surveys in that:

- The train stations are more easily identified and fewer in number than bus stops;
- The surveyors were able to remain located at fixed locations; and
- There were fewer stations and services than bus routes surveyed and therefore fewer staff required.

As a result, the cleaning process for the bus passenger surveys was more extensive and time-consuming compared to the train passenger surveys.

The following checks were conducted:

- Identifying of missing postcodes where possible from address descriptions. For areas external to the simulation area, approximate locations were judged sufficient, i.e. the first part of postcodes. Responders typically knew their home postcode but not their destination postcode and in some cases identified their location as ‘Warrington Town Centre’. Given that the surveys are primarily used for purpose splits (in conjunction with the Electronic Ticket Machine (ETM) data), which for the town centre is to be a collective sector for public transport, this was judged acceptable.
- If origin and destination addresses were provided but a bus stop missing from the response, the closest bus stop was allocated.
- Survey responses were removed under the following conditions;
    - No origin, destination, or associated purposes provided.
    - A maximum walking distance of 3km within the model simulation area. It was identified that the majority of people walk significantly less than this, but in some cases people would be willing to walk further and should not be discounted. If people travelled to the bus by another mode, this distance limit was not applied. Similarly, if end points were external to the simulation area, where locations were grouped in large zones, the limit was not applied.
    - If the origin and destination were the same according to the survey it was discounted.
    - If the origin and destination purposes were both ‘Home’ the survey was discounted.

4.2.7.3 Bus Ticketing Data

Ticketing data were received from the two main operators within Warrington; Network Warrington and Arriva. Both supplied 24-hour data; Network Warrington from 18th June (2016) to 1st July (inclusive) and Arriva from 1st June to 8th July.

The data contained limitations in their formats, neither showing specific boarding and alighting stops. The Network Warrington data is constructed on a ‘stage’ basis, which shows the origin and destination stage, but with stages containing a number of bus stops. The Arriva data identifies the boarding bus stop stage, but not the destination and again, each stage contains a number of bus stops. Without a destination, the Arriva data requires greater interpretation for the matrix development purpose.

These datasets contain data across a large timeframe and are therefore robust at a stage level. To convert the stage data to a more disaggregated stop / model zone form as part of the matrix development, the bus passenger survey data collected for this project, which was generated on a stop-by-stop basis, has been used.

For more details on how these datasets have been processed, disaggregated, and issues identified, please see Chapter 8.

4.2.7.4 Rail Data

Rail station access and exit counts were conducted on the same days as rail passenger interviews. Table 30 shows the average entry and exit numbers across the 07:00 to 19:00 period for each of the stations surveyed.

Table 30 Train Station Average Daily Passenger Entry / Exit Numbers

Location	Entry	Exit
Birchwood	1,407	1,266
Glazebrook	55	50
Newton-le-Willows	779	728
Padgate	357	229
Sankey	285	228
Warrington Bank Quay	1,666	1,854
Warrington Central	2,199	2,354

These surveys were initially conducted on a single day at each identified station. Due to the condensed timeframe for the surveys, TRACSIS had lower than identified staffing levels to conduct these station surveys and total interviews were as a result, below target levels. Therefore a second day of surveys was conducted to supplement. In order to have added confidence in the survey passenger number counts, additional counts were conducted at the second round of survey days.

For stations where a second survey was undertaken, the absolute difference between the two survey days was on average 3%, for other stations the difference was higher, but that is largely as a result of the potential variation across time periods. As a result of this cross check and on-site inspections, the first days counts were kept, as opposed to an average of the two days, so as to ensure greater correlation with the passenger interviews, which were predominantly on the first day.

For further details, refer to the Data Collection Report.

Table 31 Rail Station Survey Sample Rates

Station	Access Count	Surveyed Passengers	Sample Size	Target
Birchwood	1407	404	29%	250
Glazebrook	55	26	47%	20
Newton-le-Willows	779	388	50%	275
Padgate	357	119	33%	50
Sankey for Penketh	285	182	64%	50
Warrington Bank Quay	1,666	381	23%	300
Warrington Central	2,199	698	32%	500

4.2.7.5 Bus and Rail Interviews Expansion

Just like the RSI surveys data, the bus interviews data needed to be expanded to be used in PT matrix development. The bus interviews expansion factors process included the following steps and criteria:

- There were 2 similar yet distinct methods adopted for Network Warrington bus services and Arriva bus services, Table 32 provides a breakdown of which of bus routes surveyed are classified as Network Warrington or Arriva Services.
- Both methods provide different expansion factors for bus trips heading inbound (towards Warrington Bus Interchange) and trips heading outbound (originating at Warrington Bus Interchange).
- Both methods provide unique expansion factors for each bus service on an hourly basis and finally as time period basis.
- Both methods start by calculating the ratio of the average hourly interview trips to the average hourly bus boarding count (occupancy);
  - These hourly ratios are multiplied by the average bus service frequency during the corresponding time period.
  - The adjusted hourly ratios are then summed together to provide the respective time period ratio (for example 7:00 to 9:00 inclusive to account for the AM period factor). These time period ratios are the bus expansion factors which are then applied.
- For Network Warrington Bus services;
  - For inbound trips, the same expansion factor is applied to the stops comprising the route.
  - For outbound trips, different expansion factors are applied to trips originating at either Warrington Bus Interchange, remaining stops within the borough boundary and stops outside the boundary.
- For Arriva bus services;
  - For inbound trips, different expansion factors are applied to trips originating at stops outside the borough boundary and for the stops within the borough boundary.
  - For outbound trips, different expansion factors are applied to trips originating at Warrington Bus Interchange, and stops outside the borough boundary.

Table 33 provides an example of both methods of calculating the bus expansion factors, while Appendix C provides full details of calculating all the bus expansion factors.

Table 32 Bus Services Surveyed Categories

Service Category	Bus Service Number
Network Warrington Services	3
	3
	5
	7
	18
	19
	22
	25
	28
	35
	45
	46
	11A
	12A
	17
	29A
	29C
	32A
Arriva Services	100
	110
	329
	360

Table 33 Bus Interviews Expansion Factors Example

Route No	Direction	Location	AM	IP	PM
329	Inbound	Outside Borough	3.64	2.65	0.00
		Other Stops	0.25	2.00	0.13
	Outbound	Warrington Interchange	2.83	1.84	0.63
		Other Stops	2.74	1.83	0.74
29C	Inbound	All Stops	1.03	0.86	3.89
	Outbound	Warrington Interchange	0.67	0.96	0.81
		Remaining Stops within Boundary	0.97	1.48	1.00
		Other Stops outside Boundary	1.00	1.00	1.00

Similarly for rail passenger interviews survey the number of people surveyed whilst boarding a service at a station has been expanded up to the total number of people counted boarding all services of interest at that station during the time period.

4.2.8 Freight Data

Freight movements are typically difficult to capture in urban transport models with, for example, capture rates at RSI locations often lower than that for cars. Supplementing the traditional data collection methods with additional quantitative and qualitative information was identified as beneficial in terms of supporting the model development. Section 6.4.2 provides more detail how elements of the freight surveys were used in developing prior HGV matrices.

A separate freight report (under Appendix D of the MDCR) has been developed which covers the implications of the specialist goods counts in more detail, but a summary of the count data collected as well as the operator survey results and analysis is included here.

The three main freight specific elements are:

- The RSIs discussed earlier in this chapter;
- 8 Specialist Goods Vehicle Counts (SGVCs) at roadside (locations shown in Figure 45); and
- 19 Freight operator interviews (locations shown in Figure 46), in person or over via telephone.

While the target number of freight operators surveyed was exceeded, a number of operators were not willing to provide responses and therefore alternative operators were interviewed.

Figure 45 Specialist Goods Vehicle Count Sites

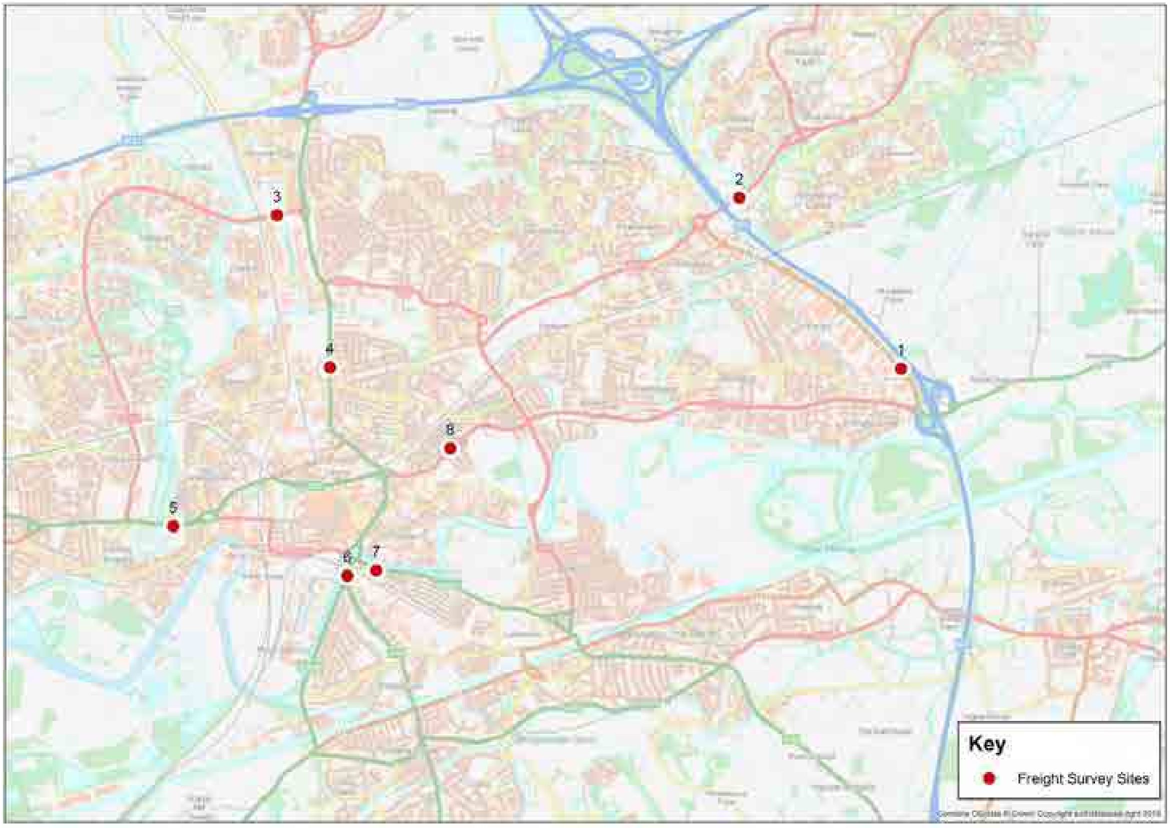


Figure 46 Freight Operator Surveys - Depot Locations

Contains OS data © Crown Copyright and database right 2010

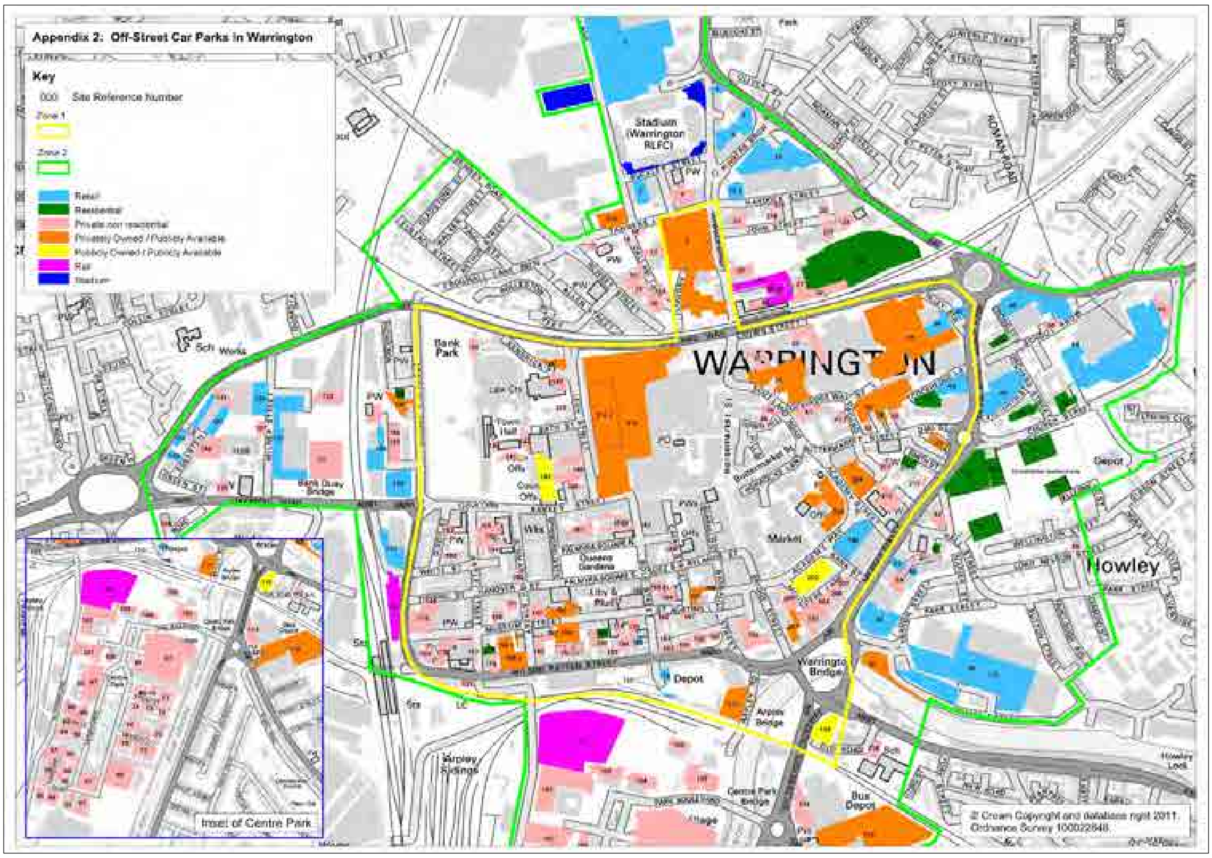
4.2.9 Parking Data

Parking data are required for an analysis of current conditions, as well as to help forecast potential future year capacity conditions, as it may impact on trip patterns.

WBC hold an inventory of car park locations as shown in Figure 47. The latest spreadsheet and map based logs have been compared with an independent check conducted to confirm any significant recent changes and identify additional significant parking areas in relatively close proximity to the town centre.

The main alteration to the log was the amendment to parking sites at Academy Way, following the closure/demolition of the multi-storey car park and instalment of a temporary parking site. Additional potential parking sites were identified primarily directly to the north, including Warrington Hospital to the north-west and Cobden Street to the north-east.

Figure 47 WBC Car Park Inventory



Car parking surveys for ten sites were commissioned in and around the central area of Warrington. Their locations are shown in Figure 48. The surveys were selected to cover a range of car parks of different size, location and price. For more information see the Data Collection Report.

No technical issues were identified with respect to the carrying out of these counts by the survey company and visual sense checks were made by AECOM against images recorded at the time. As images were not taken at the start of the surveys for designated car park sites (only the on-street parking), the survey company was asked to increase the robustness of these surveys by cross-checking on a second day. The results from that showed a close correlation with the first day, as shown in Figure 49, which includes occupancies recorded around 09:00 and 12:00;

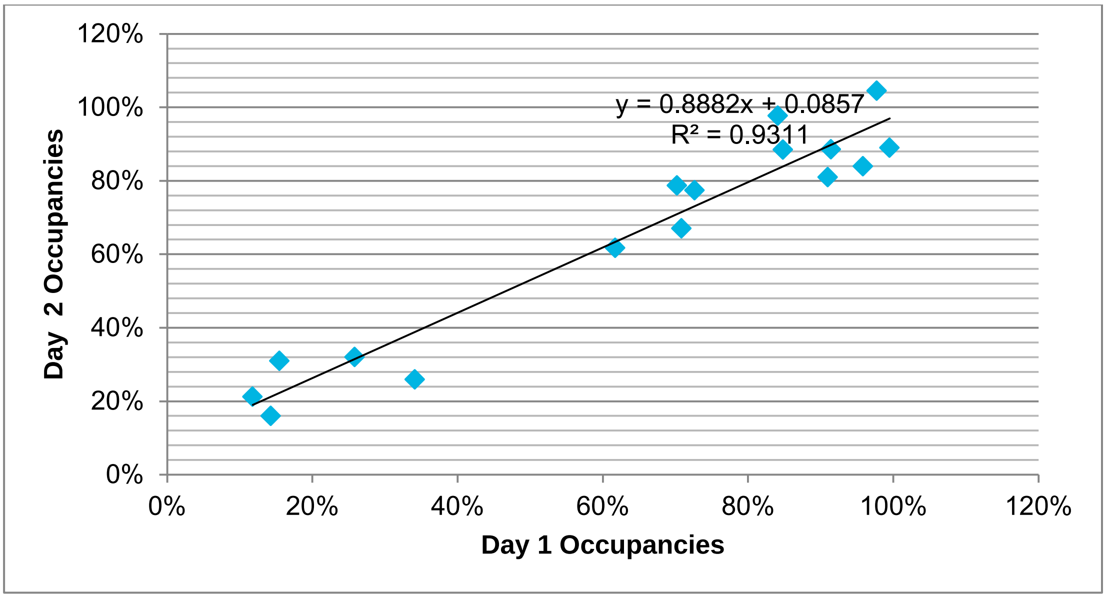
In addition to these commissioned counts, it was identified that parking data from Golden Square shopping centre might be obtained through WBC, however, the Council has not been able to obtain this.

The primary use of the parking data has been to examine the split between paid for and non-paid for parking to derive an estimate of average parking costs for use within the demand model.

In addition to this, the parking data entry/exit totals have been sense checked and compared to the trip demand of respective model zones to ensure realistic trip patterns are represented in the highway model.

Figure 48 WMMTM16 Commissioned Car Parking Surveys

Figure 49 WMMTM16 Commissioned Car Park Surveys – Consistency Check of Car Parks



4.3 Other Data Used

4.3.1 Highway Network Development Data

The WMMTM16 network data required can be categorised as follows:

1. Network Geometry;
2. Network traffic features including speed, restricted movements; and
3. Network operating features, including traffic signals.

A number of data sources have been identified within each of these categories. These are summarised in Table 34 below.

Table 34 Sources of Network Data

Category	Data Type	Source	Selection Criteria	Use
Network Geometry	- Link alignment - Other geometric attributes	- Highways England TPS Regional Model - Meridan2	- All Motorways, and A roads outside the Borough of Warrington - All A roads, B roads and selection of key C roads within the Borough of Warrington.	- Used in the production of both simulation and buffer network in SATURN for the WMMTM
Network Traffic Attributes	- Vehicle travel time - Vehicle speed	- DfT Trafficmaster & Highways England TPS Regional Model	- Data for all links within the Borough of Warrington - Weighted average weekday speed from the Trafficmaster observed data	- Used in the calibration and validation of the modelled network
Network Operating Features	- Signal data - HGV restrictions - Bridge details and restrictions	- Warrington Borough Council	- All signalised junctions within Warrington - All modelled roads in the Borough assessed for restrictions	- Used for the representation of junction capacity - Used for the representation of accurate movements across the town

4.3.1.1 OS Meridian2 Data

Meridian2 is a vector map dataset at a scale of 1:50,000 freely available from the Ordnance Survey OpenData service under the terms of the Open Government Licence. This dataset has been used to build the initial model network using GIS, which was then converted into the appropriate compatible SATURN format. Whilst Meridian2 provides a useful start point at which to generate a model network, there are 2 limitations:

- Meridian2 contains a generalised road network and will therefore does not contain every road in Great Britain; and
- Meridian2 does not contain information on drive restrictions such as one-way streets or prohibited turning, for example.

Meridian2 was used to create the model simulation area and then merged with the Highways England Regional Model coding for areas outside of Warrington. The process was as follows:

- Identification of areas of model required to use Meridan2 data;
- Using GIS, the coordinates were calculated for the start/end points of each Meridian2 link and these were then exported to Excel alongside the link distance;
- Creation of Saturn link IDs based on start/end points;
- Creation of Saturn nodes using start/end points (duplicates then removed);
- Final list of nodes and links produced in text file format matching the required Saturn structure for input to SATNET;
- Parameters (logical, integer and real) added to text file and run through SATNET facility; and
- Review and correction of any errors produced.

4.3.1.2 Trafficmaster Speed Data

Trafficmaster data is generated through in-vehicle GPS trackers. As of 2015, Trafficmaster actively polled over 110,000 vehicles. The polled data is attached to Ordnance surveys ‘ITN’ road links and, once checked by the DfT, it is then distributed to each Local Authority.

AECOM and WBC have entered into a licence agreement whereby AECOM will analyse the Trafficmaster data on behalf of the Council using Basemap’s ‘Highway Analyst’ programme. This is a cloud-based platform where users can quickly analyse, interrogate and download Trafficmaster data.

This data is updated annually, with changes to the ITN network being taken into consideration making this an extremely accurate and valuable dataset.

Data has been downloaded under the parameters and methodology specified earlier in Section 4.2.5 (Journey Time Data).

Figure 50 to Figure 52 show the average speeds in Warrington during each model time period.

Figure 50 AM Peak Average Speeds

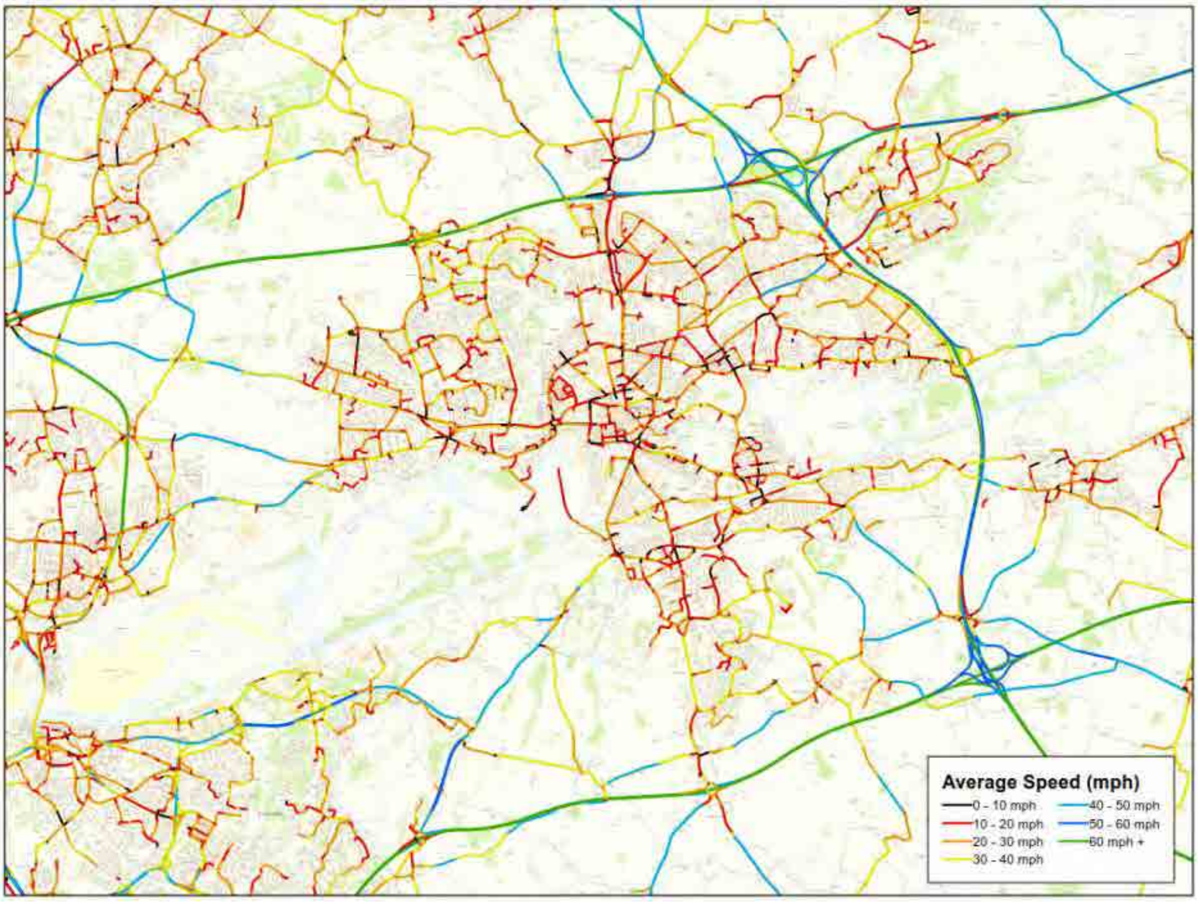


Figure 51 Inter-Peak Average Speeds

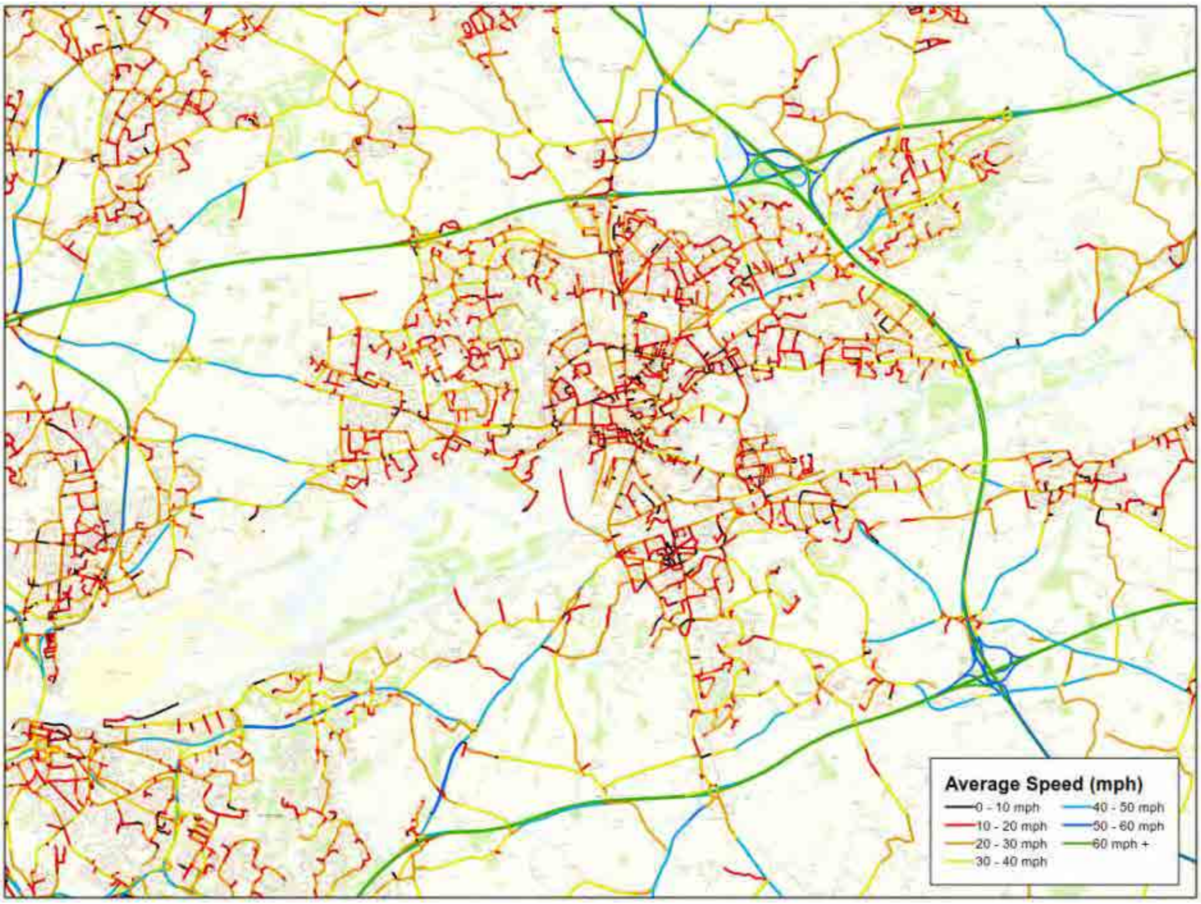
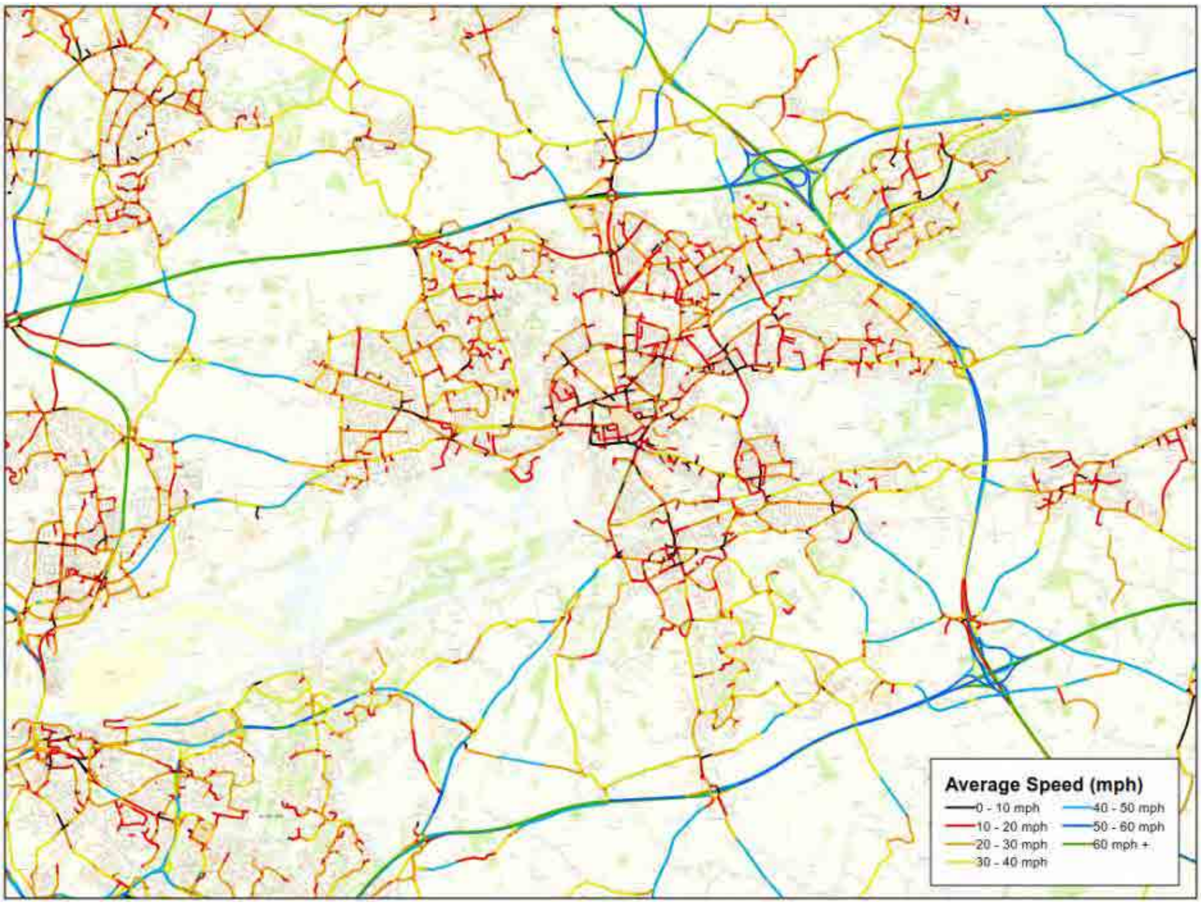


Figure 52 PM Peak Average Speeds



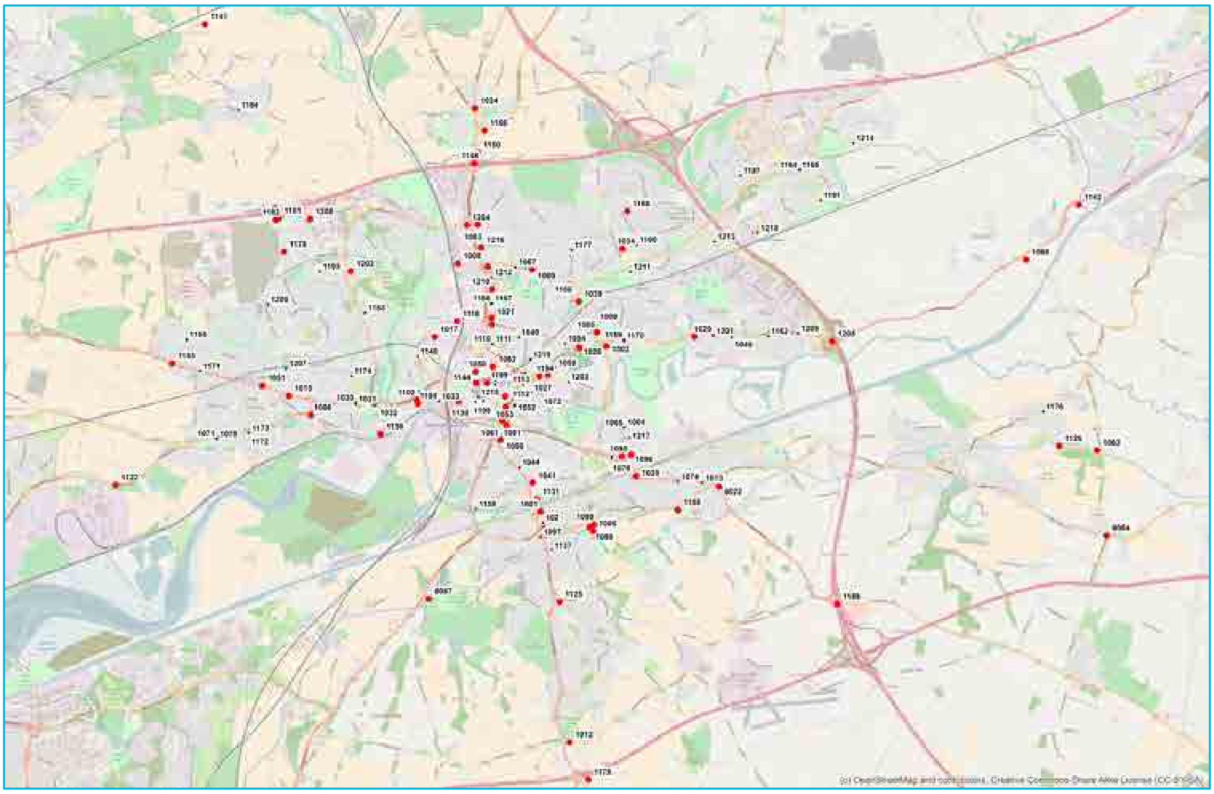
4.3.1.3 Signal Data

Signal timings for 80 junctions within the Warrington borough were provided from the Warrington Urban Traffic Management Control (UTMC) team. Of the 80 junctions, 49 are part of the demand responsive SCOOT network. As SATURN does not model demand responsiveness, the signal timings and stages at these junctions were converted to a fixed-time format that SATURN can process and were coded manually. The timings coded represented an average time for the model hour being coded using a download of the variable times recorded at each junction. An example of this output is shown in Appendix D.

Signals that did not fall under the jurisdiction of WBC were imported in the model from the Highways England Regional Traffic Model or coded using the template guidelines set out in the Coding Manual and further optimised during the calibration process.

Checks of all the traffic signal coding were conducted when importing to the network. Missing turn pockets was the most common error (3 junctions identified – 4%). More serious errors i.e. turns not allocated to any stage were picked by SATURN's internal checking (a total of 8 identified – 9%). Further checks were undertaken by WSP; the external quality assurance reviewer on behalf of WBC and a number of minor errors identified and corrected. Figure 53 displays the location of all the signalised junctions in the borough that have been coded into the WMMTM16.

Figure 53 All Signalised Traffic Junctions in Warrington



4.3.2 PT Routing

4.3.3 Bus

Bus routes were generated using three methods. Firstly, data was first sourced from Translink which enables an automated generation of routes in EMME / GIS based on a central ‘TransXchange’ database. The method involves assigning the bus services stops to the nearest model node and including the service name / number and headway from the database.

The TransXchange database however contains known errors due to old services remaining in the system having been replaced. Further, the database included service changes since the time of the survey data collection and does not facilitate the production of historic lines. Therefore a secondary ‘CIF’ database was used. This database contains similar data as TransXchange and is available for specific dates, but required more processing than the TransXchange approach.

In some cases routes were timetabled but did not appear in either database. A cross check was conducted for their presence in the cordon occupancy counts and if confirmed, these service lines were generated manually.

Figure 54 to Figure 56 displays the coverage of Network Warrington Bus Services in each time period. They show very little route variation across the periods.

Figure 57 shows the coverage of Arriva bus services in Warrington in the AM. Figure 58 to Figure 61 show the routing of AM services in Warrington. IP and PM services can be found in Appendix F.

Figure 54 Network Warrington Bus Services - AM

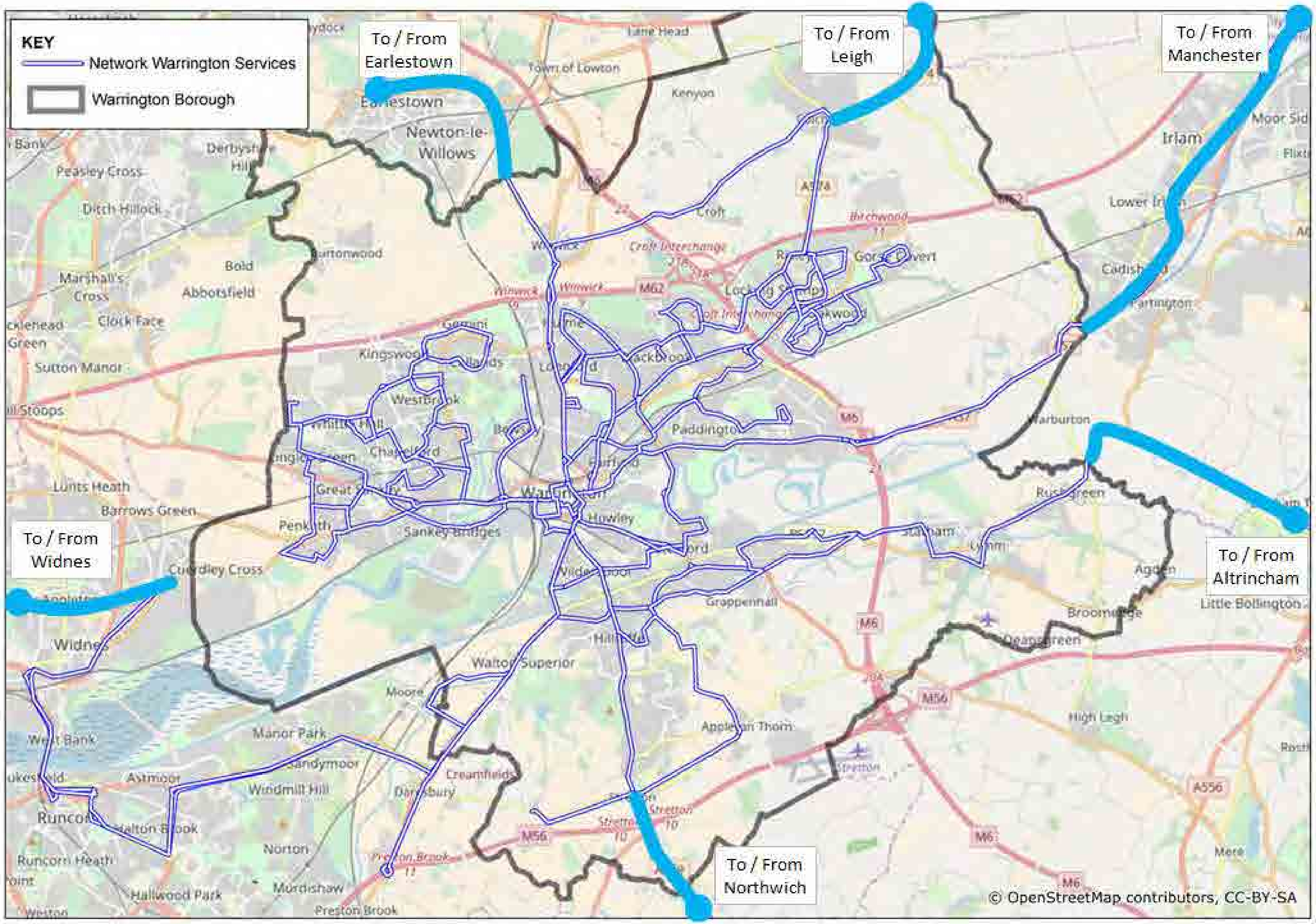


Figure 55 Network Warrington Bus Services - IP

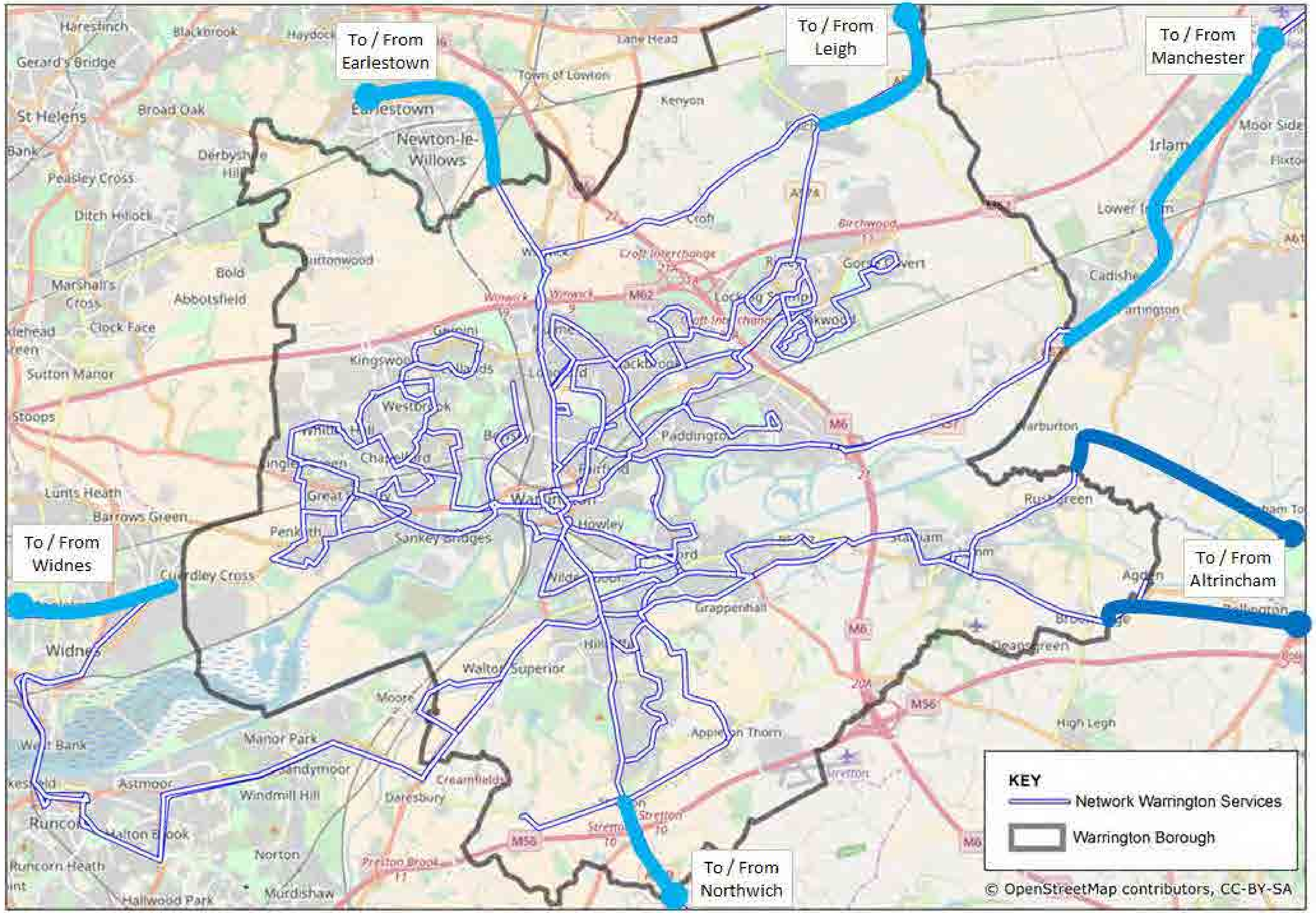


Figure 56 Network Warrington Bus Services - PM

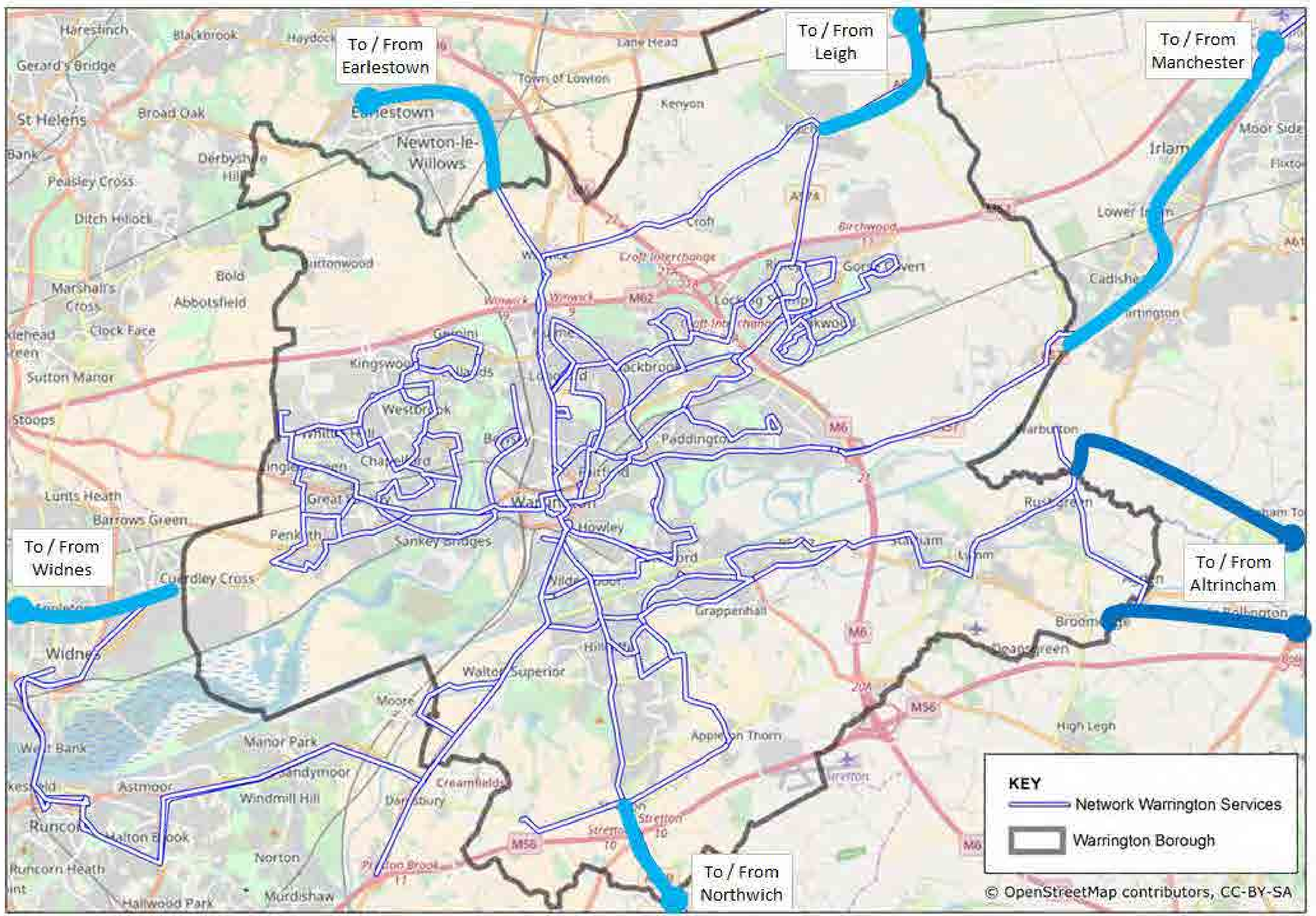


Figure 57 Bus Routes, All Peaks – Non-Network Warrington Services

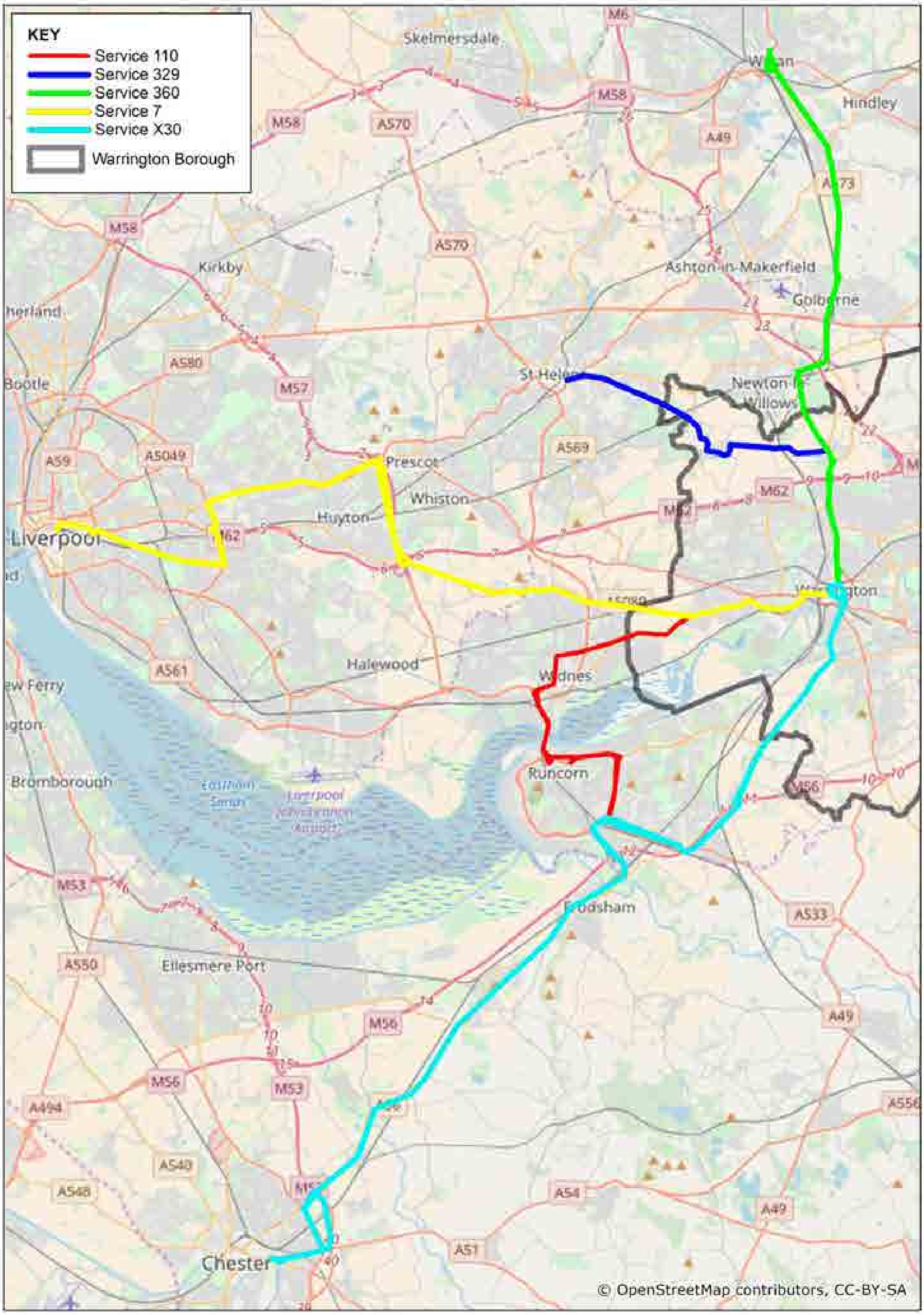


Figure 58 AM Bus Routes – Network Warrington Services (1/4)

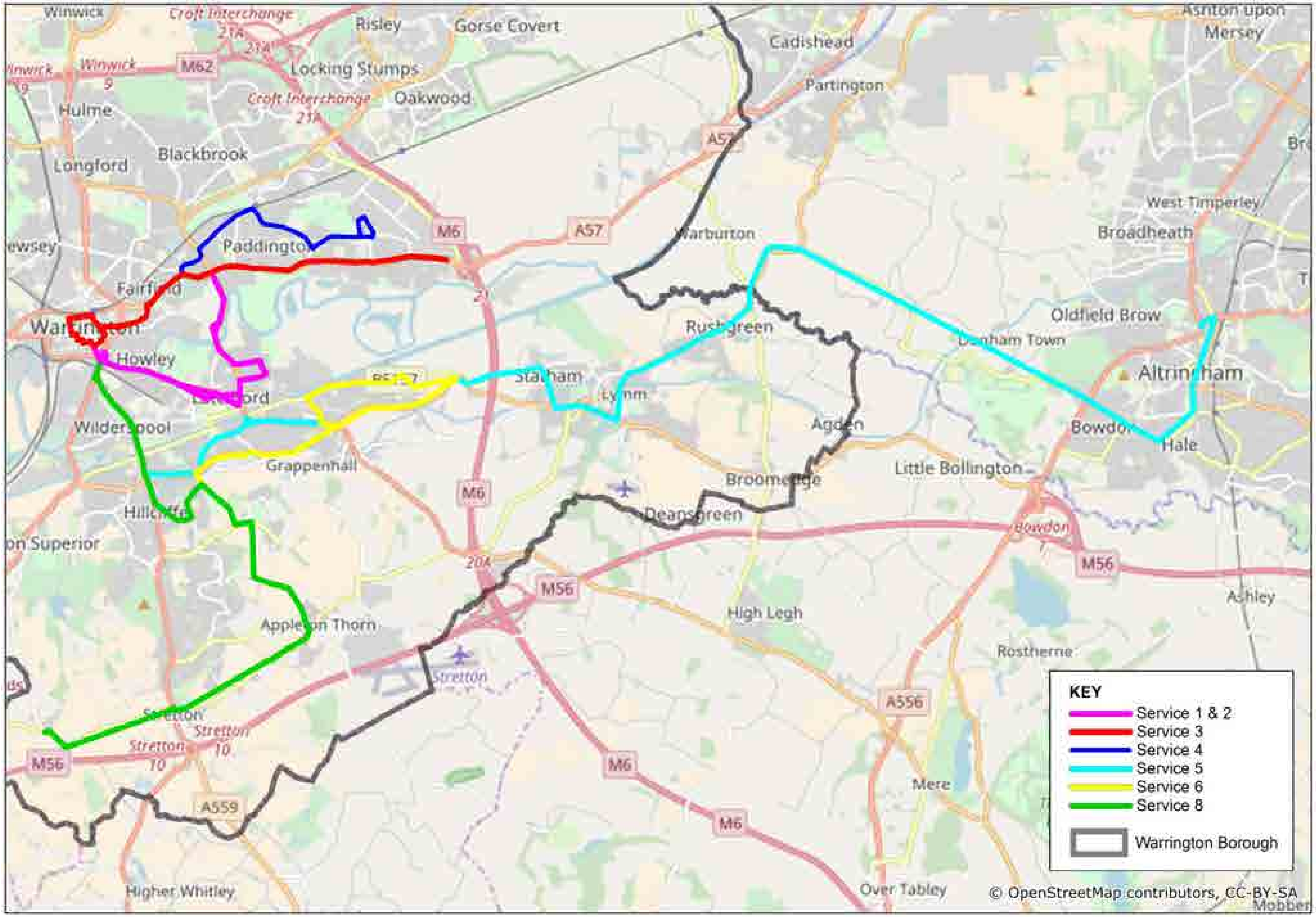
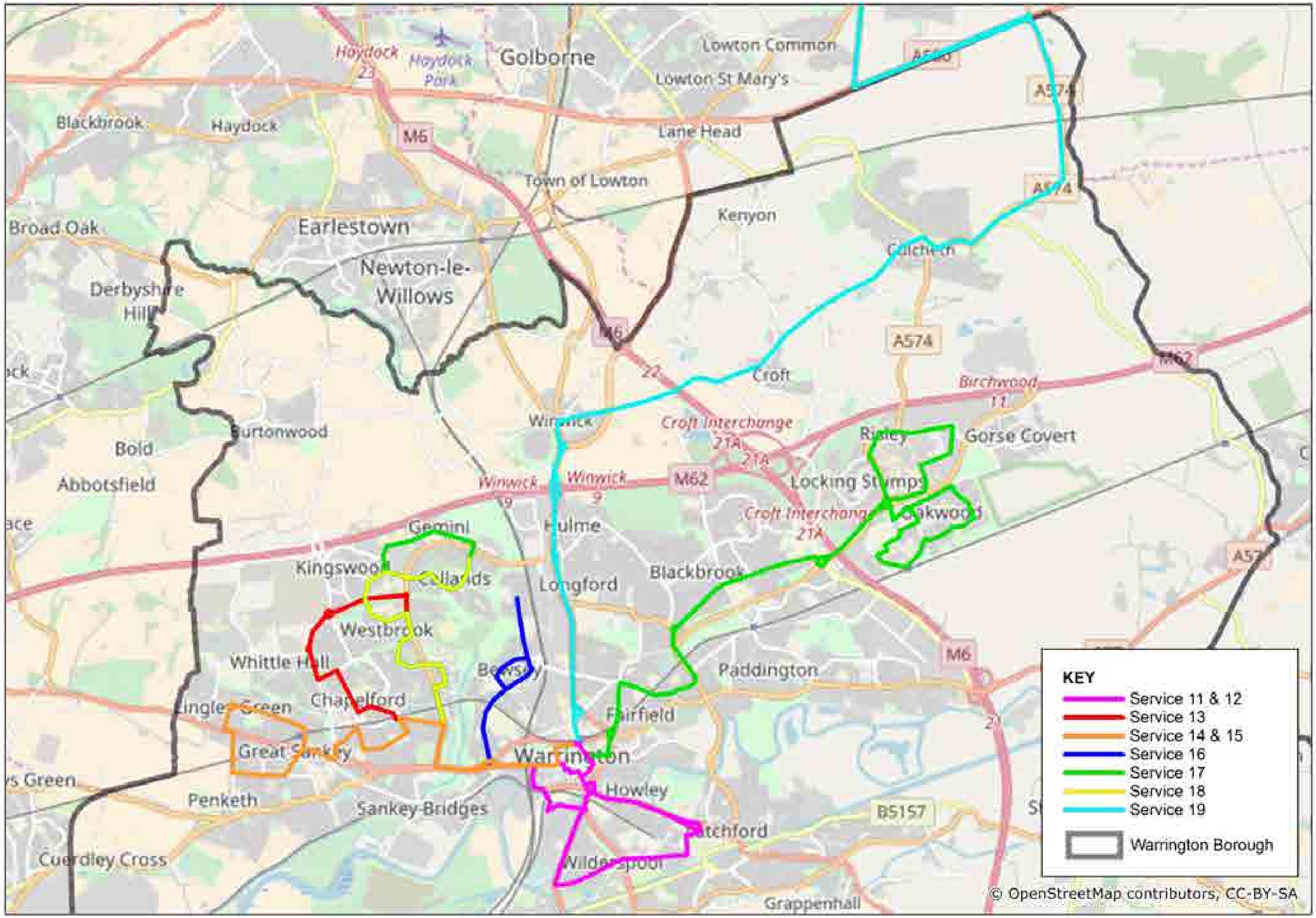


Figure 59 AM Bus Routes – Network Warrington Services (2/4)



© OpenStreetMap contributors, CC-BY-SA

Figure 60 AM Bus Routes – Network Warrington Services (3/4)

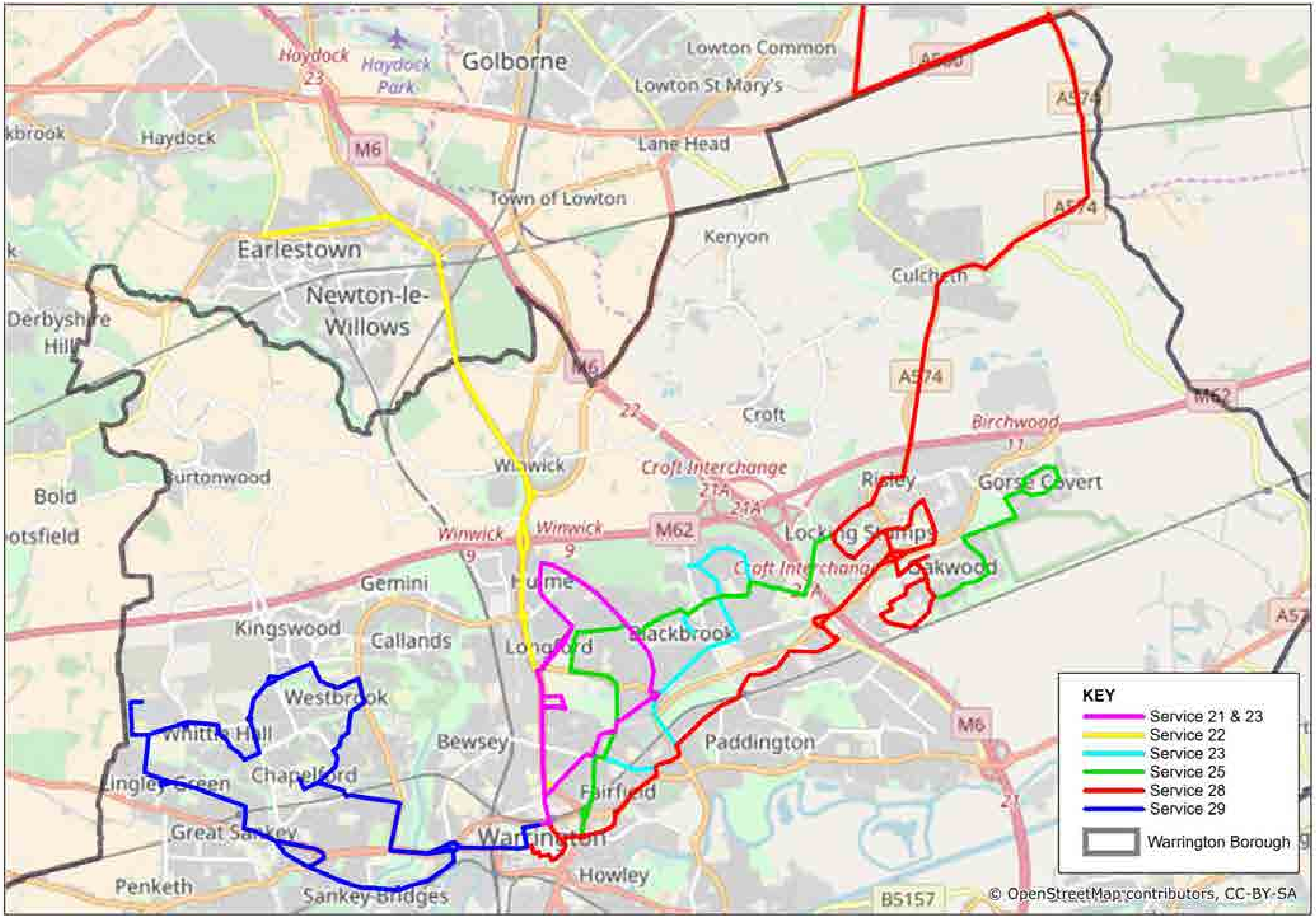
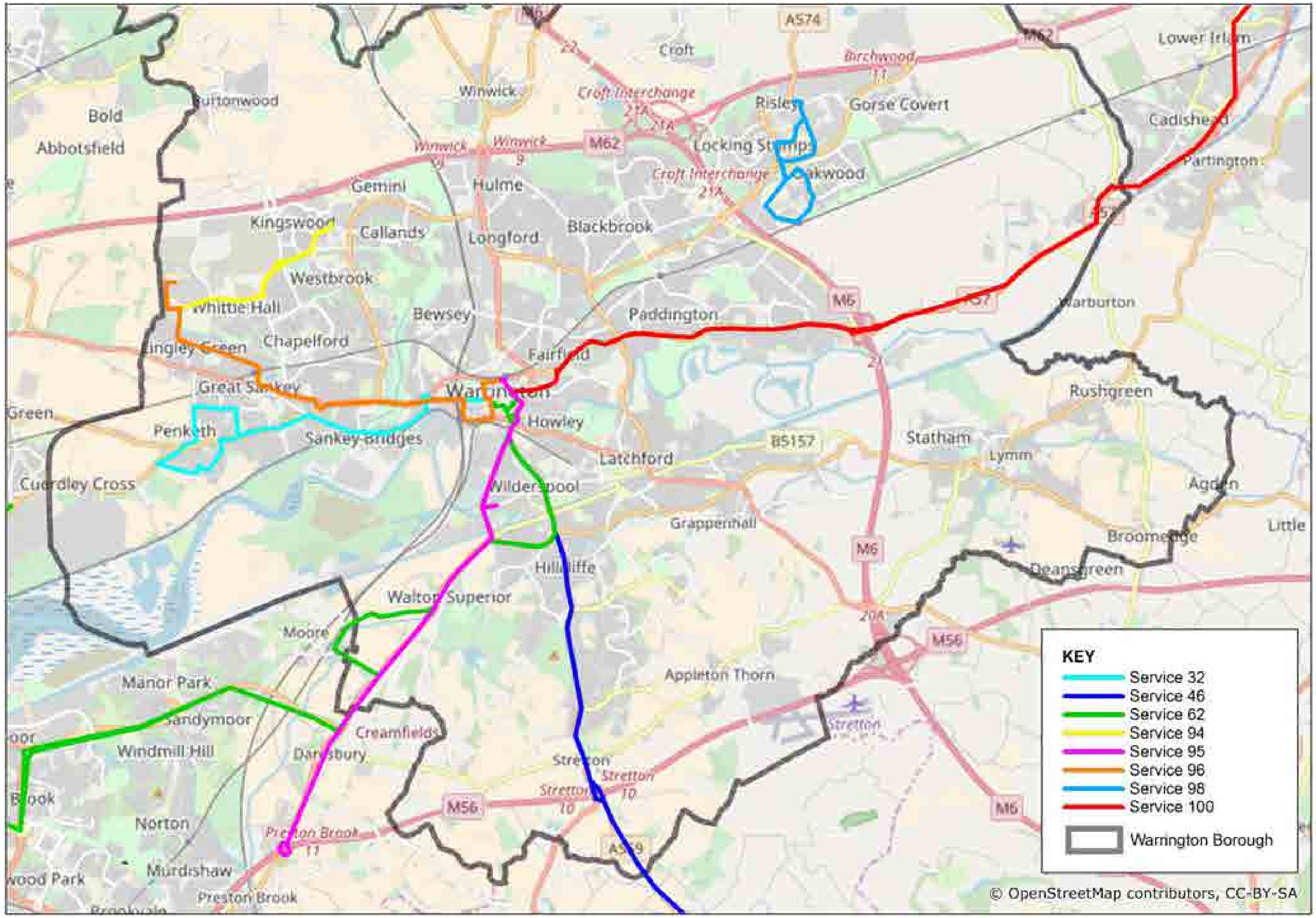


Figure 61 AM Bus Routes – Network Warrington Services (4/4)

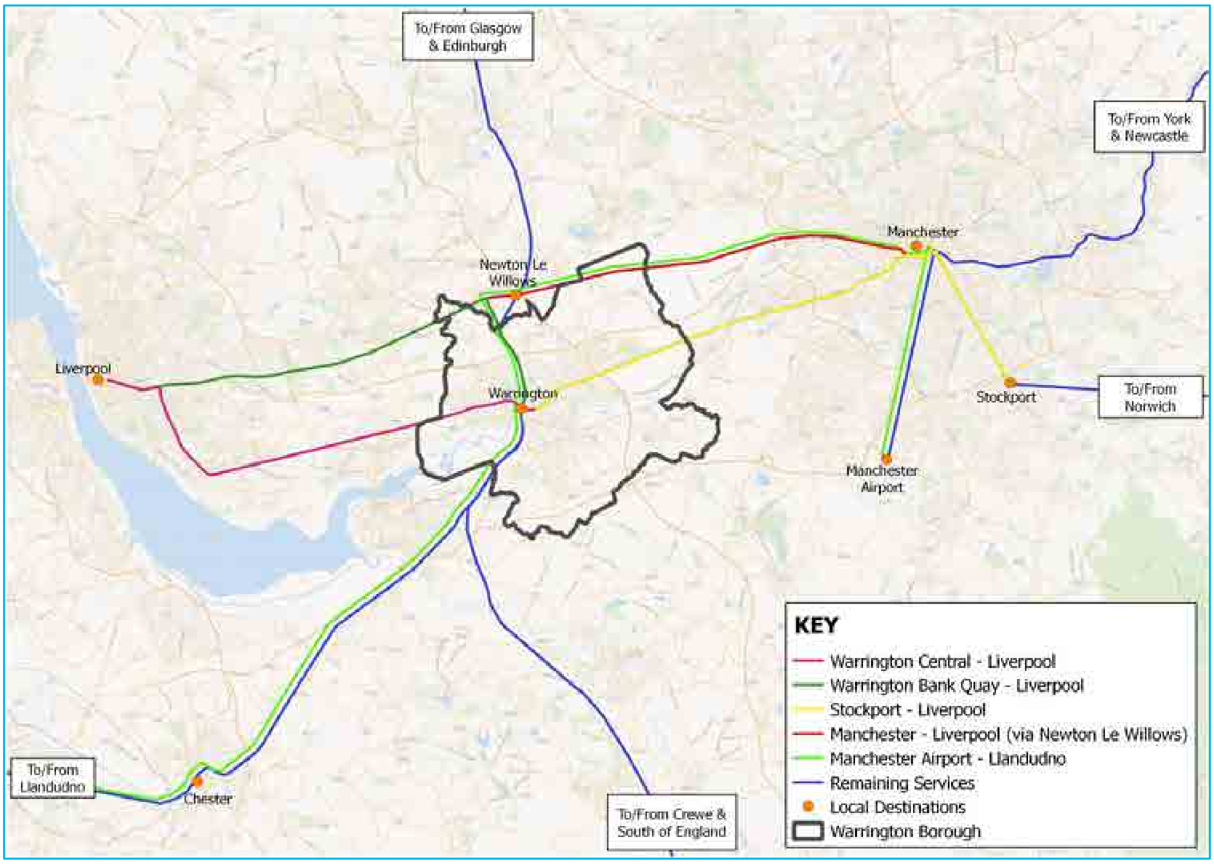


4.3.4 Rail

Rail lines were generated between stations within the simulation area using a database, with station locations being visually sense checked using aerial mapping. Representative lines were generated for grouped stations within external areas.

Figure 62 shows the inclusion of rail routes, both within and external to the simulation area (with aggregation of stations beyond the simulation area).

Figure 62 Rail Routes in Model, All Peaks



4.3.5 Summary of Data used for Calibration & Validation

A comprehensive data collection exercise has been undertaken for the development of the base year highway and PT models:

- 459 highway count sites, of which 389 went forward into calibration (85%) and 134 were specially commissioned for this project (29%);
- Trafficmaster data coverage for the whole borough to facilitate the analysis of 38 journey time routes;
- 10 parking surveys;
- 8 specialised goods vehicle surveys and 19 freight operator interviews;
- Bus ticket data for Network Warrington services alongside 22 bus passenger surveys and rail access interviews at each station in the borough; and
- Traffic signal data for 80 signalised junctions in the borough.

Each of these datasets has been checked and any anomalies found were removed where necessary or corrected as appropriate.

5. Model Development – Networks

5.1 Zone Structure

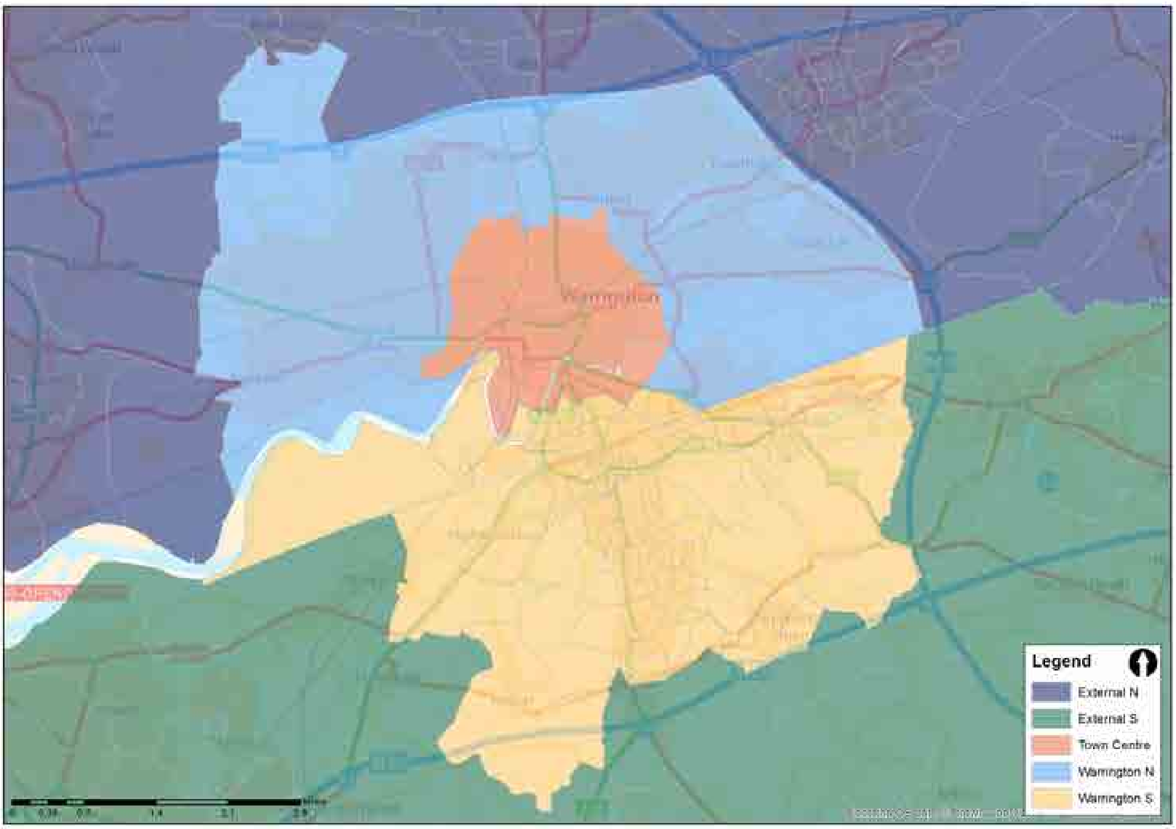
A hierarchical zone numbering system has been used in order to make it easier to present results from the model and analyse outputs. 5 sectors have been identified. The number of zones in each of these sectors in the model is set out in Table 35.

Table 35 Number of Model Zones by Sector

Sector	Sector Name	Number of Zones
1	Town Centre	82
2	Warrington North	205
3	Warrington South	111
4	External North	131
5	External South	57
TOTAL		586

Figure 63 shows the spatial groupings of the model zones into sectors that have been used in analysis of the matrices.

Figure 63 Zone Sector System used in Analysis



5.2 Network Coding

The model has been coded according to the specification and methodology set out in the WMMTM16 Coding Manual. Please refer to the AECOM report *“Warrington MMTM Coding Manual, 20 September 2015 v1”* for full details (see Appendix E).

The WMMTM16 coding manual has been developed based on the coding manual prepared for the Highways England RTMs. The methods discussed have been derived from a variety of different sources, and following guidance and best practice principles.

As the values defined within the coding manual are generated at the outset of the model development process they should be considered as appropriate starting values. It is anticipated that during model calibration the values will be modified to better fit local circumstances.

The coding manual provides detail and guidance on the following:

- The coding principles to be adopted by the WMMTM;
- Details of the SATURN Network Assignment Parameters to be used;
- Specific details of SATURN simulation network coding such as; saturation flows, GAP parameters, the treatment of Flare lanes and the representation of “exploded” roundabouts, definition of speed flow relationships;
- The approach to modelling motorway merging;
- Details of the zone coding procedures including the identification of centroid locations and options for connecting the zones into the simulation and external networks;
- The methodology for coding of bus routes; and
- The process of using the Trafficmaster data for the WMMTM16 development.

Figure 64 shows the extent of the model simulation area.

A thorough checking process was undertaken to ensure that the network coding was undertaken to an acceptable standard.

Google Maps aerial photographs have been compared to the coding in the SATURN network to code the number of lanes. Lane markings have been used to determine the turning movement allowed in each lane. The SATURN coding has also been checked to ascertain whether all banned turns are properly represented and correct priority markers have been used. Saturation flows per lane for each turning movement have been calculated to a consistent standard in accord with the coding manual.

Roundabouts have been checked to make sure that they have been coded correctly. Common errors when coding a roundabout in SATURN include coding each turn with a different saturation flow. SATURN requires that roundabouts should be coded with a link saturation flow and this should be applied to all turns. Time to circulate the roundabout and the saturation flow around the roundabout has also been checked against observed Trafficmaster travel times for reasonableness.

A summary of the checks and errors found during internal checks is presented in Table 36.

Figure 64 Extent of Model Simulation Area

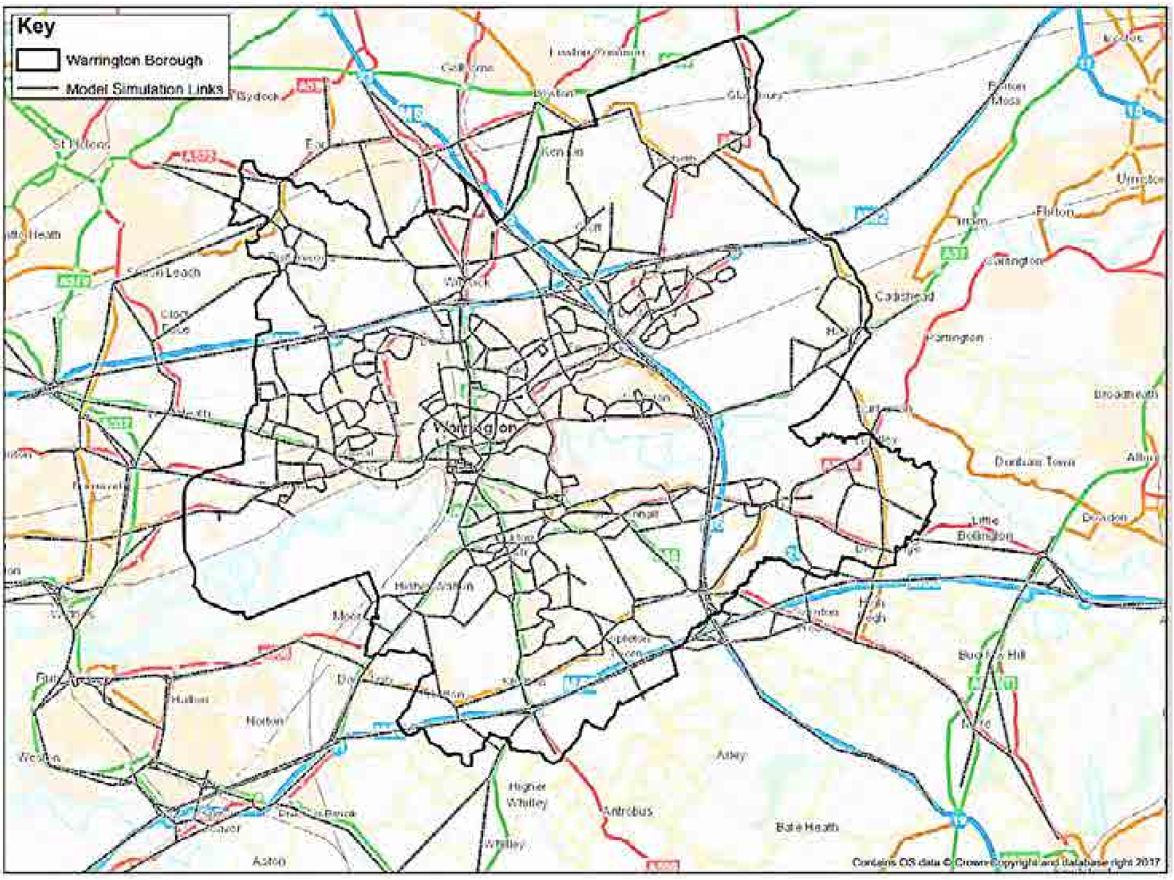


Table 36 Internal Network Checks Summary

Description	Total	Comment
Simulated Nodes	2,484	Including straight ahead, intermediate nodes and bus stop nodes
No. of Junctions	2,447	
Simulated Junctions Checked	358	Primarily junctions
Percentage of Junctions Checked	14%	

Description of Node Error	Number of Errors	Comment
Saturation Flow	64	All errors from .LPN file checked
Turning Filter (Pocket)	5	Errors regarding location of filter (nearside/offside)
Priority Markers	12	All errors from .LPN file checked
Link Length	52	All errors from .LPN file checked and fixed
Banned Turns	8	Primarily errors in turns not clearly visible from satellite turns
High level of delays	-	Dummy matrix test has shown no excessive delays
One way/No entries	3	One way links/bus only links coded correctly
Semi-fatal errors	218	Total number of semi-fatal errors when merging RTM with simulation network. Errors were mainly associated with missing zone structure-external links. The introduction of a zone structure reduced this significantly to less than 60 which were also fixed (.LPN file)
Serious warning	2,150	Serious warnings in the simulation area were checked, assessed and fixed when appropriate (.LPN file)
Network connectivity	-	Dummy matrix test showed no issues with network connectivity between the zones
Buffer Network	-	Since the buffer and motorway box network was imported from the RTM that has been checked and validated, no further in depth checking was carried

5.2.1 Zone Centroids

Centroid connectors have been coded so that zone connectivity is represented in the model. Whilst most zones have a single connector, where necessary, multiple centroid connectors have been assigned to a single zone. The specific issues relating to the definition of centroid connectors are given in TAG Unit M3-1, Section 2.4. These were taken into account when defining the centroid connectors to take into account local access and egress from zones.

The placing of centroid connectors has been carefully designed in order to ensure the loading of traffic onto the network is realistic. This has been achieved through the use of both spigots and spanning connectors for the FMA. According to the SATURN User Manual, Chapter 15:

- **Spigot:** Refers to a zone which is connected to an external simulation node which itself is connected to a node in the middle of an internal simulation link; and

- **Spanning:** Centroid connectors are connected to links, specifically the A and B node used to define the link

Furthermore, loading has been focused on the road hierarchy where appropriate; to ensure that lower order feeder roads are typically used as loading points. The number of centroids per zone has been minimised to limit excessive reassignment effects through model calibration and forecasting. Around 90% of the zones use a single connector with 9% using two connectors. Only 1% of the zones require 3 connectors which is the maximum number found in the model.

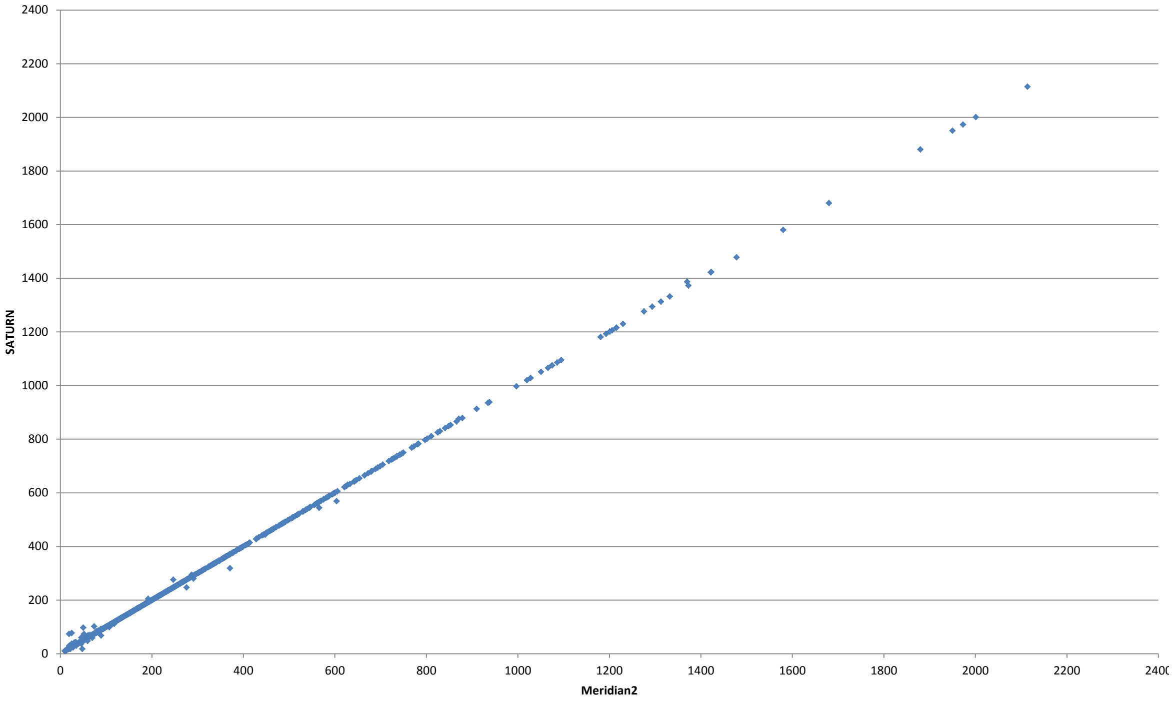
Please refer to the AECOM report *“Warrington MMTM Coding Manual, 20 September 2015 v1”* for more details (see Appendix E).

5.2.2 Link Data

The link data have also been verified by checking the location of each node using GIS and the coded distance and speed/flow curve assignment to the links. These checks were primarily carried out on the urban network and the motorway box. Figure 65 shows a scatter plot comparison of SATURN and Meridian2 distances in metres. Only 5% of the distances do not match exactly. Outliers have been investigated and corrected where appropriate.

It is important here to recognise the difference between free-flow speed and the mean cruise speed. Within an urban area, many links suffer from delays that are independent of the flow along them. These delays are caused by incidents along the link, e.g. buses stopped at bus stop, pedestrian crossings, and vehicles manoeuvring into and out of parking spaces. In these cases it is appropriate to set the SATURN free-flow speed to be equal to the mean “cruise” speed. This is the typical speed at which traffic will travel along the link ignoring any delays caused by the junction at the end of the link. The use of mean cruise speed allows the speed to be set independent of flow.

Figure 65 Meridian2 and SATURN Link Distances (m) Comparison



Trafficmaster data and built-up area data were utilised to create a link classification for the simulation area. It was decided that the 20 and 30mph zones would be coded in the model as they were. For the rest of the simulation area a combination of rural, suburban and town centre links along with small town, single and dual carriageway classification was used. Figure 66 displays the link classification applied to the simulation network within Warrington.

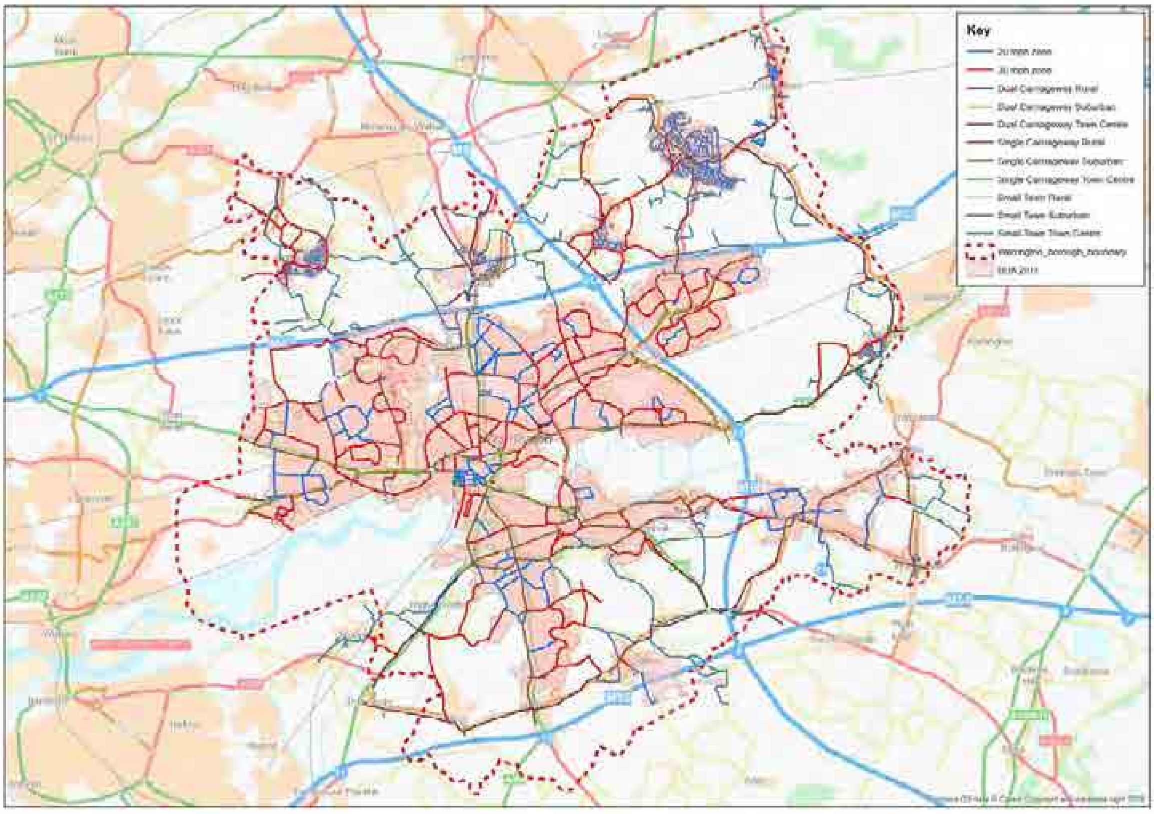
In order to calculate the cruise speed for each link type the weighted average was used (Table 37). Outliers were examined and links adjacent to junctions were removed from the calculations.

Table 37 Cruise Speeds Applied in the Model by Link Type

Link Type	Cruise Speed Applied (km/hr)
Dual Carriageway – Rural	60
Dual Carriageway – Suburban	55
Dual Carriageway – Town Centre	35*
Single Carriageway – Rural	60
Single Carriageway – Suburban	50
Single Carriageway – Town Centre	45
Small Town – Rural	45
Small Town – Suburban	40
Small Town – Town Centre	20

* low sample size affected weighted average

Figure 66 Link Classification



5.3 Public Transport Network

5.3.1 Zones

For consistency, the public transport model uses the same zone system as the highway model.

5.3.2 Network Structure

The network structure for the bus element of the public transport model is the same as the highway model for highway links within the simulation area. This final version of the joint network followed a review of the draft highway network with respect to distance of nearest model nodes to actual bus stop locations. A standard 50m threshold was applied within the simulation area and a visual sense check conducted. This identified a number of locations where additional nodes were required and in turn, added to the model network.

Figure 67 Bus Stop Network Development – additional node requirement identification

The PT model also contains some additional links:

- Walking links where there are considered to be sufficiently high pedestrian flows walking along non-highway paths, such as through the pedestrianised town centre;
- Rail links showing the approximate rail line routes within the simulation area and representative combined routes to the external area; and
- Representative car specific centroid connectors to rail stations to cater for people who drive to stations and then use the train.

Figure 68 PT Network Link Types (Full Extent)

Figure 69 PT Network Link Types (Medium Zoom)

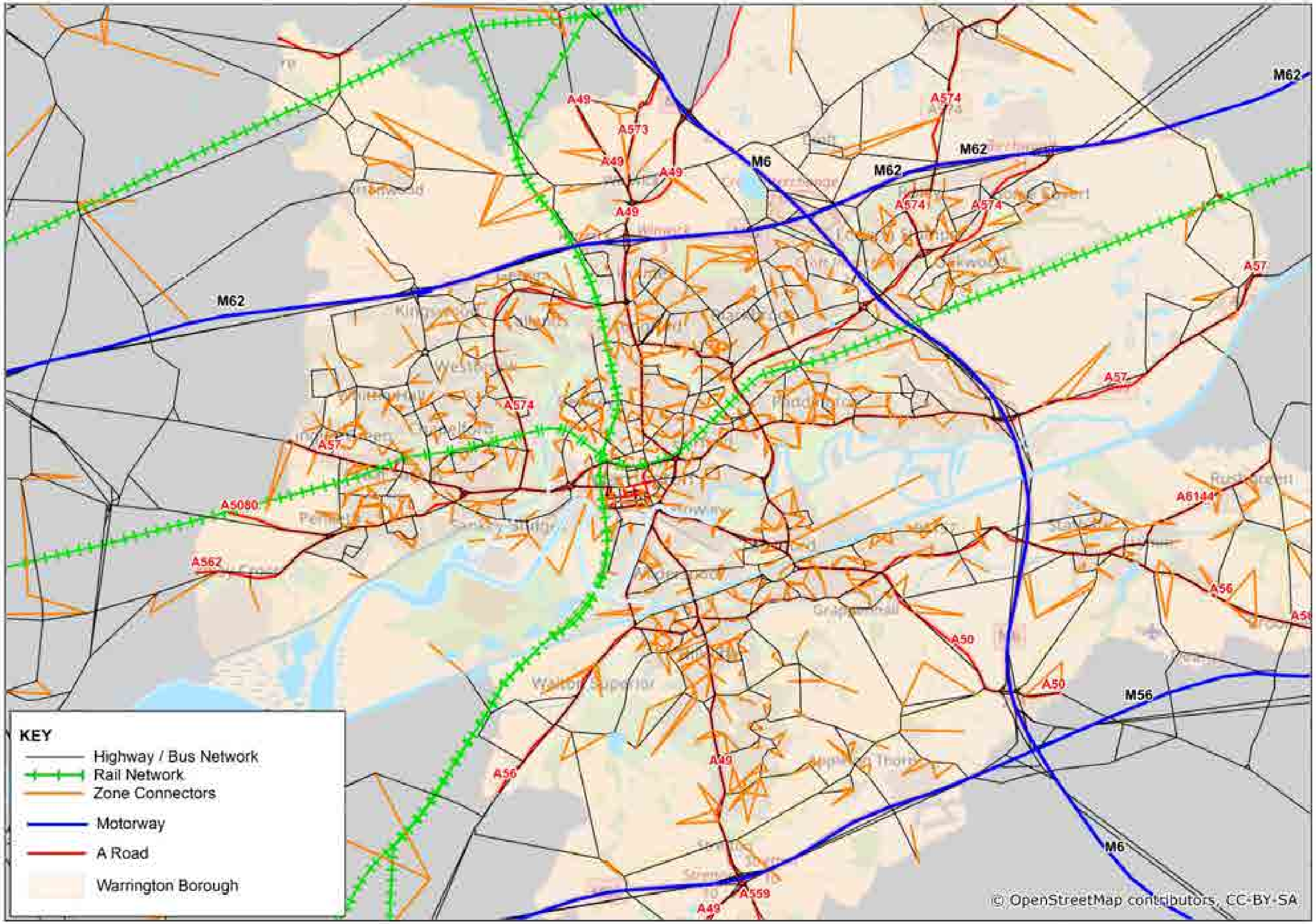
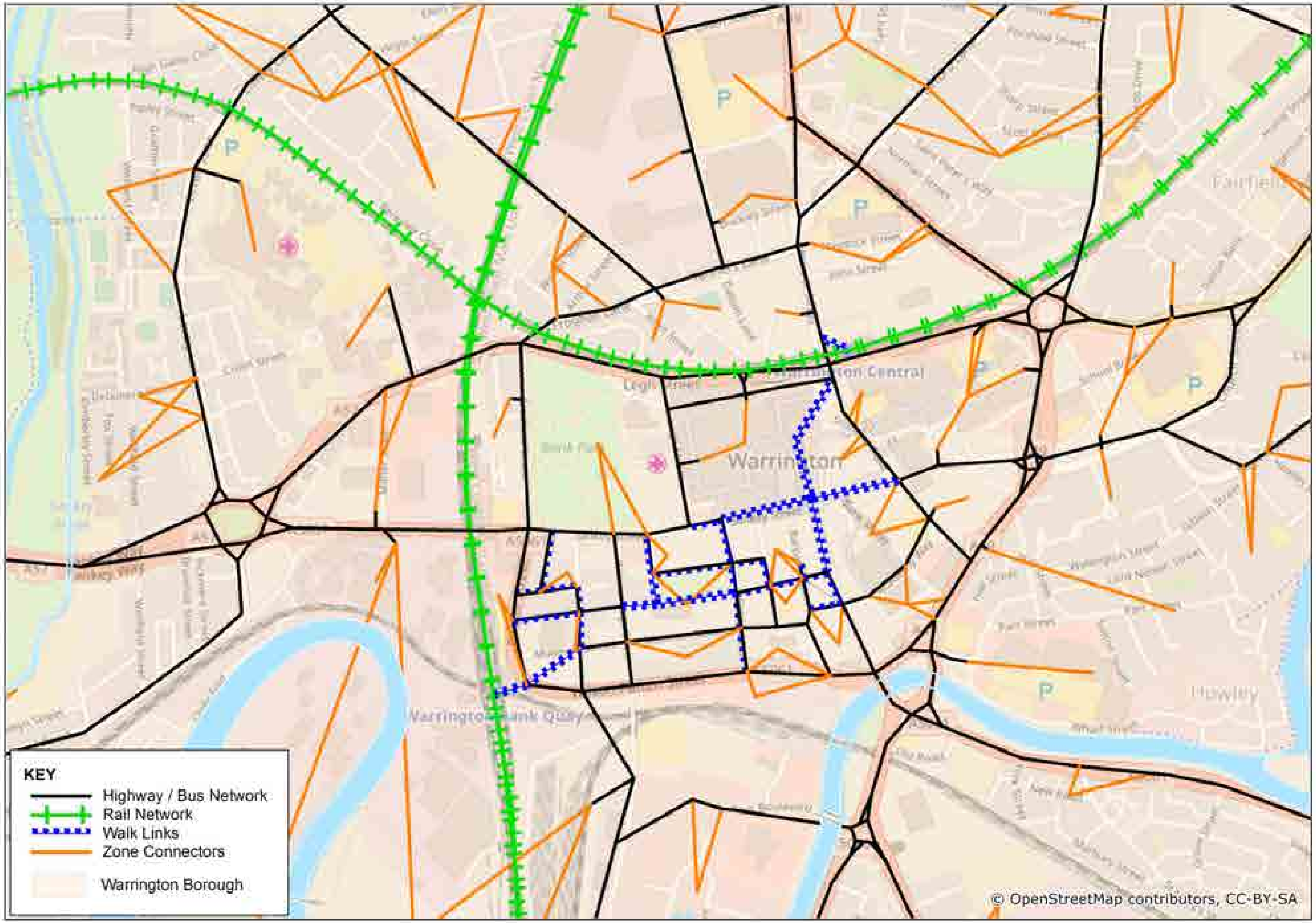


Figure 70 PT Network Link Types (Warrington Town Centre)



5.3.3 Walk

Public transport users access bus or rail services directly from / to centroids or walk along highway or ‘walk only’ pedestrianised links. A review of pedestrianised areas within the simulation area was conducted using aerial mapping to determine which links were considered appropriate to include.

5.3.4 Fares (average yield)

As recommended by WebTAG, a mode specific boarding penalty was generated to be applied to the PT model assignment.

The penalties were derived from analysing the respective fares. Bus and rail fares comprise of a combination of different fare types for different operators, but for the purpose of the model there is required a simplified average yield (fare) per kilometre for each mode, therefore a representative yield per kilometre is generated based upon observed data.

For the assignment purposes the fare-distance rates were converted to generalised cost minutes using an average value of time derived from government data at;

https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours

5.3.4.1 Bus

Bus fare data has been sourced primarily from Network Warrington ETM data. This data is disaggregated by stages and enables an average distance related fare to be approximated and used in the model; this includes taking into account the proportion of users who have concessionary tickets.

Arriva ETM data has been used for comparison of the composition of ticket types, which showed a close correlation with the Network Warrington data.

Figure 71 shows the line of best fit based on identified fare costs for standard single tickets between known origin and destinations, sourced from the bus operator website. From this, a fixed constant (boarding cost per journey) and variable parameter (cost per kilometre) were estimated based on the regression analysis.

Figure 71 Bus Fare to Distance Regression Analysis

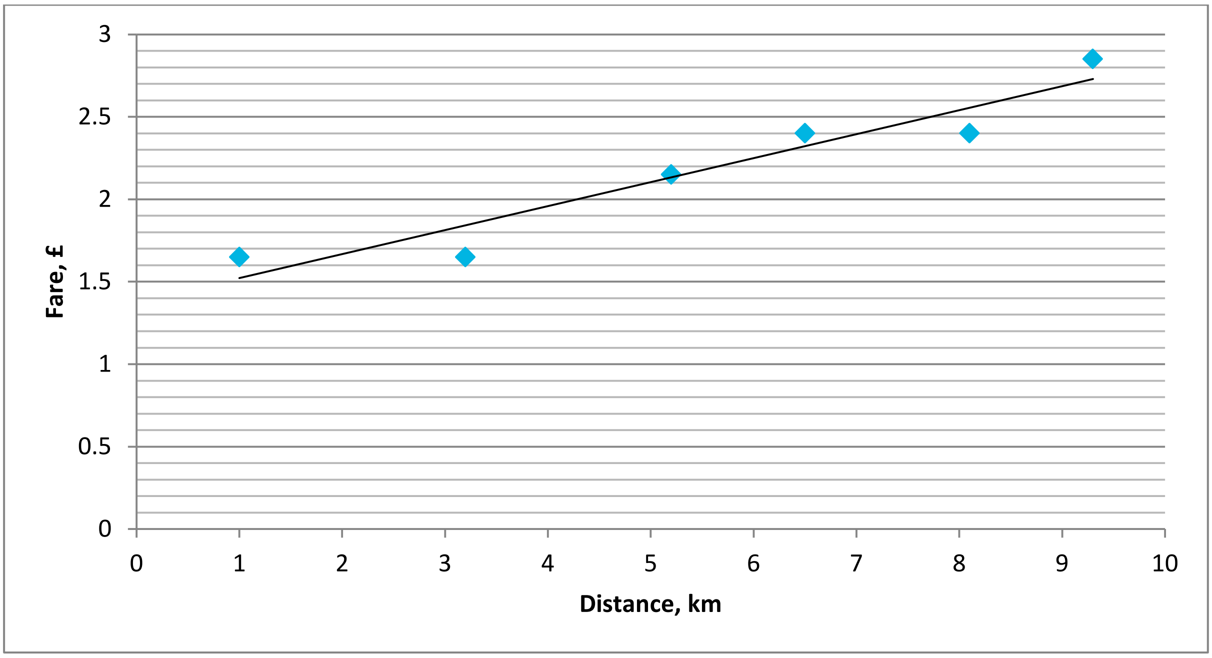


Table 38 presents a breakdown of the proportions of different types of tickets purchased by bus users, based upon the commissioned passenger survey data for the study. The relative price for the different types, weighted by their respective proportions, produces an adjustment factor to generate an overall cost, taking into account that some people benefit from concessions. Bus trips incur a boarding penalty of 6.60. The distance multiplier equated to 0.60 for bus users.

Table 38 Bus Ticket Type Analysis

Ticket Description	Network Warrington	Arriva
Standard Ticket (bought on bus)	37%	27%
Touch card	15%	25%
Proportion non-pass	**52%**	**52%**
Disabled pass	6%	7%
Other pass	2%	0%
Pensioner pass	32%	36%
Proportion pass	**40%**	**44%**
Child / student	8%	4%
Proportion Student	**8%**	**4%**

5.3.4.2 Rail

Average distance to fare (single) values were generated for a range of long and short distance rail trips to generate a relationship based upon regression analysis as shown in Figure 72, sourced from the national rail website. Peak specific fares were not used as the survey data showed that the majority of tickets are season and returns. Of the single tickets, the majority across each time period are 'anytime today', with very few 'off-peak' specific. With this in mind as well as the unknown aspect of how much people paid for advance train specific trains, it was not considered that this aspect was significant to warrant time period specific variations in fares.

Taking these distance parameters and applying an overage VOT from the ONS data; for rail trips the fixed component (boarding penalty) was approximated at 8.79 (minutes). The distance multiplier equated to 0.49 for rail users.

Figure 72 Rail Fare to Distance Regression Analysis

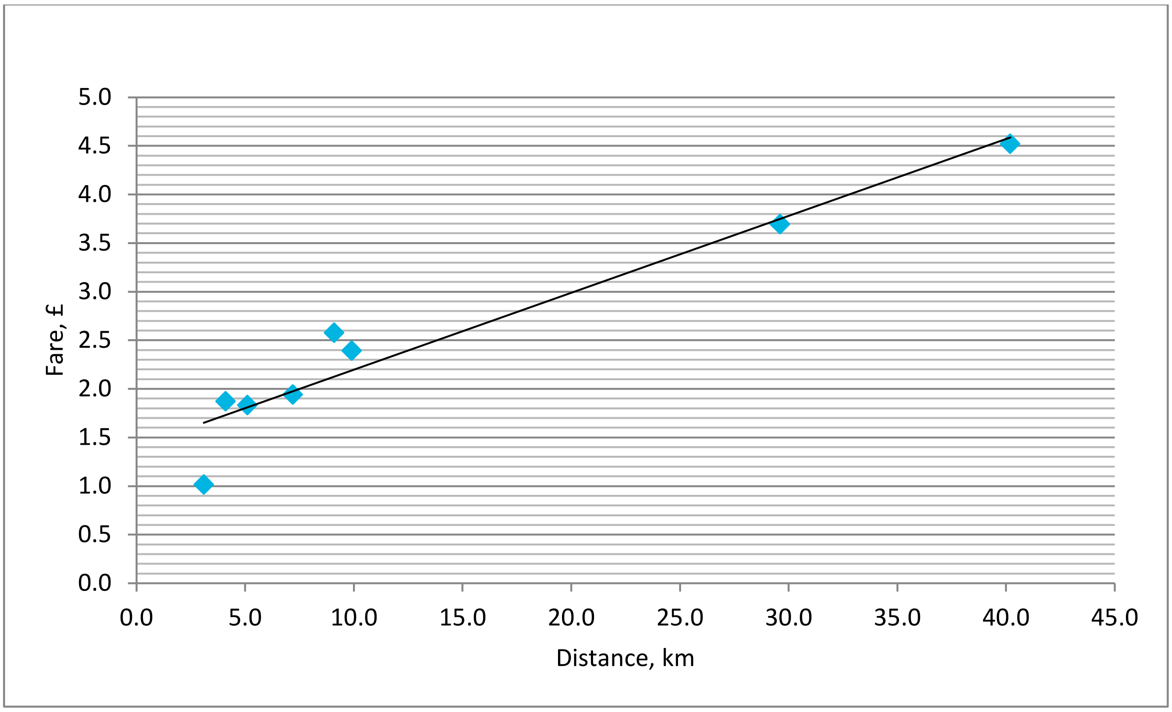


Table 39 Rail Ticket Type Proportions

Duration	Duration %	Concessionary (Yes/No)	Yes/No %
Single	18.7%	Yes	13.7%
Return	70.7%	No	86.3%
Season	10.6%		

5.4 PT Network Checks

5.4.1 Refinement & Improvement

5.4.1.1 Bus

Bus services were checked by manually reviewing the model lines and time period specific headways against timetables and maps pertaining to services as at June 2016. Any inconsistencies arising from the assumptions within the automated process were subsequently corrected.

Bus stops were assigned to the nearest available stop which, as identified in 5.3.2, used a 50m threshold in the simulation area, with some stops being grouped together. Outside of the simulation area disaggregation was increased in line with the network detail.

A cross check of the services against ticket data (where ticket data available) to confirm all services were accounted for and coded.

The coding of each service and route were checked against June 2016 timetables published by Network Warrington to ensure accuracy in the model.

Finally, an independent review by WSP of the services was conducted and any identified changes made.

5.4.1.2 Rail

Being relatively minor in terms of numbers of links, the rail network required only visual sense checks by an independent analyst.

Service characteristics were reviewed through the input spreadsheet / service lines files again independently, checking frequency / headway calculations and travel times between stops against published timetables.

5.4.2 Verification

5.4.2.1 Bus

Sense checks carried out confirming that identified services were observed at cordon counts where they were expected to be present.

5.4.3 Quality Assurance

Network reviews were conducted by an independent external consultancy and any amendments identified and agreed to be required, carried out prior to ‘sign off’.

6. Model Development – Prior Highway Matrices

6.1 Context

This section sets out how the prior trip matrices were developed for the WMMTM16 model. The section covers three main processes:

- The analysis and assessment of the mobile phone data set;
- The creation of a set of synthetic matrices using gravity modelling; and
- The use of the mobile phone data and synthetic matrices to create the prior highway matrices and comparisons against other observed datasets.

6.1.1 Data Sources

To develop the initial highway matrices, the following data sources have been used:

- Mobile phone data, provided by Telefonica;
- RSI data;
- ATC and MCC traffic counts;
- Census data;
- Valuation Office data;
- NTEM data;
- NTS (National Travel Survey[6]) data;
- Local planning data and trip rates; and
- Trafficmaster data.

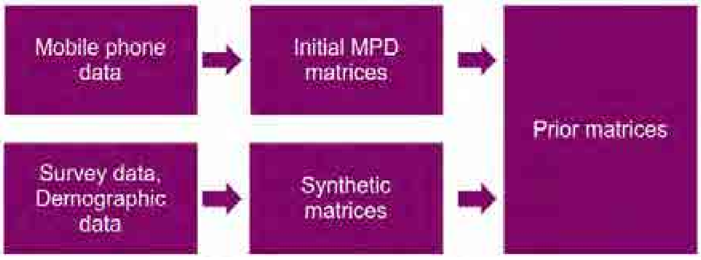
The primary data source for matrix building is the mobile phone data but as this is a new source of data where the strengths and weaknesses are still being realised and understood, a number of RSI surveys were added to the data collection programme to assess whether the mobile phone data was consistent with other forms of data and provide confidence in the output. Please refer to the AECOM report *"Warrington Transport Model: Data Collection Report (MDCR), January 2017"* for more information relating to the methodology, collection and initial analysis of each of these datasets.

The remaining sections in this chapter detail how each of these datasets have been used in the development of the WMMTM16 matrices.

6.2 Mobile Phone Data

Mobile phone data (MPD) has been used as the primary component for the basis of prior highway trip matrices. Figure 73 summarises the prior matrix development process.

Figure 73 Process of Developing Prior Matrices



---

[6] The National Travel Survey (NTS) data that has been used was received from UK Data Services. We obtained individual survey records from 2007-2015 which covered household records, individual person and trip records. Data was received for Cheshire, Greater Manchester and Merseyside. The data was used to generate trip length distributions, trip rates and trip purpose splits. All references to NTS data in this report refer to this raw dataset and not the standard tables produced as part of the Annual Report.

Telefonica were commissioned by AECOM to prepare origin-destination matrices for travel in the Warrington area. A cordon area was defined and trips were included if they penetrated this cordon, as shown in Figure 74. The key benefit to using MPD is that it provides a larger dataset in terms of geographic coverage and timeframe than an automatic number plate recognition (ANPR) based approach or RSIs in isolation.

Figure 74 Extent of Model Cordon

The trips were allocated to a start and end zone based on a Lower Super Output Area (LSOA)-level zoning system with the returned data from Telefonica then being aggregated to match the model zoning system as described in Section 2.3.6. A total of 714 zones were provided to Telefonica.

6.2.1 Specification

Telefonica provided the mobile phone data according to the following specification:

- Trips were sampled using neutral days (Monday to Friday, excluding bank holidays and school holidays) in April, May and June 2016 – 43 days in total (out of a possible 91).
- Trips were segmented as follows:
  - By mode – road, rail, and HGV, with walk/cycle trips removed;
  - By purpose:
    - Home based work – from home
    - Home based work – to home
    - Home based other – from home
    - Homebased other – to home
    - Non home based

- By time period[7]:
    - Early off-peak (00:00-07:00)
    - AM peak period (07:00-10:00)
    - AM peak hour (08:00-09:00)
    - Interpeak (10:00-16:00)
    - PM peak period (16:00-19:00)
    - PM peak hour (17:00-18:00)
    - Late off-peak (19:00-00:00)

Trips starting outside the cordon were segmented based on the time they entered the model cordon. Trips starting inside the model cordon were segmented according to their start time.

For more details on the methodology of how the mobile phone data was collected by Telefonica, and subsequent verification undertaken by Telefonica, please refer to refer to the Telefonica report "*AECOM Warrington Report v0.1*" in Appendix G.

6.2.2 Mobile Phone Data Limitations and Bias

Origin-destination matrices estimated from mobile phone data have certain strengths compared to conventional data sources, which are of particular relevance to the model. The mobile data provides a wider geographical coverage, a higher sample size and captures day to day variability of trips giving potential time and cost savings for data collection and processing.

However this is a relatively new source of data which are not collected exclusively for transport planning. There are key weaknesses, uncertainties and biases associated with origin-destination matrices derived from mobile phone data which the initial review and verification completed by Telefonica highlighted:

- Park and ride rail trips are represented in the mobile data as rail trips from the initial origin to the final destination.
- Comparisons with trip length distributions from NTS indicate that trips below two miles are likely to be under-represented in the mobile phone data. However, this will depend on the cell resolution – in urban areas (e.g. Central Manchester) short distance trips are more likely to be represented, while in rural areas the threshold may be slightly higher.
- Comparisons with NTS on trip start times indicate that education trips are likely to be under-represented in the mobile phone data. This will partly be a natural consequence of the short-trip bias (since many education trips are short), but may also be due to some education trips being made by people who do not carry phones. Where education trips are included in the mobile phone data, they are likely to be counted as home-based-work trips as it is very difficult to differentiate between work and education trips due to similar numbers of 'long' hours being spent in a single location (work trips are classified as where the mobile phone is located for daytime hours in a minimum of 18 of 20 weekdays in a month).

Additionally, from our experience in using mobile phone data for the Highway's England Regional Models development the following factors needed careful consideration:

- **Definition of a 'trip'**: To translate the mobile phone data records into matrix trips, Telefonica have defined a number of rules. A 'trip' was defined as beginning when a phone is detected moving from one cell to another and ending when the phone remained within a single cell for at least half an hour. Clearly these rules limit the types of trips that can be identified, limiting the recognition of short distance and short stop-over trips and can also register false trip-ends if a phone fails to move between cells for 30 minutes on its journey.
- **Spatial resolution and data accuracy**: The translation of cell records into zones depends on a perfect linkage between cell locations and MSOAs. It is known that phones can sometimes link to

---

[7] The time periods requested are different to the modelled time periods as Telefonica could not provide a breakdown lower than hourly totals.

different cells from the same location at times and there is an imperfect match between cells and MSOAs, particularly in urban areas in cases where cell masts are close to MSOA boundaries.

- **Identification of short trips**: The identification of trips depends on identifying movement of phones between mobile cells. Trips made entirely within a cell would thus not be identified. In addition short trips of a short duration which do not stay at the destination zone for a sufficiently long time would not be identified as a trip, it is possible in this way that several short trips are chained into a single longer trip.
- **Identification of mode, vehicle type and vehicle occupancy**: Telefonica developed algorithms to identify rail trips and remove these from the dataset; other public transport and freight trips cannot be identified. Trip matrices represent person trips rather than vehicle trips and the technology is unable to produce occupancy rates for trips.
- **Identification of trip purpose**: Trip purposes are defined in the dataset in terms of home/non-home and work/non-work based trips. The home zone is defined within the process as the location where the phone appears to be overnight on most days and the work zone as the location where the phone appears to remain through most of the working day on most weekdays. Clearly whilst this is realistic for a large majority of trips it will fail to correctly place shift workers and education trips would be identified as work trips.
- **Expansion of mobile data sample**: The mobile sample was expanded by Telefonica to total population at an MSOA level on the basis of Telefonica's estimates of their market share in the MSOA. Issues to be considered were how representative of the total population were the trip records captured and the accuracy of Telefonica estimates of market share, which may vary significantly across a city or county, at a local level.

Together these limitations informed the development of the verification tests designed to assess the robustness of the data supplied. The key problems anticipated with the data were that it might potentially:

- Fail to accurately represent short trips due to zonal allocation and identification of the end of a trip;
- Misallocate trips between neighbouring zones due to zonal allocation;
- Misrepresent trip purposes due to the definition of trip end purposes; and/or
- Misrepresent actual trip numbers due to methodology of sample expansion and market share.

6.2.3 Mobile Phone Data Verification

Section 3.3 presented the challenges faced with using mobile phone data in modelling. The collection and use of mobile phone data is a new technology and area of analysis and as such there is no existing guideline at this stage on how to use mobile phone data to produce origin-destination matrices. In fact there is little guidance in WebTAG on matrix building and the merging of different data sources in doing so.

In addition to the checks undertaken by Telefonica noted above, an approach has been developed to use existing data sources to test and seek to establish at which resolution level (both spatially and demand segments) the mobile phone data set should be used and then from there to make use of other data sets to refine and disaggregate from this point.

These tests were designed to examine:

- The accuracy of the technology to identify trip origins and destinations at a zonal level;
- The ability of the technology to identify trips as measured by observed trip rates; and
- The ability of the technology to identify ranges of trips as measured by trip length.

The results of this investigation were used to inform how the data were used and changes that had to be made to the data in developing the prior trip matrices.

The investigation covered:

- Zonal allocation;
- Trip rates;
- Trip distribution;
- Trip lengths;
- Trip purpose; and
- Daily profile.

6.2.3.1 Zonal Allocation

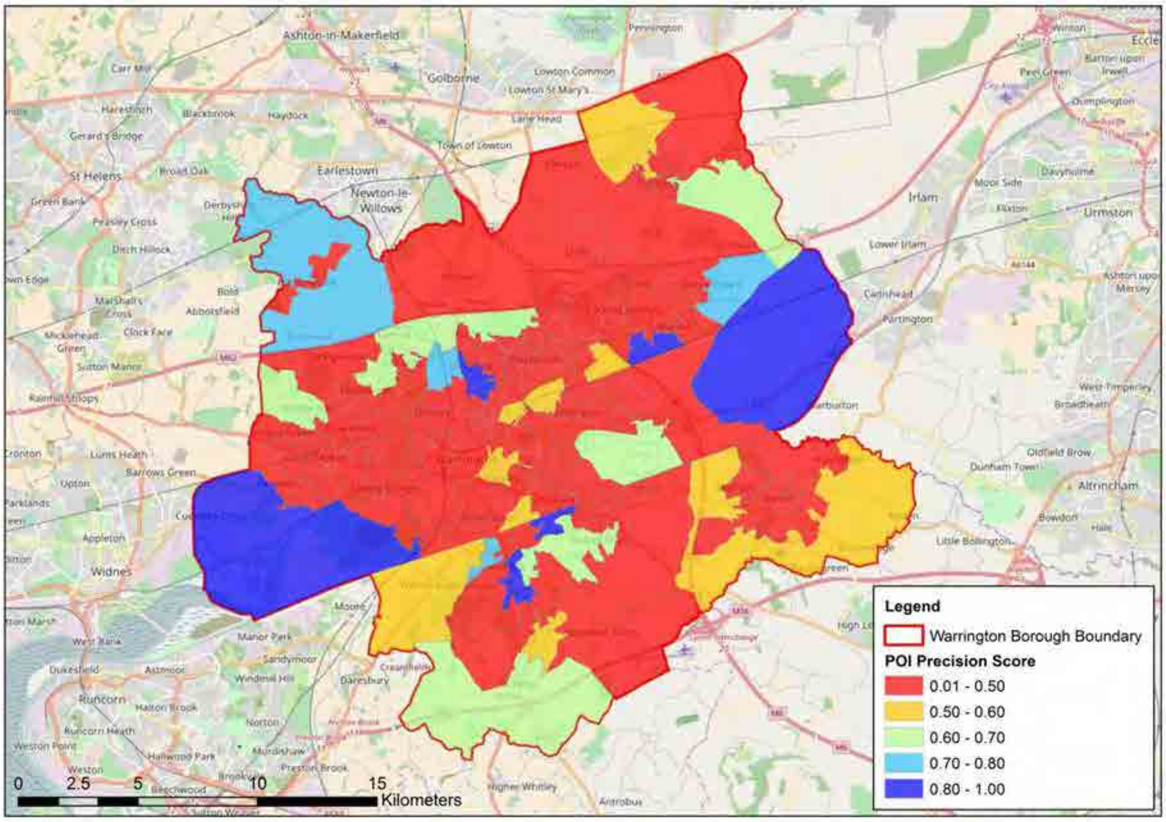
At AECOM's request Telefonica undertook analysis of the accuracy of the spatial allocation of trips within the survey data. This was carried out through an investigation of Points of Interest (POI).

Where a user has multiple dwells which overlap each other, these will be associated with a particular Point of Interest (POI). By analysing all of the dwells associated with a particular POI the position of the POI can be identified with a higher degree of accuracy, because more information will be provided. All of the events associated with a POI were analysed and the relevant cell geographies were compared to the zone system supplied by AECOM, so that each POI was associated with a zone. Every time a user visited a cell associated with one of their POIs, this was recorded as a trip to the associated zone.

Categorisation of POIs is based on the temporal patterns of a user's dwells at each POI throughout the study period. POIs where users spend a large amount of time overnight are classed as home POIs. All users must have a home POI. POIs where users spend long periods of time during the working day are defined as work POIs. All other POIs are defined as 'other' POIs.

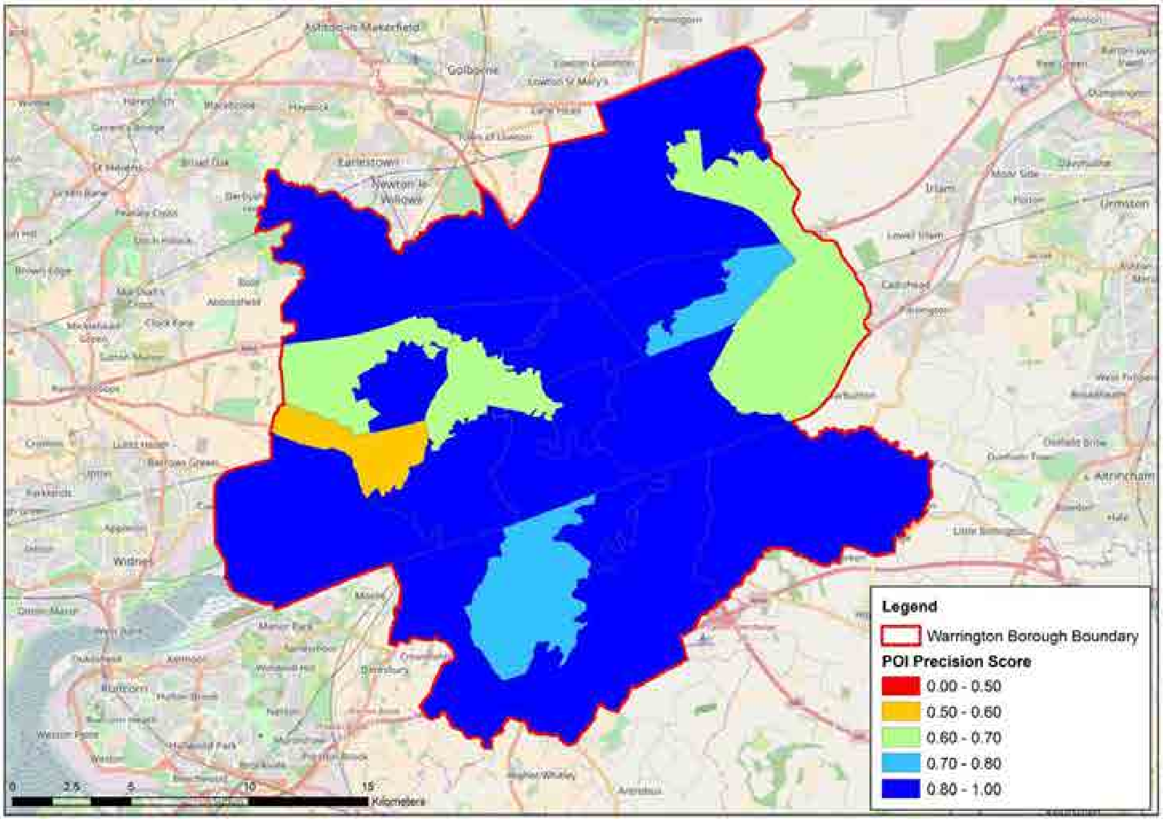
The first set of POIs scoring was analysed and processed at an LSOA level within the study area and the result is shown in a thematic map in Figure 75.

Figure 75 First POI Scoring, LSOA Level



As can be seen in Figure 75 much of the central model area had low POI scores which demonstrates low level of accuracy of allocation. Therefore further analysis was undertaken to aggregate the LSOAs with low scores to a level of MSOA or group of MSOAs level in order to increase the confidence in the mobile phone data. A thematic map of the final set of POIs scoring is shown in Figure 76.

Figure 76 Final POI Scoring, MSOA Level



The results provided guidance on the level of spatial aggregation at which the allocation of trip ends could be used with a high degree of confidence. This informed the matrix development process and defined the aggregation level at which the Telefonica data was used to produce the prior matrices.

To investigate the zone allocation consistency within the data set scatterplots were produced to examine the symmetry between the “from home” matrices and the “to-home” matrices at an MSOA level. The results showed a very high degree of correlation and fit suggesting a consistency between from home origins and to home destinations.

The regression for combined purpose trips is shown in Figure 77 and the correlation by trip purpose in Table 40.

Figure 77 Symmetry of MPD at MSOA level in the model area

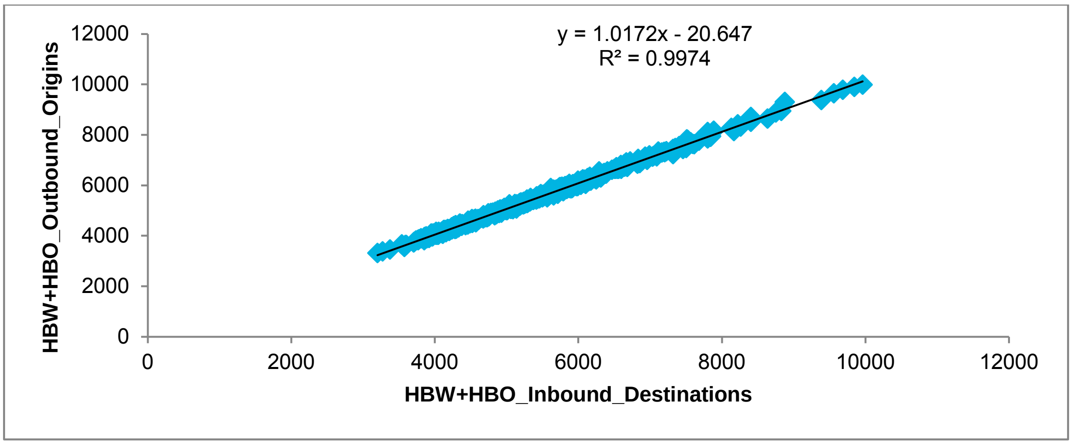


Table 40 Correlation by Trip Purpose

	Slope	R^2
Work Trips	0.96	0.99
Non-Work Trips	1.00	0.99

6.2.3.2 Trip Rates

A comparison was made between the average person trip rates from the NTS data and trip ends in the mobile data. This is shown in Table 41. The results show a close correspondence between the observed and modelled trip rates, although the rates in the mobile phone data are lower than the NTS rates. The primary difference is an overstatement of work trips and understatement in other trips in the mobile dataset. This relates primarily to the treatment of education trips discussed in section 6.2.3.5 below.

Table 41 All day from-home trip rates vs. NTS

	HBW	HBO	All HB	NHB
Mobile Phone	0.68	0.78	1.46	0.38
NTS	0.36	1.19	1.55	0.35

6.2.3.3 Trip Distribution

A comparison was undertaken of work trips between Warrington and neighbouring local authority areas with journey to work data from the 2011 Census. The results are shown in Figure 78 and Figure 79. The result shows that the mobile data broadly match the observed data.

Figure 78 HBW From-Home vs. census JTW (all day district level)

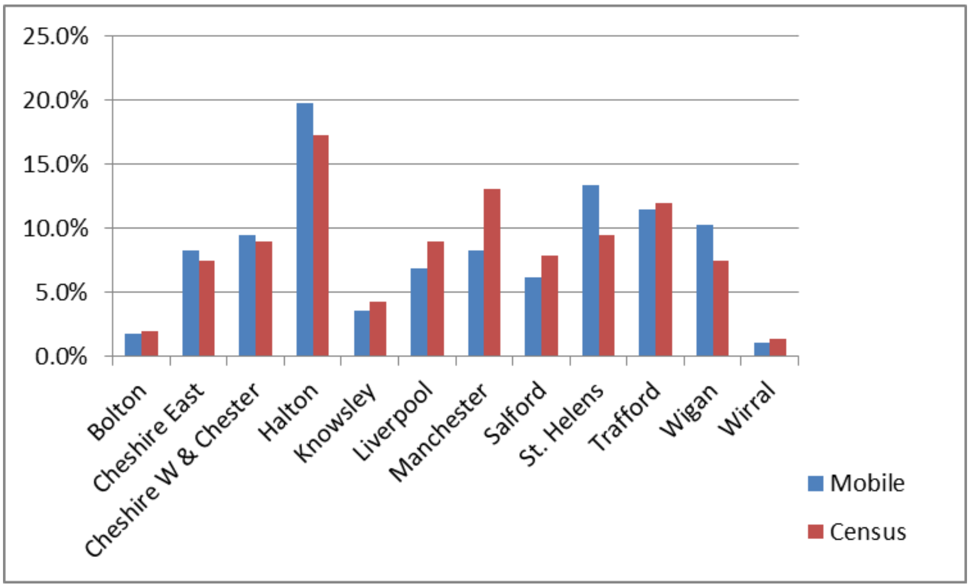
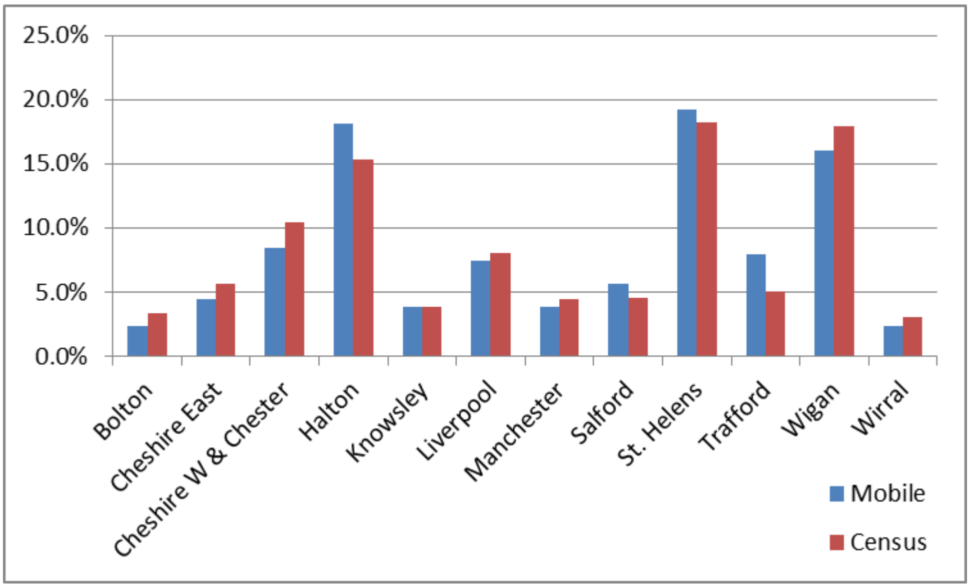


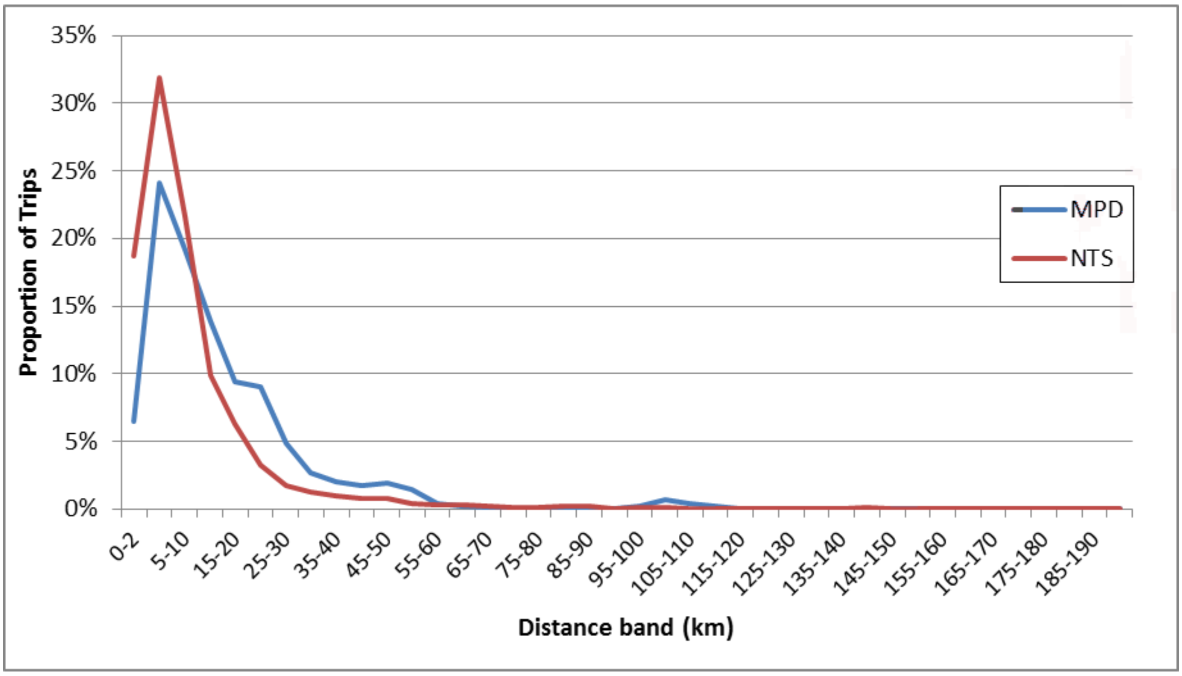
Figure 79 HBW To-Home vs. census JTW (all day district level)



6.2.3.4 Trip Length Profile

Figure 80 shows a typical comparison between the trip length profile derived from the NTS data with that derived from the mobile phone data. A consistent finding for all purposes was that the shortest distance trips were under represented within the mobile data set. This is consistent with the findings of other studies of mobile phone data. It was concluded that it would be necessary to infill the prior matrices to represent the missing short distance trips.

Figure 80 Comparison of Trip Length Profiles between Mobile Phone Data and NTS data for Home-Based Trips (12-hour)



Trip Purpose

A comparison was undertaken of the trip purpose split between the provisional data set and independent data from NTS and is set out in Table 42. The results suggest an over-representation of commute trips and an under-representation of non-home based trips. This is similar to findings elsewhere and may be explained by home based education trips being categorised as work trips rather than other purpose trips. The correction made for this misallocation is discussed in section 6.5.9.

Table 42 Comparison of Trip Purpose Splits – 24 Hour

Trip Purpose	NTS	NTEM	Mobile Phone Data
HBW_From_Home	10%	13%	19%
HBW_To_Home	10%	13%	18%
HBO_From_Home	31%	31%	21%
HBO_To_Home	30%	31%	21%
NHB	20%	12%	21%

6.2.3.5 Test F – Daily Profile Check

Checks were carried out to examine the split in total demand by time period, comparing the time of day distribution in the NTS survey data with the mobile phone data. Profiles for each trip purpose are shown in Figure 81 to Figure 83. The results show that the mobile data profiles provide a reasonably good fit to the observed daily profiles.

Figure 81 Daily Profile – Home Based Work Trips

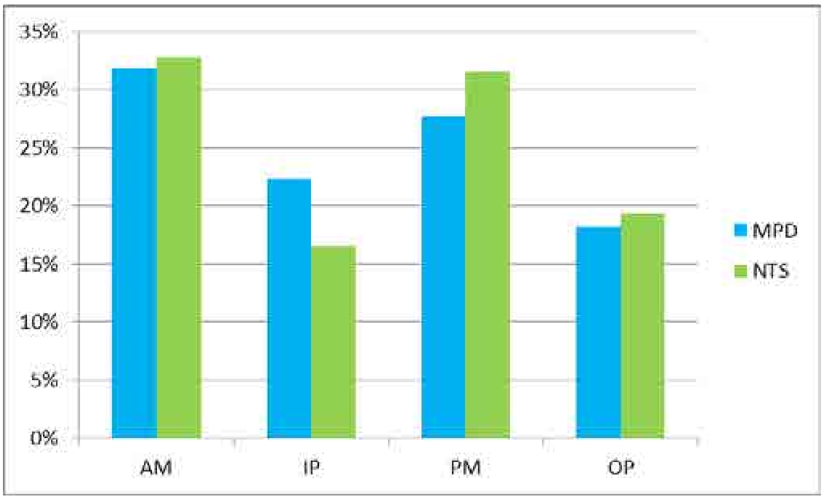


Figure 82 Daily Profile – Home Based Other Purposes

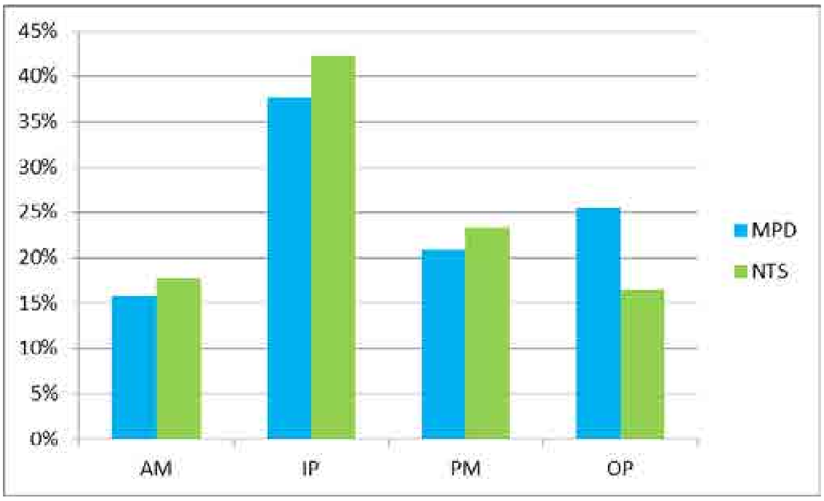
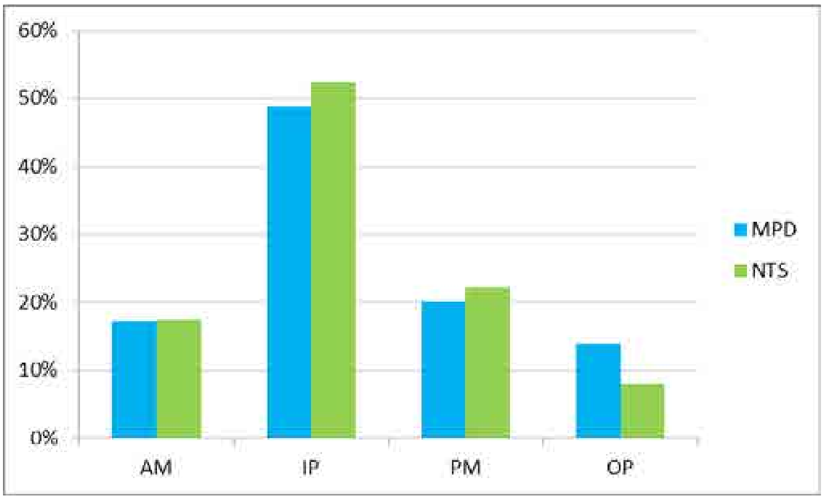


Figure 83 Daily Profile Non Home Based Trips



6.2.3.6 Conclusion of Initial Verification Tests

A summary of the comparisons made is shown in Table 43. The primary conclusions drawn from the assessment of the data were that:

- Zonal allocation at an LSOA level was insufficiently accurate for use in developing prior matrices. Mobile phone data should be treated at a level of MSOA or MSOA group as indicated by the POI analysis and disaggregated to model zone using demographic data.
- The variability of trip rates and the trip length distribution tests show that there is a consistent under-reporting of short distance trips within the data, which may vary from area to area in response to the size of the mobile cells.
- Allocation to purposes demonstrates an over-reporting of work trips and under-reporting of non-home based trips.

Thus while the data set may be considered relatively representative of longer distance travel within the study area, there is a need for corrections to the data to allow for:

- Processing the data into the appropriate spatial resolution;
- Underestimation of short distance trips; and
- Reallocation of trips between work and education purposes.

To achieve the necessary trip infilling and disaggregation, it was considered necessary to supplement the mobile phone data with a set of synthetic matrices. The development of the synthetic matrices is discussed in Section 6.3.

Table 43 Results of Mobile Phone Data Verification Tests

Test	Data Check / Comparison	RESULTS / Comment
A	Symmetry of origins to destinations	High level of symmetry shows that zonal allocation of trips is consistent for a given trip maker. This provides confidence in the consistency of the method used to allocate trip ends to the Mobile phone data zones.
	All day trip origins and destinations against customised NTEM trip ends	The analysis shows that zonal allocation is inaccurate at the LSOA level. Allocation improved significantly with aggregation to MSOA and above. The data should not be used at the zonal level at which it was initially supplied, but should be used at the grouped MSOA level and disaggregated using observed data.
B	Trip Rates	Overall the implied trip rates within the mobile data set are slightly lower than the reported trip rates from NTS; although there is a mismatch by purpose. This provides a degree of confidence in the identification of individual person trips within the mobile data set,
C	Trip Distribution	Generally good overall fit between observed and modelled data for work trip destinations.
D	Trip Length Profile	As anticipated prior to analysis the results show an under representation of shorter distance trips and overestimate of longer distance trips. This should be corrected by replacing the short distance trips with synthetic trips and making further adjustments to trip length patterns
E	Trip Purpose	Generally good fit however there is an over-allocation of trips to the commute category at the expense of HBO trips. This should be corrected during the prior matrix development.
F	Daily Profile Check	Generally good fit, any overall mismatch would be corrected in adjustments will be made during matrix estimation.

6.3 Synthetic Matrix / Gravity Model Process

As discussed in section 6.2 above, it is concluded that additional synthetic matrices would be required to compliment the mobile phone data in the development of the prior matrices. Synthetic matrices would be required to:

- Disaggregate the mobile data to model zones and by trip purpose, and
- Infill the missing short distance trips in mobile phone data.

Consequently a set of synthetic matrices were developed, using a gravity modelling process, at the level of the zoning system created for the model and for car trips at a 24 hour level for each of five trip purposes:

- Home-based work;
- Home-base employer’s business;
- Home-based other;
- Non home-based employer’s business; and
- Non home-based other.

In each case the home based purpose matrices were further split by from home and to home journey legs. Matrices were constrained to the observed movements from the roadside interview data for fully observed movements.

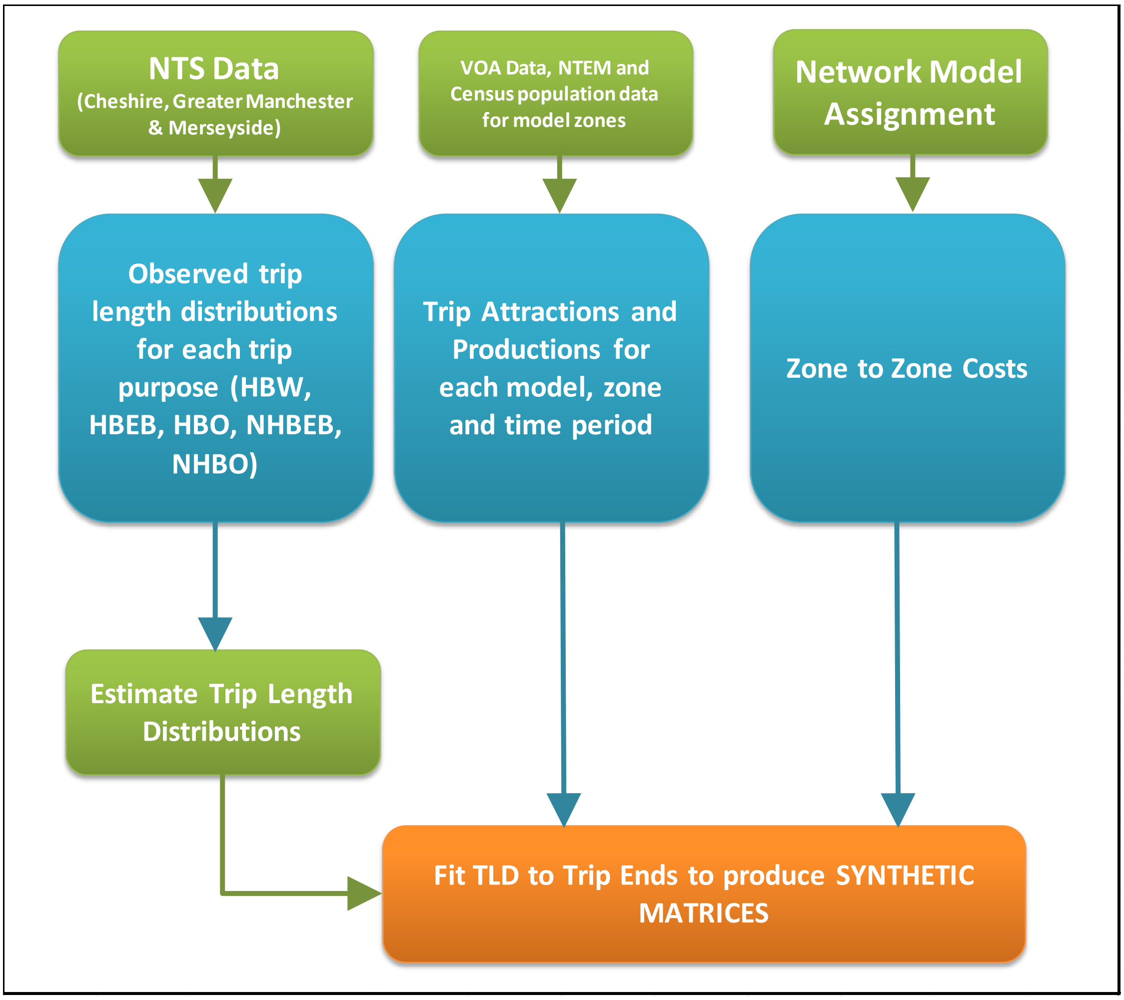
The gravity models were calibrated against trip length distributions derived from local NTS data. Trip distances for input to the gravity model were skimmed from a copy of the highway model using fixed link travel times controlled to observed Trafficmaster data. Comparisons of the NTS data and the fitted gravity model functions are shown in Appendix J.

The inputs to the synthetic matrix building process were:

- Trip ends (attractions and productions)
- Trip cost skims; and
- Calibrated deterrence function.

The process for developing synthetic matrices is shown in Figure 84.

Figure 84 Synthetic Matrix Building Process



6.3.1 Trip Ends

Trip ends for each zone were estimated using the Department for Transport's National Trip End Model (NTEM), Valuation Office Agency (VOA) data and 2015 Census population. The VOA data provided non-domestic land-use information such as Gross Floor Area (GFA).

The home-based trip end productions were disaggregated to the model zones using the total of postcode-based 2015 population for each zone in the study area. 2015 postcode population was derived by factoring the 2011 values provided by UK Data Services website to 2015 values using the mid-2015 population from the Office for National Statistics (ONS).

The home-based trip end attractions and none-home based trip ends were estimated by undertaking regression analysis between the NTEM trip ends and total GFAs of various land uses at MSOA level. In order to estimate the trip ends for the model zones, the coefficients derived from the regression analysis were then applied to the total land-use GFAs of each zone.

6.3.2 Trip Cost Skims

Cost skims were derived from a preliminary fixed link speed version of the WMMTM SATURN network. Link travel times were sourced from 2015 Trafficmaster data. Costs were calculated in terms of generalised minutes generated from the network model.

6.3.3 Deterrence Functions

Deterrence functions were calculated for each trip purpose by fitting log-normal functions to observed distributions of trip numbers within each generalised cost band derived from NTS. For this purpose, NTS data was obtained for Cheshire, Greater Manchester and Merseyside, and to ensure current travel patterns were reflected only survey records collected during the period 2008 to 2014 were used. Units were converted to minutes and the parameters expressed in a standard lognormal form.

$$\frac{1}{C_i \sigma \sqrt{2\pi}} exp\left(\frac{-(lnC_i - \mu)^2}{2\sigma^2}\right)$$

Where C is the generalised cost

σ and μ are the fitted distribution parameters

For each trip purpose the gravity model carries out a balancing process to fit a trip matrix that satisfies the trip length distribution constraints and the trip end constraints. The process iterates to improve the fit to the trip length distribution on each iteration.

Comparisons of the trip length distributions for each purpose are included in Appendix J. The results show a good fit between the synthetic matrices and the NTS data for home based trips. However, due to smaller sample sizes, the fit for non-home based trips is not as good in some distance bands.

6.3.4 Constraining to Observed Data (RSIs)

The roadside interview data provided fully observed trip information for specific sector to sector movements. For fully observed movements the synthetic matrices were constrained to reflect the observed levels of demand.

6.4 Prior Matrix Development – Stage 1

This analysis has been undertaken in three stages, each of which is described in more detail below

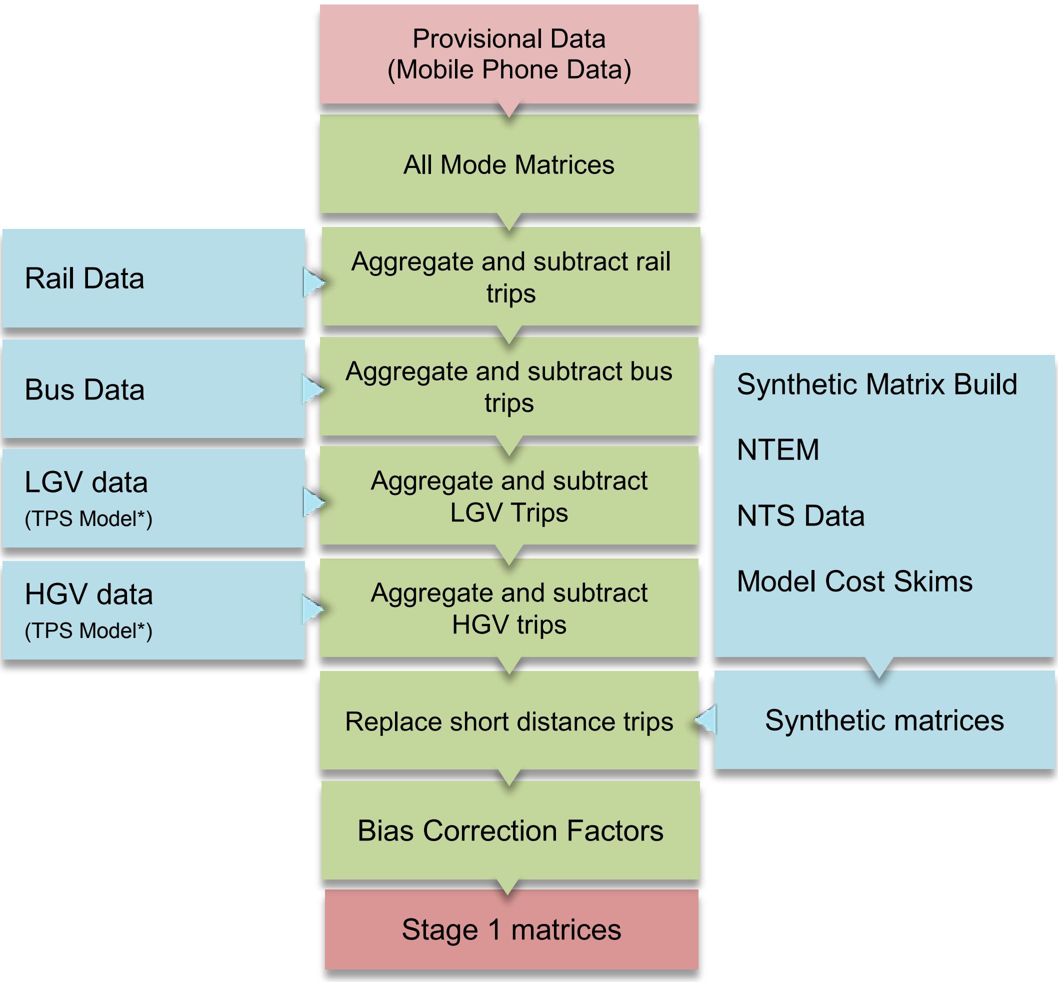
- Prior matrix development – stage 1, initial data processing;
- Prior matrix development – stage 2, further refinements; and
- Matrix estimation.

The first stage of the matrix development consisted of the following tasks:

- Aggregate rail, bus and freight matrices to a MSOA level;
- Remove rail trips from the mobile phone dataset;
- Remove bus trips from the mobile phone dataset;
- Remove freight trips from the mobile phone dataset;
- Disaggregate the car only trips to the model zones using synthetic matrices;
- Re-allocate education trips; and
- Replace short distance trips with synthetic data.

The sequence of steps is illustrated in Figure 85. This stage was specifically designed to target the issues identified with the expansion of the mobile phone data sample, mode identification, and short-trip bias discussed in Section 6.2.2.

Figure 85 Stage 1 Matrix Build Process



[8]

6.4.1 Development of Prior LGV matrices

The matrices were developed using a gravity model process taking as inputs the LGV demand matrices from the Highways England Trans Pennine South Regional Transport Model (TPS Model). These in turn were initially derived from Trafficmaster data collected across the whole of the UK and matrix estimated across Northern England

6.4.1.1 Trip ends

Trip ends were input at a WMMTM16 zone level. To create them the TPSRTM zones were aggregated as appropriate to an MSOA or a group of MSOAs level. Post code population and Valuation Office (VOA) data were then used to disaggregate the origin and destination trip ends into the WMMTM16 model zones in the study area. Elsewhere the number of jobs from NTEM was used to disaggregate the trips.

6.4.1.2 Trip distance skim

The distance skims were obtained by skimming link distance from the WMMTM16 SATURN network.

---

[8] * LGV and HGV data was obtained from the Highways England Trans-Pennine South Regional Model (TPS Model)

6.4.1.3 Trip Length Distribution

For the LGV gravity model process, the total number of trips and distances travelled by individuals were extracted from the NTS data for LGVs and summarised into distance bands.

6.4.2 Development of Prior HGV Matrices

A combination of observed and synthetic data underpinned the matrix build for the HGVs. The prior HGV demand matrices were derived from the HGV matrices of the Trans Pennine South Regional Transport Model. The matrices were developed using the gravity model process.

The method of creating the three input files that fed into the gravity model process is described below.

6.4.2.1 Trip Ends

The trip ends from the TPS model were used in this process. The trip ends were aggregated into 12 internal and 68 external sectors. The internal trip ends were then disaggregated into model zones using the VOA, population and SGVC (Specialised Goods Vehicle Count) data. The external trip ends were disaggregated into the model zones using the total number of jobs in MSOAs. The process and method of using the various data sources are explained in detail below.

6.4.2.2 Internal Trip Ends

The primary data source for domestic freight movements on road is CSRGT (Continuing Survey of Road Goods Transport) which has been provided by the DfT for 2013, 2014, and 2015. Data was provided at two different geographical levels:

- NUTS3: Cheshire, Greater Manchester, Merseyside and Lancashire; and
- NUTS2: Other counties.

Based on CSRGT, total number of trips to/from and within Warrington was 6,500 vehicles a day. This value was disaggregated into the model zones based on an analysis of SGVC (Specialised Goods Vehicle Counts), VOA and population data. The process of disaggregating the trip ends was completed in two stages explained below.

6.4.2.3 SGVC (Specialised Goods Vehicle Count)

Counts from 23 operators with highest number of HGVs were analysed to indicate the depot of the start or end of the observed trip and then proportion of counts for each location was estimated over the total number of observed HGVs which was 6,000 vehicles. The SGVC were located across the Warrington network and this was taken to be a reasonably representative observation. Table 44 shows a summary of the analysis.

Table 44 SGVC Analysis

Operator	Count	Proportion
Royal Mail	242	0.040
ASDA	196	0.033
ICELAND	191	0.032
DHL	116	0.019
Eddie Stobart	115	0.019
Winwick Road Skip Hire	113	0.019
BT Skip Hire	112	0.019
Warrington Borough Council	96	0.016
Marks and Spencer	43	0.007
Next	43	0.007
Secured Mail	35	0.006
ABC Mix	33	0.006

Operator	Count	Proportion
Speedy Hire	32	0.005
XPO Logistics	30	0.005
Hope Construction Materials	29	0.005
Biffa	28	0.005
NLC Transport	27	0.005
DFS	26	0.004
Veolia	20	0.003
Beesley & Fildes	14	0.002
Horizon Platform	13	0.002
TNT	9	0.002
Stapletons	7	0.001
Total	**1,570**	**0.262**

6.4.2.4 VOA (Valuation Office Agency data) and Population Data

The remaining number of HGVs was disaggregated into the model zones using the population data and also the VOA data for certain land uses in each model zone. There was insufficient data formally to calibrate a relationship between land use and trip ends and assumptions were made and assigned to the land uses which are shown in Table 45.

Table 45 Land Use Assumptions

Land Use Type	Ratio	HGV counts
Factory	0.166667	738
Storage, Warehouse, Depot	0.333333	1477
Shops, Showroom, Retail	0.25	1108
Restaurant	0.083333	369
Office	0.083333	369
Residential	0.083333	369
Total	1	4430

Initially the total number of HGVs was derived from the CSRGT data, however due to the lack of information and poor quality of the data the total number of trips were increased to match the totals in the TPS model.

6.4.2.5 Trip Length Distribution

For the prior HGV matrix development, trip length distributions were extracted from the TPS model.

6.4.2.6 Trip Distance Skim

The trip distance skim was drived from the link distance from the WMMTM16 SATURN network. The gravity model process was run for five iterations and the matrices from the fifth interation were used as prior LGV and HGV matrices.

6.4.3 Bias Correction Factors

A piece of research, carried out on behalf of the Technical Control Group for the Highways England Regional Transport Models in 2016, and the mobile phone data providers identified a number of consistent and significant biases inherent in mobile phone trip data as a function of the method in which the mobile phone data is collected and analysed. As a part of this research, detailed NTS data was used to derive a set of factors to correct the bias introduced by the issues relating to trip rate and trip length described earlier. This approach was adopted across all the Regional Models. Two specific sources of bias were considered particularly critical and a process was applied to correct for these:

- **Trip Rate** – to correct for the assumption that trips by mobile phone users are representative of the total UK population in terms of frequency of trip making; and
- **Trip Length** – to correct for differences in trip length distribution between mobile users and the general population.

Given that the data collection process used to obtain mobile phone data was the same as that used for the Regional Transport Models the same biases were found to be present and the same actions were taken to correct for these biases. For this reason, the factors in Table 46 were applied to the each of the matrices received from Telefonica, using distances skimmed from the model network, prior to any further processing.

Table 46 Bias Correction Factors Applied to Provisional Mobile Phone Data

Distance band (km)	Bias correction factor		
	Trip Length	Trip rate	Total
0 - 5	1.088	0.935	1.017
5 - 10	0.957	0.935	0.895
10 - 15	0.926	0.935	0.866
15 - 20	0.910	0.935	0.851
20 - 30	0.898	0.935	0.840
30 - 40	0.888	0.935	0.830
40 - 50	0.881	0.935	0.824
50 - 100	0.875	0.935	0.818
100 - 300	0.874	0.935	0.817
300+	0.890	0.935	0.832

6.4.4 Reallocation of Education Trips

Telefonica are not able to specifically identify trips made by users aged under-18, so they do not segment education trips in their outputs. However, some pay-as-you-go users were included in the sample, and many of these are associated with people in education. Education trips made by these users will usually be included in the home-based work trips, because they are trips between home and a place where the user regularly spends long periods of time during the time. To reallocate these trips, an education trip matrix, based on school records, was provided by Warrington Borough Council.

The education trips were removed from the HBW trips and added to the HBO trips.

6.4.5 Replacement of short distance trips

The comparison of trip length distributions between the provisional data and the synthetic matrices showed that the provisional data set under-represented shorter distance trips. To correct for this problem short distance trips in the provisional data were removed for trips up to 5km and replaced by trips from the synthetic matrices.

6.4.6 Removal of Non Car Trips from the Provisional Data Set

6.4.6.1 Public Transport

The public transport matrix development is discussed in more detail in Section 8.3. Rail and bus trips were aggregated to the level of an MSOA or a group of MSOAs and then subtracted from the appropriate trip purpose matrices from the 24 hour prior mobile phone data.

6.4.6.2 Removal of LGV and HGV Trips from the Provisional Data Set

The LGV and HGV matrices described above were aggregated to an MSOA or a group of MSOAs level and removed from the 24 hour mobile phone data.

6.4.6.3 Summary

The trips removed from the provisional data set at each stage are shown in Table 47.

Table 47 Breakdown of Provisional dataset by mode

	Person Trips	Percentage
Initial matrix total	8,194,983	100%
Rail trips	29,235	0.36%
Bus trips	19,413	0.24%
LGV trips	362,799	4.43%
HGV trips	174,791	2.13%
Remaining car trips	7,608,744	92.85%

6.4.7 Vehicle Occupancy

The demand matrices are calculated in terms of person trips. For assignment to the network and comparison against traffic counts, it is necessary to convert the matrices to vehicle trips using an estimate of the number of people per vehicle. The values in Table 48 were derived from the March 2017 WebTAG databook and a comparison is provided with the RSI data collected. Although the differences are not that great (between -3% and -15%), the RSI sample represents only a proportion of the trips in the model. It was therefore deemed more appropriate to retain WebTAG standard values.

Table 48 Vehicle Occupancy Factors

Purpose	Average occupancy (WebTAG)	Average Occupancy (RSI Data)
HBW	1.170	1.090
HBEB	1.190	1.150
HBO	1.670	1.470
NHBEB	1.190	1.160
NHBO	1.670	1.420

6.5 Matrix Assessment after Stage 1

The matrix totals at the end of Stage 1 are shown in Table 49.

Table 49 Matrix Totals after Stage 1

Time Period	Commute	Business	Other	LGV	HGV
AM (3 hour)	602,435	64,288	385,461	107,319	41,950
IP (6 hour)	469,216	166,457	1,043,088	204,586	87,395
PM (3 hour)	522,998	78,913	558,886	107,378	31,462
OP (12 hour)	360,695	77,904	624,165	73,532	15,731

Once this process had been completed the output matrices were once again compared with observed data to examine the fit in terms of:

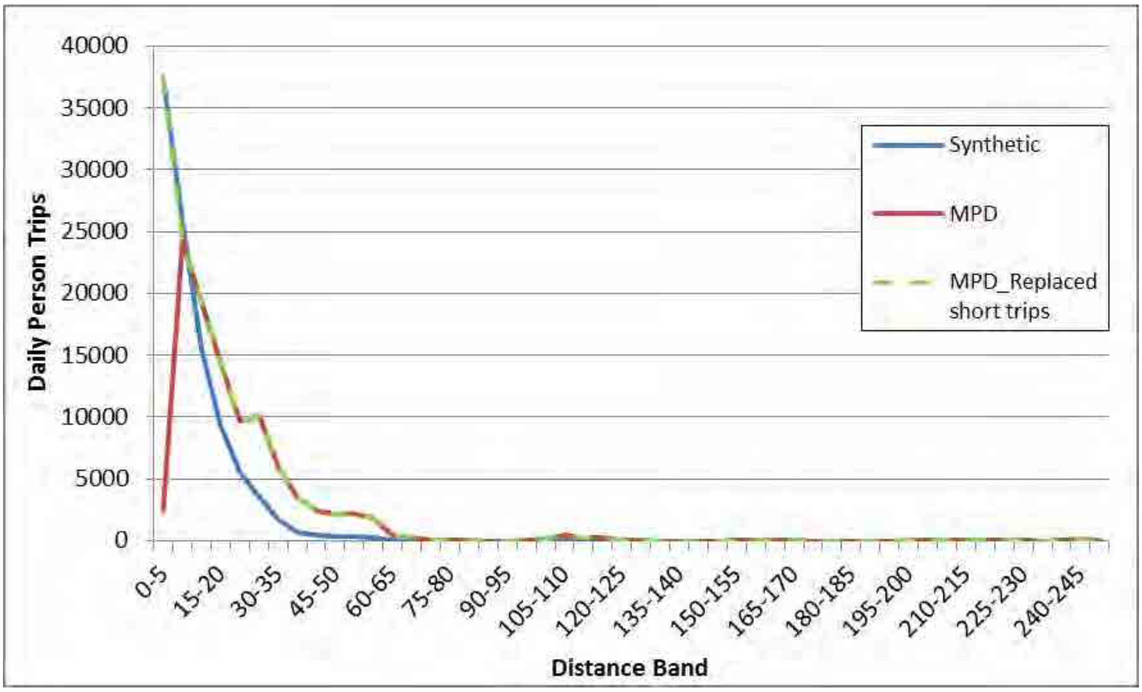
- Trip length distribution and
- Overall trip volumes.

6.5.1.1 Trip Lengths

An example of the trip length comparison is shown in Figure 86 for home based work trips. The results showed a much improved fit between the trip length profile in the prior matrix and the observed data. However there remains a mismatch between the observed trip length profile and the prior matrix in the middle distance bands.

The results show a much improved fit between the trip length profile in the prior matrices and the observed trip lengths reflected in the synthetic matrices The results demonstrate that the data sets derived from the mobile phone data, once the short trips had been replaced by synthetic matrices produce a good fit to observed trip lengths.

Figure 86 Trip Length Comparison for Home based Work Trips



6.5.1.2 Comparison of flow on cordons and Screenlines

In addition comparisons were made between the overall observed volume of traffic crossing the outer and inner Warrington cordons with the volumes in the prior matrices. Differences between observed and modelled flows aggregated over the screenlines and cordons are shown in Table 50. The results show that overall there was a shortfall of between 10% and 15% in demand across the network.

Table 50 Flow Comparisons on Screenlines and Cordons

	AM Peak	Inter Peak	PM Peak
Screenlines (total)	-15%	-13%	-13%
Outer Cordon	-10%	-10%	-10%
Inner Cordon	-11%	-11%	-11%

6.6 Prior Matrix Development - Stage 2

To improve the fit between the provisional data and observed travel characteristics further analysis was carried out. It is acknowledged at this stage that these steps will necessarily distort the mobile phone data such that it no longer represents pure observed data; however the tests have shown that the data set does not fit other observed data sets so these changes are inevitable.

6.6.1 Adjustment to Trip Length

Adjustments were made to match the trip patterns observed within the RSI dataset. These were additional adjustments which were made only to fully observed trips through the RSI sites. Differences between fully observed RSI data and the mobile phone data for each trip purpose are shown in Appendix J. To correct for errors by distance, factors were derived by comparing the provisional data to the fully observed RSI data and then applied to the matrices depending on trip length. Table 51 shows the factors applied to each band by purpose and direction.

Table 51 Adjustment Factors

Band (km)	HBW_FH	HBW_TH	HBEB_FH	HBEB_TH	HBO_FH	HBO_TH	NHBEB	NHBO
0-5	1.049	0.637	0.678	0.254	0.651	0.658	1.268	0.954
5-10	0.997	1.016	1.974	1.406	1.819	1.585	1.280	1.274
10-25	0.928	0.972	0.911	0.790	0.858	0.889	0.555	0.541
25-50	0.965	1.190	0.467	2.118	1.223	1.129	0.506	0.590
50-100	1.336	0.770	0.434	0.871	0.273	0.498	1.000	1.000
100-300	1.000	0.802	1.000	0.577	1.000	1.179	1.000	1.000

6.7 Matrix Assessment after Stage 2

This point represented the end of Stage 2 of the matrix building process.

The 24 hour matrices were converted back to three hour period matrices and the between peak periods using the ratio of peak to 24 hour trips in the mobile phone data matrices. Three hour peaks were converted to the model peaks using ATC data across the modelled area. Firstly, the survey data was used to convert the 3 hour matrices into the model peak periods. Then the matrices were divided by two thirds to get the hourly trip matrix required for assignment.

The factors for converting the 3 hour matrices to 1.5 hour peak period from the survey data were:

- 0.576 for the AM peak; and
- 0.547 for the PM peak.

Table 52 Weekly Flow by 15 Minute Intervals used to Derive Peak Period Factors

AM	Total Demand (weekly)	PM	Total Demand (weekly)
07:00	29,338	16:00	45,650
07:15	35,012	16:15	48,698
07:30	43,332	16:30	56,727
07:45	50,628	16:45	54,123
08:00	52,461	17:00	55,483
08:15	48,050	17:15	57,309
08:30	53,647	17:30	59,210
08:45	49,975	17:45	56,912
09:00	45,958	18:00	53,352
09:15	40,170	18:15	48,407
09:30	38,185	18:30	44,129
09:45	35,692	18:45	41,665
FACTOR	0.576	FACTOR	0.547

The final matrices are shown in Table 56.

At this stage the comparisons carried out on the original provisional data and the Stage 1 were repeated to verify the matrices against observed data. This involved an assessment of:

- Trip length distribution; and
- Flows on major screenlines.

6.7.1 Trip Length distribution

A comparison between the trip length distribution in the adjusted matrices and the trip length distributions derived from RSI data are shown in Figure 87 to Figure 91. Since the relationship between RSIs and the Stage 2 matrices is largely dependent on the factors applied then the close fit demonstrated by the results shows that the adjustments had the desired effect and brought the distribution in the matrices closer to the RSIs observed values. These distribution plots represent only the fully observed movements within the RSI data.

Figure 87 Home-Based Work, Stage 2

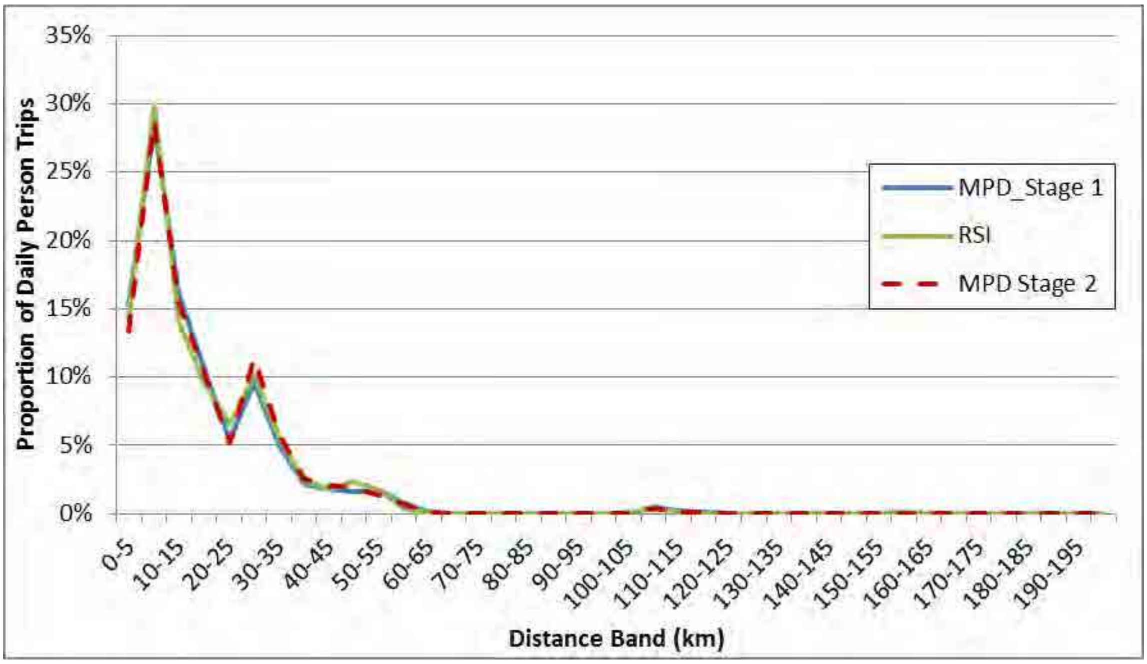


Figure 88 Home-Based Employers’ Business, Stage 2

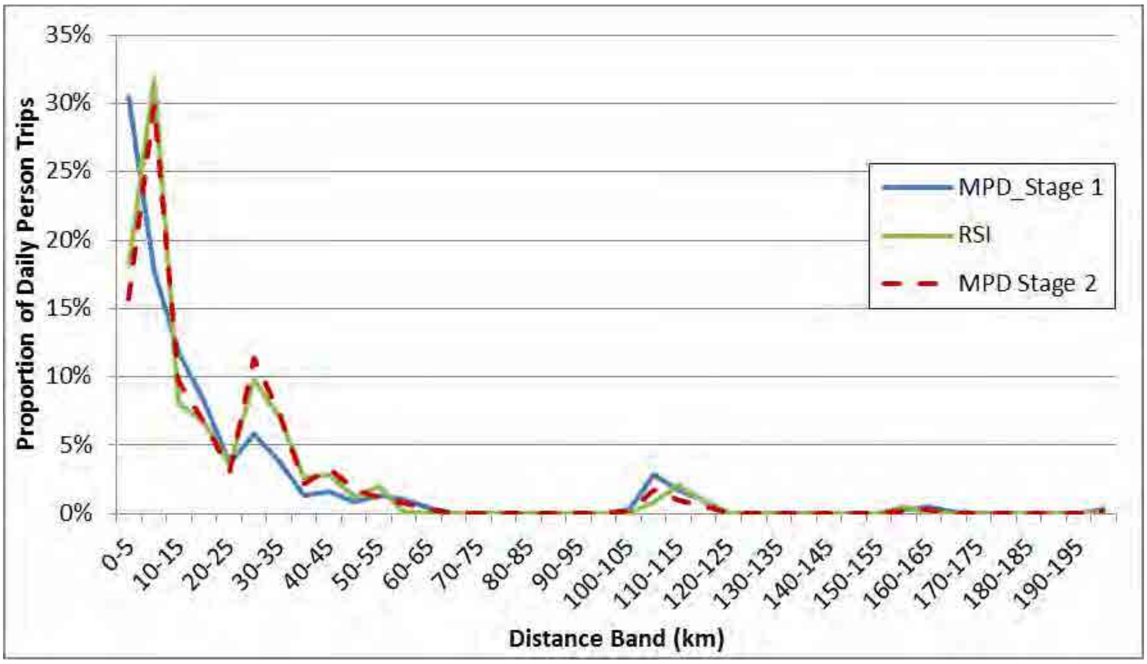


Figure 89 Home-Based Other, Stage 2

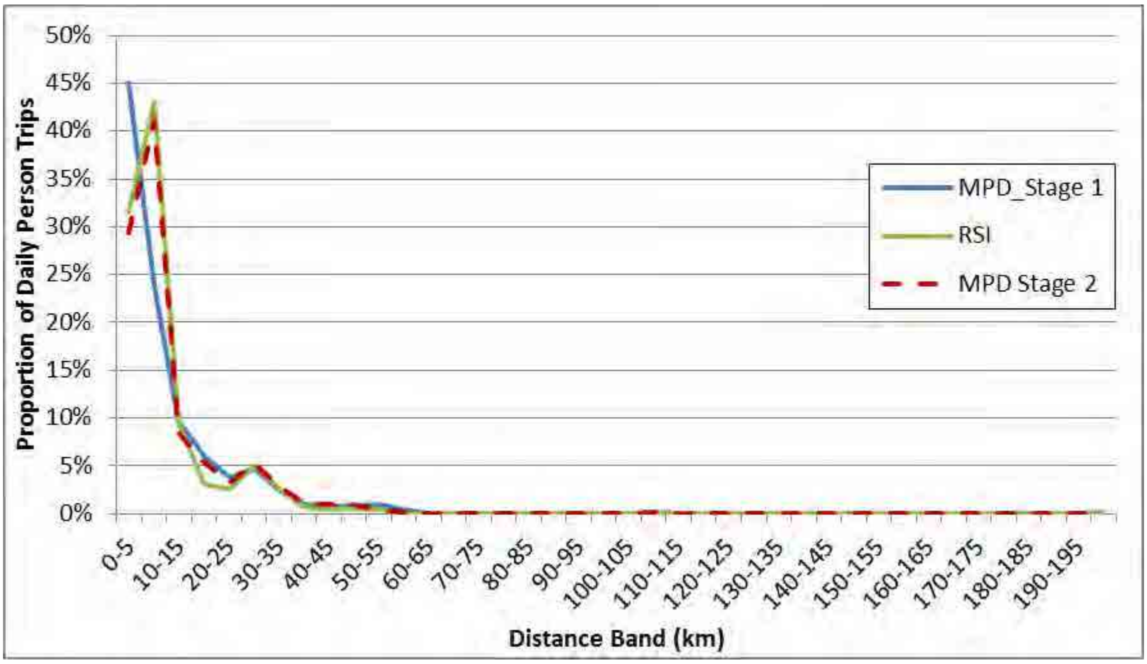


Figure 90 Non Home-Based Employers' Business, Stage 2

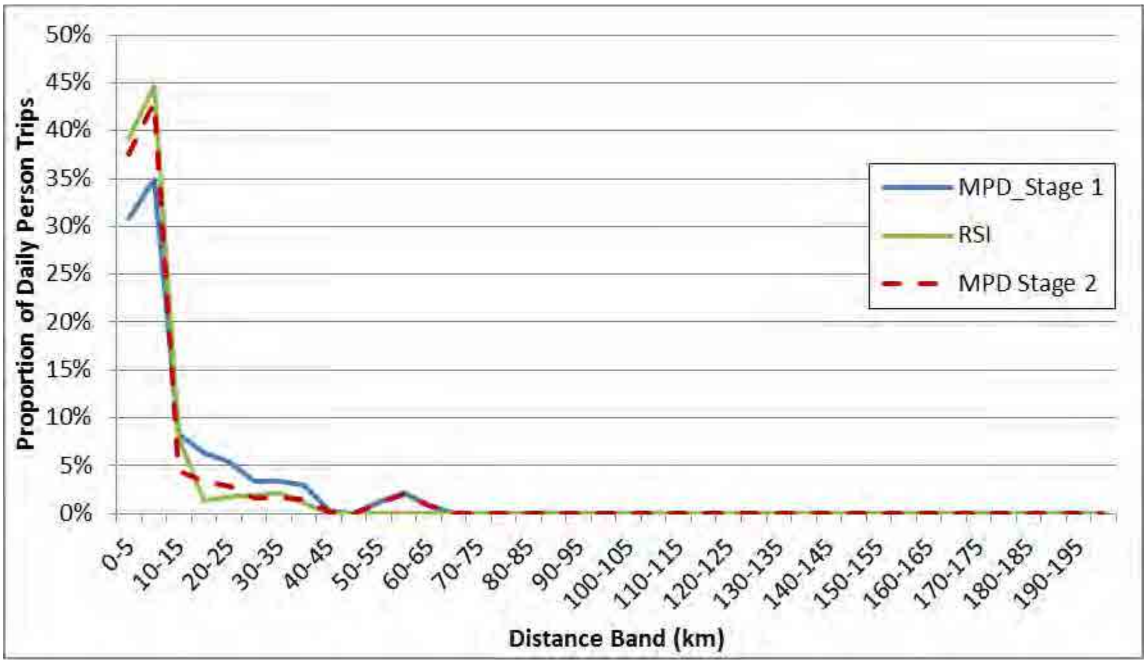
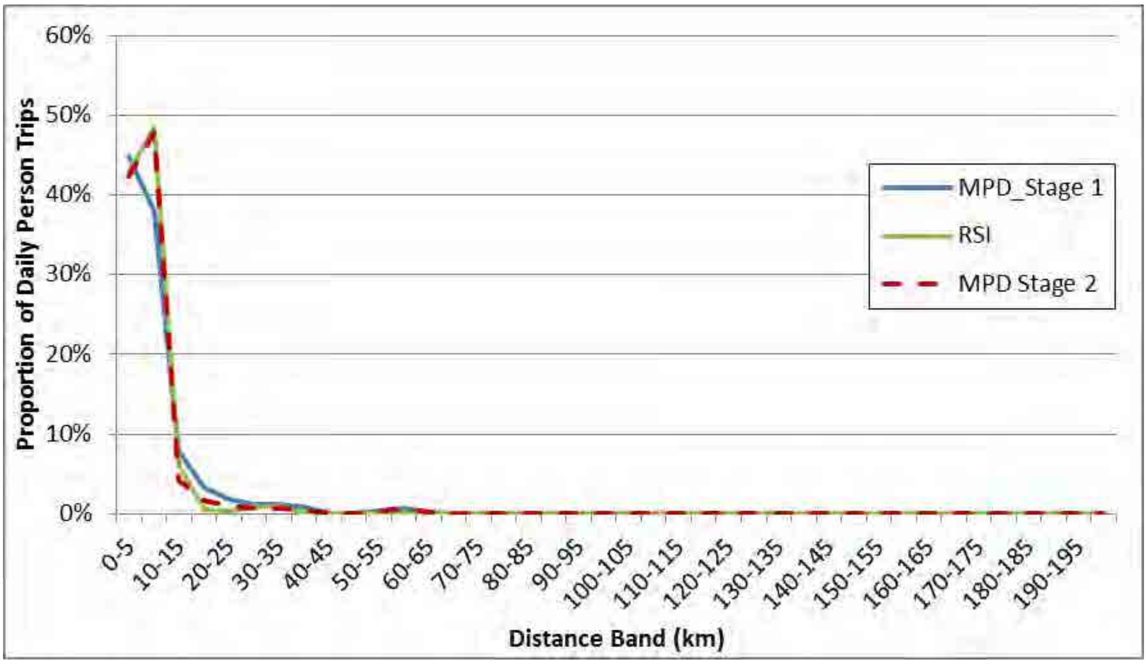


Figure 91 Non Home-Based Other, Stage 2



6.7.2 Comparison of Matrix Flows

A comparison of the assigned and observed flows across the main cordons and screenlines following the matrix adjustments are shown in Table 53, Table 54 and Table 55. The results show that the differences on the main town centre cordons are close or lower than 10%. Differences on other screenlines are of a similar level although, some particularly in the inter peak are higher. Differences are both positive and negative suggesting that there is no consistent over or under estimate of demand.

There are no strict guidelines covering acceptable difference but the purpose here is to get the prior matrices in to as good a position as possible before commencing matrix estimation. It is also worth noting that some of the screenlines used here are relatively short and therefore quite high percentage differences are possible.

Table 53 Comparison of Screenline flows – Prior Matrix AM Peak

Screenline	Direction	Observed Volume	Modelled Volume	Difference	%age Difference
A49 North / South	Northbound	2,864	3,212	348	12.1%
	Southbound	3,145	3,124	-21	-0.7%
Birchwood	Northbound	4,270	3,795	-475	-11.1%
	Southbound	4,133	4,586	453	11.0%
Canal - NEW	Northbound	3,565	3,525	-40	-1.1%
	Southbound	2,942	2,813	-129	-4.4%
Rail EW	Eastbound	2,125	2,340	215	10.1%
	Westbound	1,622	1,781	159	9.8%
Rail NS	Northbound	5,233	5,233	0	0.0%
	Southbound	4,609	4,873	264	5.7%
Outer Cordon	Inbound	12,668	11,782	-886	-7.0%
	Outbound	14,137	13,342	-795	-5.6%
Inner Cordon	Inbound	8,776	8,660	-116	-1.3%
	Outbound	6,268	6,017	-251	-4.0%

Table 54 Comparison of Screenline flows – Prior Matrix Inter Peak

Screenline	Direction	Observed Volume	Modelled Volume	Difference	%age Difference
A49 North / South	Northbound	1,975	2,308	333	16.9%
	Southbound	2,177	1,893	-284	-13.0%
Birchwood	Northbound	2,580	2,290	-290	-11.2%
	Southbound	2,364	2,561	197	8.3%
Canal - NEW	Northbound	2,531	2,471	-60	-2.4%
	Southbound	2,547	2,537	-10	-0.4%
Rail EW	Eastbound	1,802	1,245	-557	-30.9%
	Westbound	1,751	1,220	-531	-30.3%
Rail NS	Northbound	3,457	2,722	-735	-21.3%
	Southbound	3,361	2,848	-513	-15.3%
Outer Cordon	Inbound	9,410	8,973	-437	-4.6%
	Outbound	9,525	8,538	-987	-10.4%
Inner Cordon	Inbound	6,824	6,290	-534	-7.8%
	Outbound	6,934	6,398	-536	-7.7%

Table 55 Comparison of Screenline flows – Prior Matrix PM Peak

Screenline	Direction	Observed Volume	Modelled Volume	Difference	%age Difference
A49 North / South	Northbound	2,846	3,092	246	8.6%
	Southbound	2,756	3,115	359	13.0%
Birchwood	Northbound	4,542	4,279	-263	-5.8%
	Southbound	3,489	3,785	296	8.5%
Canal - NEW	Northbound	3,007	3,233	225	7.5%
	Southbound	3,326	3,446	120	3.6%
Rail EW	Eastbound	2,056	2,386	330	16.0%
	Westbound	2,127	2,499	372	17.5%
Rail NS	Northbound	4,916	5,162	246	5.0%
	Southbound	5,233	5,353	120	2.3%
Outer Cordon	Inbound	14,127	14,665	538	3.8%
	Outbound	13,424	14,426	1002	7.5%
Inner Cordon	Inbound	7,190	7,934	744	10.3%
	Outbound	9,235	10,234	999	10.8%

6.8 Final Prior Matrices

The prior matrices have been developed using the Telefonica mobile phone data, disaggregated to zone and trip purpose using the synthetic matrices. Given this and on the basis of the analysis of trip patterns and overall volumes, it was concluded that the prior matrices reflected the broad demand for travel within Warrington, and that the matrices should be taken forward to matrix estimation for further refinement.

Table 56 Prior Matrix Totals by Purpose

Time Period	Commute	Business	Other	LGV	HGV
AM (3 hour)	606,088	64,686	391,235	107,319	42,681
IP (6 hour)	470,980	167,648	1,052,659	204,584	88,930
PM (3 hour)	526,589	79,566	566,123	107,378	32,009
OP (12 hour)	361,739	78,252	626,720	73,532	15,731

7. Highway Model Calibration

7.1 Context

Whilst the tests described in Chapter 6 were focused on the preparation of the matrices, additional checks have also been undertaken on both the model network and assignments to ensure that once the matrix was assigned, the outputs from the model were representative of travel conditions in the study area and could be assessed against the relevant WebTAG acceptability criteria.

WSP have also conducted two reviews of the model network; V91 in February 2017 during the initial network development stage and a second review on V109 in August 2017 as part of the calibration stage. Please refer to the report *'Warrington SATURN Model: Model Review', October 2017 for more details* on this final review. A summary of these findings is also included below.

7.2 Network Checks

The model network checks broadly fall into 3 categories:

- Network completeness;
- SATURN compilation tests; and
- Network routing.

Each of these checks are discussed in more detail below.

7.2.1 Network Completeness Check

The purpose of this check was to prove that the network produced is structurally complete, including both the simulation and buffer network. The network was checked for basic connectivity to ensure that there was a possible path between each OD pair. This was done by careful checking of the error messages generated by SATURN. SATURN also provides error checking of the link distances relative to the straight line distance between the nodes. This of course assumes that the node locations are accurately defined in the model. The error messages from SATURN have been checked to try and ensure that individual link lengths are coded correctly.

The WSP review of the 'Warning 32' errors within the model LPN files to determine differences in two-way links identified 13 links where there was a discrepancy between link lengths. These have all been reviewed by AECOM and corrected. The main cause of error was where a link had been split and the new distance had not been updated.

7.2.2 SATURN Compilation Check

The purpose of this test was to ensure that the network (including buffer) compiled in SATURN with the option "WRIGHT = TRUE" without any unacceptable errors. The test also confirmed that the initial network development was successfully built using SATNET.

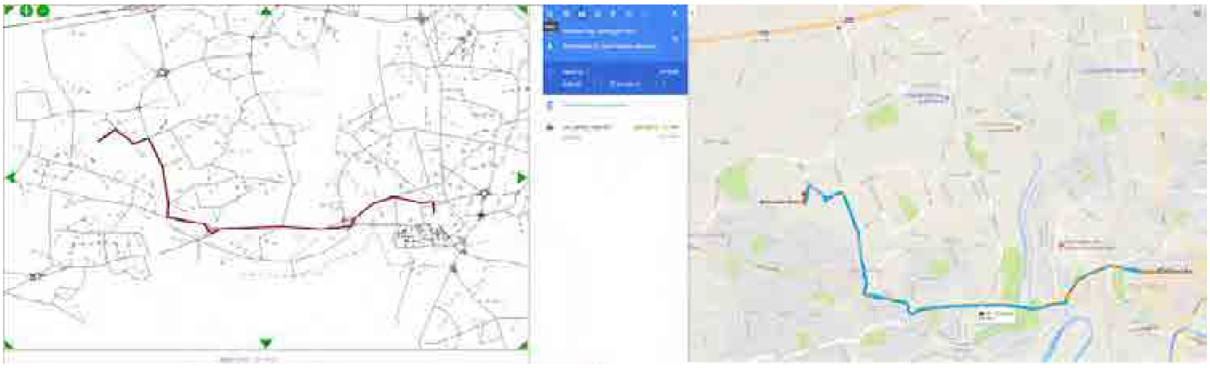
Prior to this test it was ensured that the networks had been prepared with no FATAL or Semi-Fatal errors. This was completed as part of the Network Completeness Check. Major warnings and serious warnings were addressed during this acceptance test. Some of these warnings were further addressed during the main calibration stage. All other warnings and serious warnings were investigated and remedial measures were undertaken where necessary.

7.2.3 Network Routing Check

This test was undertaken by WSP to check the key routes in the model area. As part of this network routing test 28 O-D pairs were identified and checked in each time period. The routes shown in the networks were then compared against Google route planner. The routing comparisons between SATURN and Google are presented in Appendix H and an example is shown in Figure 92.

Where routing in the model was not correct, it is normally associated with the flow on one corridor being higher than the count while the neighbouring corridor is low. A number of instances of this were identified in the model and a closer inspection of the coding in these corridors was undertaken compared to conditions on the ground. Where there was evidence of local conditions influencing speeds and / or capacity, these were taken into account in the network coding.

Figure 92 Example of OD Route checks



7.3 Assignment Checks

Once the network checks were complete, assignments were undertaken with the initial prior matrices to identify and fix any additional network-related issues. Focus was on ensuring that convergence of the assignment / simulation loops was being achieved. The following checks were undertaken and appropriate corrections made:

- Assignment convergence;
- Link speed checks;
- Node convergence; and
- Node delays.

7.3.1 Assignment Convergence

This check involved altering some of the assignment parameters within SATURN, more specifically those relating to the termination criteria. The final parameters applied are shown in Table 57.

Table 57 Assignment Parameters Altered

Assignment Parameter	Description	Value Applied
PCNEAR	Percentage change in flows judged to be “near” in successive assignments **Default 1%**	1
ISTOP	The loops stop automatically if ISTOP % of the link flows change by less than “PCNEAR” percent (default 1%) from one assignment to the next. **Default 98%**	99
MASL	Maximum number of assignment/simulation loops **Default 15**	200
NISTOP	The number of successive loops which must satisfy the “ISTOP” criteria in the test for convergence of the assignment/simulation loops **Default 4**	4
NITA	Maximum number of assignment	30

Assignment Parameter	Description	Value Applied
	iterations **Default 20**	
NITS	Maximum number of simulation iterations **Default 20**	50
RSTOP	The loops stop automatically if RSTOP % of the link flows change by less than “PCNEAR” percent (default 1%) from one assignment to the next. **Default 97.5%**	98.5
STPGAP	Critical gap value (IN %) used to terminate assignment-simulation loops when KONSTP = 1 or 5 **Default 1%**	0.05

SATURN includes a number of options that allow the user to control how SATURN models the movement of traffic within the highway network. At the very simplest level, these can be left at default values but it is generally recommended that the user consider changing these values to suit the characteristics and requirements of the model being built. The convergence of the model has been improved significantly as a result of this process.

The convergence requirements for highway assignment models are set out in WebTAG and shown in Table 58.

Table 58 WebTAG Convergence Criteria and Acceptability Guidelines

Model	Indicator	Criteria	Acceptability Guideline
Highway Convergence	% GAP	<0.1%	For final 4 assignment iterations
	Link Flows	% of links changing by less than 1%	>98% of cases in final 4 assignment iterations

The results of the model convergence as part of the calibration and validation exercise can be found in Section 7.5.4.

7.3.2 Link Speed Checks

During the model build stage work was undertaken to establish cruise speeds within the urban area and to assign these to the various link types. These were sense-checked against a review of speed limits in the area using Google StreetView.

7.3.3 Delay Checks

This formed part of the network review undertaken by WSP of the delay incurred at junctions. It is a function of the volume of traffic travelling through that junction and key to ensuring that the route choice in the model is sensible. Once the matrix had been assigned, it was possible to undertake the following assessment:

- Identifying locations where very high delays were being modelled or very low flows. Each one was checked and the reason for it identified. Where this was due to network coding errors these were corrected.

WSP have produced junction delay plots have been produced for junctions / nodes which show delays in excess of 60 seconds, to help identify whether there were any potential issues with junction coding, signal timings or other factors which could cause issues within the model. 32 junctions were identified for further review by AECOM. Please refer to Table 1 of the WSP report '*Warrington SATURN Model, Model Review, October 2017'* for full details.

Each of these junctions has been reviewed by AECOM and the key patterns noticed where delays occurred was in relation to:

- Of the 32 junctions identified, 23 are in the node area 80,000 i.e. outside of the Borough. Information for these junctions has been derived from the Highways England Trans-Pennine South Regional Model and so may contain template coding information where junction data was not available or provided by the respective local authority. Delays at these locations are a function of the number of zone load points in the vicinity loading high demand onto sparser network. No further action taken at this stage but it is important to note that these areas will have been reviewed from a capacity perspective during the early stages of calibration to ensure demand could access the network and many of these junctions have had delays significantly reduced already.
- Of the 9 remaining junctions listed, each of these has been reviewed in more detail and the following noted:
    - The timings applied at signalised junctions – either at a location where no data was collected and/or available, or a signalised junction that is part of the SCOOT network and therefore timings have to be converted to fixed within SATURN; or
    - Delays appear highest on minor arms where green time (and demand) is low relative to the rest of the junction.

An example is shown in Table 59.

Table 59 Example of Delays in Base Model and Checks Undertaken

Node no.	Junction	AM	IP	PM	Max turn delay	Comment
1482	A49 junction with Hawleys Lane / Long Lane	✓	✓	✓	231 secs	Delay is on minor arm exit from Retail Park. Known delay area due to ahead/right turn blocking left turn filter.
1179	A562 Penketh Road with Liverpool Road	✓		✓	466 secs	Delay is on minor arm exit from Thornton Rd. Fixed timings coded as per observed data.
2614	Cromwell Avenue with A57	✓		✓	456 secs	Delay is highest on minor arm (David Lloyd arm). AM demand is approximately 150 compared to 900+ for other arms.

7.4 Matrix Checks

The purpose of this section of the report is to demonstrate that the calibration of the WMMTM16 trip matrix has not substantially distorted the prior matrices (those matrices as described in Chapter 6). The calibration process from prior to final matrices, and the comparisons made were as follows:

- Assigned model flows using the prior matrix were compared with counts;
- A first estimation starting with the prior matrix was run using controls from calibration counts grouped into mini-screenlines;
- A comparison was made between the prior and post estimation matrices;
- A comparison was made between model flows and counts at calibration and validation screenlines; and
- A comparison was made between the observed and modelled journey times.

This process was repeated each time the matrix was estimated following a change.

7.4.1 Scope of Matrix Estimation

The purpose of matrix estimation (ME) is to improve the fit of the prior matrix against observed flows.

The main features of the matrix estimation process were as follows:

- For all user classes matrix estimation is only applied to the prior matrix; it is never the case that ME is applied to a previously matrix estimated matrix.
- ME is applied to all user classes simultaneously. This ensures that, for all user classes, the output from the ME process will be (a) based on the best available information and (b) have been derived on a consistent basis.
- ME was applied on model links only; no turning count data was used (though link data derived from turning counts was used).

The application of ME within SATURN provides the user with a range of flexibility in terms of how the process is set up and constraints set on adjustments to the prior matrices. The approach adopted is outlined below.

7.4.1.1 Initial Iteration

Step 1 - Initial Assignment- An initial assignment was run (SATALL) using the “prior” matrix to create an assigned highway network with modelled link volumes on each section of the network (UFS file). A path file containing the assigned paths for each iteration of the assignment model was also an output from this process (UFC).

Step 2 - Calculate PIJA Factors- PIJA factors are the proportion of trips from each origin and destination which use a particular link. They are generated by the program SATPIJA which takes as its input the UFS and UFC files from an assignment. PIJA factors were calculated for the initial assignment run in Step 1.

Step 3 - Matrix Estimation (SATME2) -The ME process adjusts the “prior” matrix in an attempt to better reflect observed traffic volumes at key locations on the network. The update to the “prior” matrix takes into account the relationship between observed and assignment volumes at selected locations on the network and the proportion of trips between each origin-destination pair at these locations. This process required the “prior” matrix, the PIJA file and the observed count data and an ME control file.

Step 4 – Re-run of Assignment Model- The final step in this stage was to re-run the assignment model with the updated matrix and check the comparison of observed and modelled flows to see if the calibration/validation of the model is improved and met calibration/validation criteria.

7.4.1.2 Second (and Subsequent) Iterations

When the updated matrix is reassigned, often an acceptable level of calibration/validation is still not achieved, and further assignments are needed. This is because the PIJA factors and demand are interrelated. A specific level and pattern of demand, in this case the “prior” matrix, will result in a specific set of PIJA factors. If a different level of demand is assigned this would result in a different set of PIJA factors.

As the updated matrices are generated from the “prior” matrix PIJA factors, these factors will not be representative of the level of demand in the updated matrices, and hence when the updated matrix is assigned to the network improved validation is not achieved.

The approach adopted to overcome this was to use the updated matrices to generate a new set of PIJA factors, which should represent a scenario where modelled traffic flows are closer to the observed traffic flows compared to the assignment of the ”prior” matrix, and hence the PIJA factors will be more representative of traffic levels closer to the observed.

The following steps (5 to 7) reflect subsequent iterations of ME to improve the model calibration/validation.

Step 5 - Calculate Revised PIJA Factors- A revised set of PIJA factors were calculated that reflect the assignment of the updated matrix to the network. These factors reflect a situation where assigned volumes are closer to the observed compared to the initial assignment of the “prior” matrices.

Step 6 - Matrix Estimation- The ME process is rerun. This process always uses the original “prior” matrix as the starting matrix, but uses the PIJA factors from the assignment of the updated matrix to the network.

Step 7 – Re-run of Assignment Model - The assignment model is re-run again with the latest updated matrix. The observed and modelled traffic flows are compared again to see if the calibration/validation of the model is improved and meets calibration/validation criteria.

Steps 5 to 7 were repeated for 10 iterations to generate an updated matrix that results in an improved model calibration / validation. For each subsequent iteration, the starting point is always the original ‘prior’ matrix and the PIJA factors generated from the previous iteration.

7.4.2 Use of Mini-Screenlines

As per WebTAG guidance (Unit M3.1 Para 8.3.5}, the ME process was undertaken across mini-screenlines; either breaking down the main calibration and validation screenlines into smaller sections, or grouping a number of neighbouring counts. Use of grouped screenlines is consistent with WebTAG (where it is recommended that HGV counts need to be grouped in order to increase the overall level of confidence). It is noted that using mini screenlines loses the resolution that is required to improve the individual link performance.

Validation data are intended to be an independent dataset which are used to prove the validity of the model. These data generally would not be used in building the model however they have been used in the second estimation process; it was found that we could achieve an improved validation by including the validation counts in estimation without having any significant additional changes to the demand matrices.

A total of 19 (2-way) mini screenlines (groupings of 2 or more individual sites) have been used and their location is shown in Figure 95. 10 of the mini screenlines have 3 or more sites assigned.

Figure 93 shows the 103 individual sites (not allocated to a screenline or cordon) that went into ME. Figure 94 shows all sites that went into ME (277).

Figure 93 Sites not on a Screenline or Cordon Used in Matrix Estimation

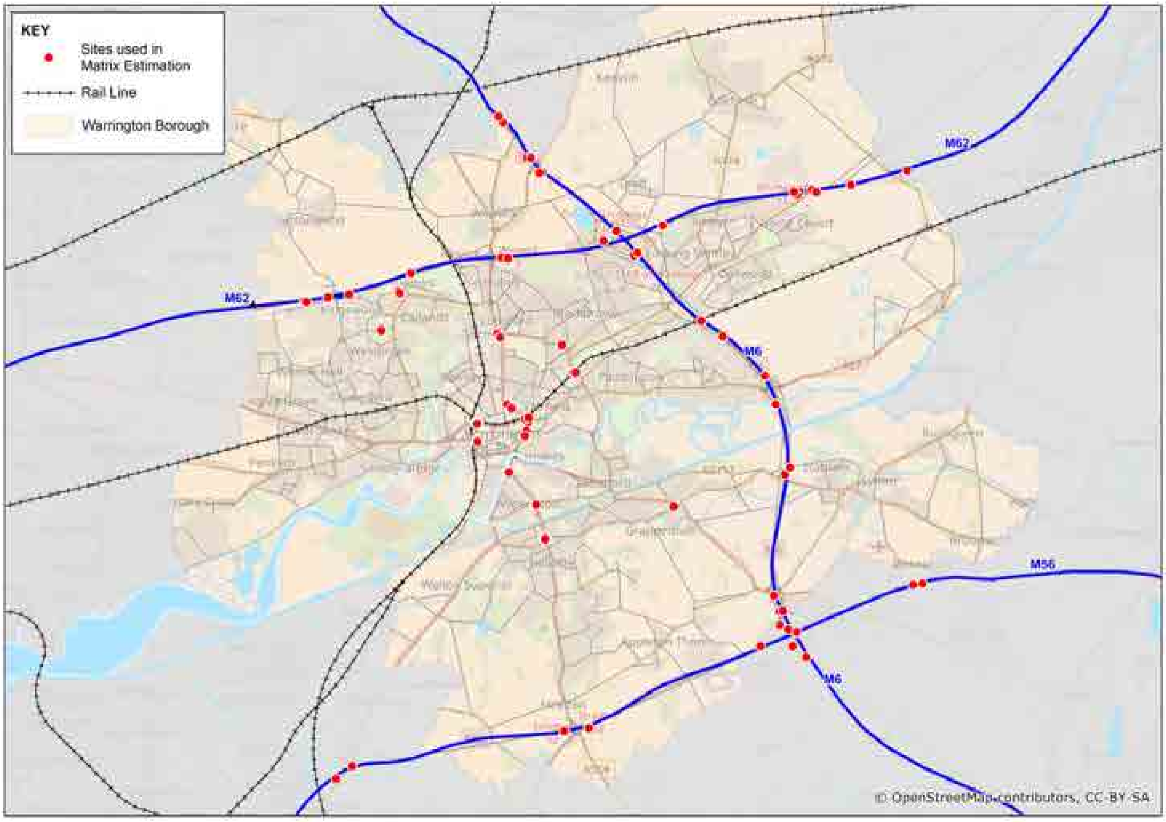


Figure 94 All Sites Used in Matrix Estimation

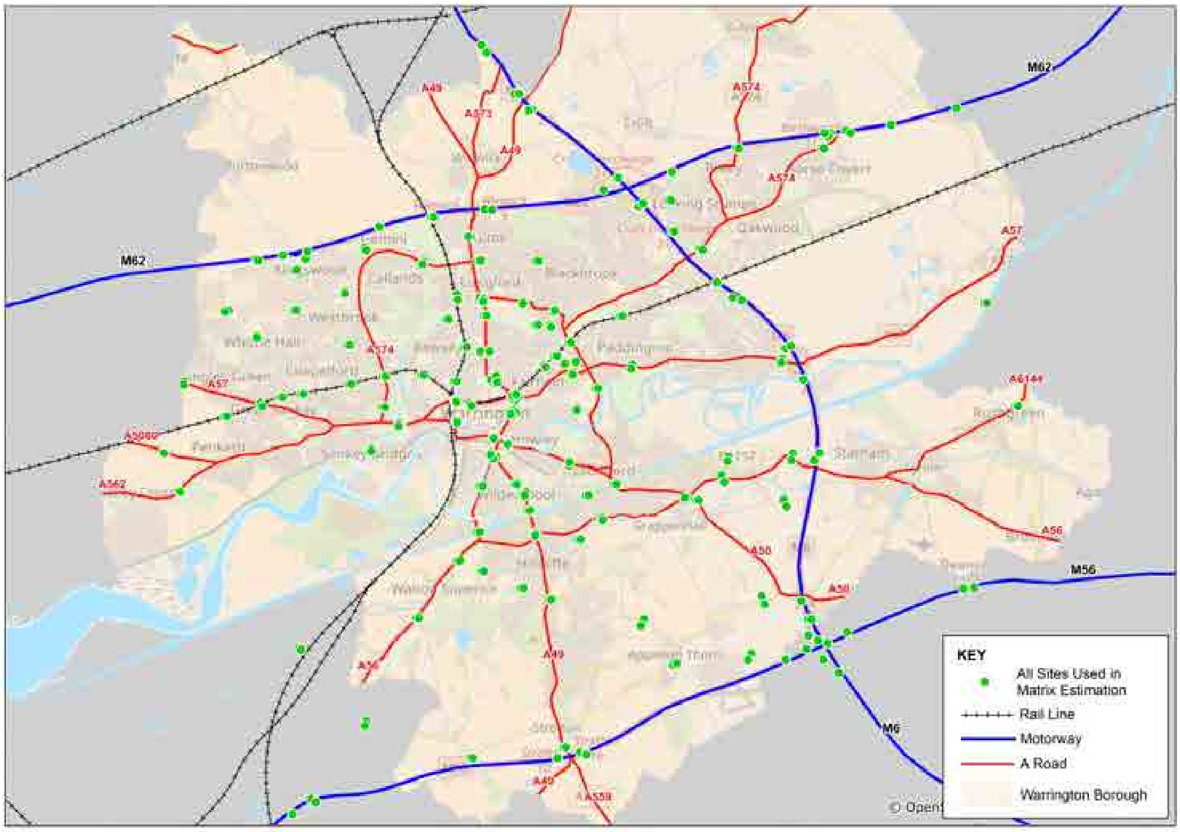
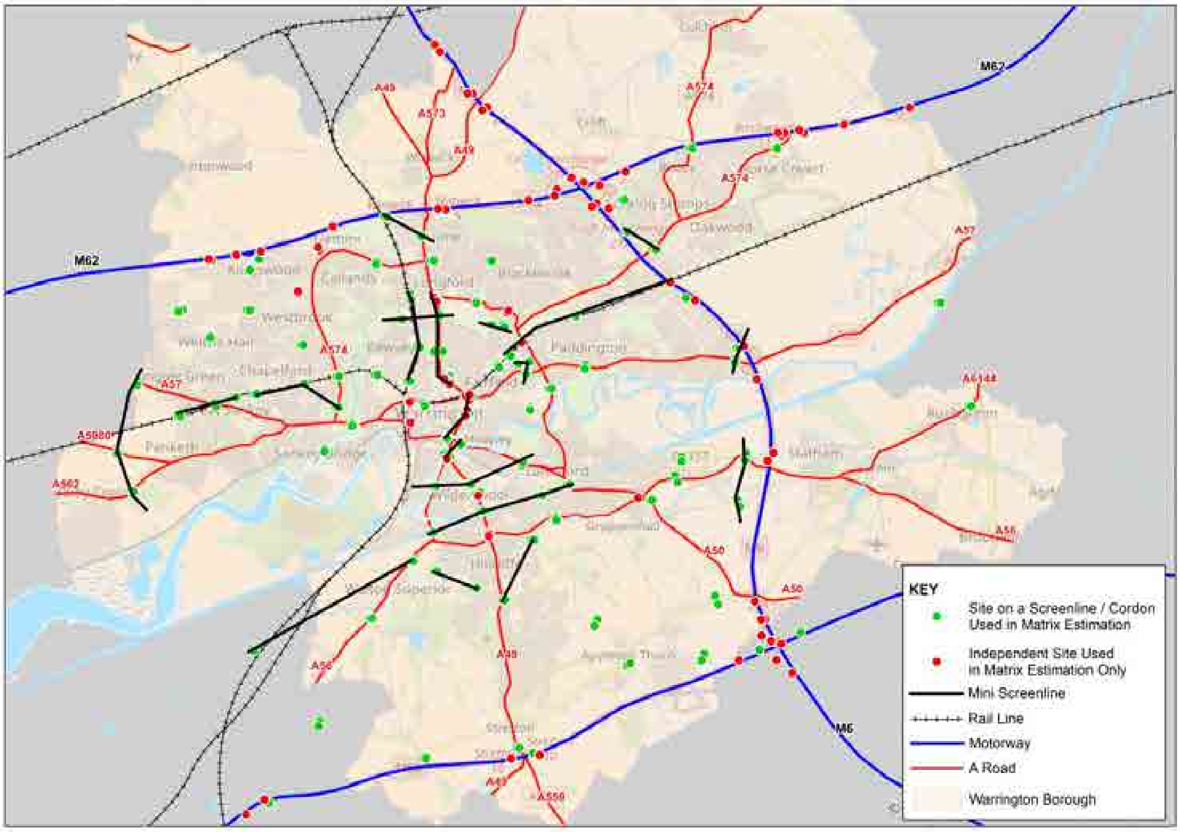


Figure 95 Matrix Estimation Mini Screenlines



7.4.3 Matrix Estimation Output Checks

The impact of ME has been assessed using the guidelines presented in WebTAG M3-1, Section 8.3. The following outputs have been produced:

- Sector to sector level matrices by vehicle type – prior and post ME, with absolute and percentage changes.
- Scatter plots of matrix zonal cell values, prior and post ME, with regression statistics (slopes, intercepts and R^2 values) – See Appendix J for scatter plots.
- Scatter plots of zonal trip ends, prior and post ME, with regression statistics (slopes, intercepts and R^2 values) – See Appendix J for scatter plots.
- Trip length distributions - cars, prior and post ME, with means and standard deviations.
- Trip length distributions - LGV and HGV, prior and post ME, with means and standard deviations.

WebTAG unit M3.1 Table 5 presents a set of criteria against which to assess the WMMTM16 matrices against. These are presented in Table 60.

Table 60 Significance of Matrix Estimation Changes

Measure	Significance Criteria
Matrix Zonal Cell Values	Slope within 0.98 and 1.02 Intercept near zero R^2 in excess of 0.95
Matrix Zonal Trip Ends	Slope within 0.99 and 1.01 Intercept near zero R^2 in excess of 0.98
Trip Length Distributions	Means within 5% Standard Deviations within 5%
Sector to Sector Level Matrices	Differences within 5%

SOURCE: WebTAG M3.1 Table 5

Matrix Zonal Cell Values

Correlation statistics were calculated on for the changes in matrices at a zone to zone level for each purpose and time period. The results are given in Table 61. Please see Appendix J for the scatter plots. When compared with the WebTAG criteria stated above, the majority of matrix changes fall within the required bounds. The gradients for commute trips for the inter peak and evening peak periods fall marginally outside the required limits, while the peak hour HGV trips fall outside the required boundary.

Table 61 Zone to Zone Statistics for Pre and Post matrix Estimation.

Purpose	AM		IP		PM	
	Gradient	R^2	Gradient	R^2	Gradient	R^2
Commute	0.99	0.96	0.96	0.95	0.97	0.97
Business	1.00	1.00	1.00	1.00	1.01	1.00
Other	1.01	1.00	1.00	1.00	1.01	1.00
LGV	0.99	0.97	1.02	1.00	1.03	1.00
HGV	0.91	0.98	0.96	0.98	0.91	0.98

7.4.3.1 Matrix Zonal Trip Ends

Table 62 and Table 63 give a tabulation of the regression values for the post and prior trip end totals. For each comparison the intercept value has been forced to zero. The results show that for car trips the values are within or close to the WebTAG requirements For HGV trips, where there was less confidence in the prior matrices the R^2 values are high although the slopes vary from the required values.

Scatter plots comparing the profiles of prior and post estimation zonal trip end totals are included in Appendix J for each purpose and time period.

Table 62 Trip origin regressions – prior v post matrix estimation

Purpose	AM		IP		PM	
	Gradient	R^2	Gradient	R^2	Gradient	R^2
Commute	1.00	1.00	1.00	1.00	1.00	1.00
Business	1.01	1.00	0.99	1.00	1.01	0.99
Other	1.01	1.00	1.00	1.00	1.00	1.00
LGV	1.03	1.00	1.02	1.00	1.04	1.00
HGV	0.92	0.99	0.98	0.99	0.93	0.99

Table 63 Trip destination regressions – prior v post matrix estimation

Purpose	AM		IP		PM	
	Gradient	R^2	Gradient	R^2	Gradient	R^2
Commute	1.01	1.00	1.01	1.00	1.01	1.00
Business	1.04	0.99	1.04	0.99	1.04	0.98
Other	1.01	1.00	1.01	1.00	1.00	1.00
LGV	1.03	1.00	1.03	1.00	1.03	1.00
HGV	0.91	0.99	0.96	0.98	0.91	0.98

7.4.3.2 Trip Length Distributions

Table 64 shows the percentage changes for the mean and standard deviation of trip lengths as a result of matrix estimation. One value lies outside the range given in the guidelines for the mean trip length for LGVs during the PM peak period.

Trip length distribution plots comparing the profiles of prior and post estimation trips are included in Appendix J for each purpose and time period.

Table 64 Trip Length Distribution – Percentage Change – prior v post matrix estimation

Purpose	AM		IP		PM	
	Mean	SD	Mean	SD	Mean	SD
Commute	0.4%	0.2%	-0.4%	-0.7%	0.4%	-0.7%
Business	1.0%	-1.6%	-1.1%	-2.2%	-0.5%	-3.4%
Other	0.1%	0.0%	-0.8%	-1.1%	-1.5%	-2.0%
LGV	0.5%	-1.6%	0.4%	-1.3%	2.3%	-1.8%
HGV	-3.8%	-1.2%	-3.6%	-1.8%	-3.6%	-0.6%

7.4.3.3 Sector Matrices

For the purposes of sector to sector checks we have assessed five areas as defined earlier in Section 5.1. The WebTAG guidelines indicate that changes should generally be less than 5%, the percentage changes shown below are in many cases greater than this. Two key factors responsible for this are:

- The nature of the prior matrices, for which the area to area trip patterns were derived from fully observed data but for which the splitting to a fine zonal level was based on synthetic data; and
- The large number of controlling counts, which provided for a very fine level of tuning of trip ends.

Thus the results show that while broad observed trip length and origin and destination patterns were unchanged, there was a larger readjustment of origin-destination movements within the area. Changes, in terms of percentage and GEH values for each sector to sector movement are shown in Table 65, Table 66 and Table 67.

Table 65 Sector to Sector Changes in Matrix Estimation – AM Peak

		Town Centre	Warrington N	Warrington S	External S	External N
Town Centre	% Change	4.4%	36.1%	3.4%	9.8%	16.6%
	GEH	2.3	10.9	4.6	2,3	5.3
Warrington North	%change	20.7%	25.7%	33.0%	-6.3%	4.5%
	GEH	9.2	16.4	8.4	2.4	3.0
Warrington South	%change	17.4%	17.0%	9.6%	5.2%	1.5%
	GEH	4.4	4.4	4.6	2.1	0.5
External South	%change	-25.4%	-3.8%	2.5%	-0.1%	4.0%
	GEH	9,1	1.3	0.8	0.5	6.9
External North	%change	15.1%	1.9%	-4.4%	-2.3%	0.8%
	GEH	6.7	1.2	1.4	3.9	4.1

Table 66 Sector to Sector Changes in Matrix Estimation – Inter Peak

		Town Centre	Warrington N	Warrington S	External S	External N
Town Centre	% Change	-22.3%	15.8%	9.2%	-11.5%	-5.2%
	GEH	9.1	6.5	2.3	3.3	2.1
Warrington North	%change	19.4%	27.4%	27.5%	11.4%	27.7%
	GEH	7.8	13.9	6.0	3.3	13.5
Warrington South	%change	18.0%	16.4%	12.7%	15.0%	14.4%
	GEH	4.3	3.8	4.7	4.1	3.5
External South	%change	-6.3%	-21.2%	-2.0%	-0.9%	-3.5%
	GEH	1.8	7.0	0.6	2.6	5.1
External North	%change	3.0%	18.7%	1.2%	-1.1%	0.8%
	GEH	1.1	9.4	0.3	1.6	3.3

Table 67 Sector to Sector Changes in Matrix Estimation – PM Peak

		Town Centre	Warrington N	Warrington S	External S	External N
Town Centre	% Change	4.2%	28.9%	7.8%	9.3%	9.0%
	GEH	2.2	13.4	2.2	2.9	4.2
Warrington North	%change	20.5%	24.0%	11.9%	-4.5%	20.0%
	GEH	8.2	14.0	3.1	1.5	11.7
Warrington South	%change	10.1%	21.6%	20.0%	28.0%	-1.3%
	GEH	2.4	5.7	8.5	8.4	0.4
External South	%change	-11.2%	-17.5%	4.5%	-0.3%	-5.2%
	GEH	3.6	7.1	1.5	1.2	9.2
External North	%change	7.0%	19.4%	19.9%	0.3%	1.4%
	GEH	2.7	12.0	6.3	0.6	7.0

7.4.5 Stress Tests

Stress tests were carried out on the AM and PM peak during calibration to further review network coding. The test requires increasing total network demand by 10%, the objective being to identify which junctions become overloaded with the increased flow, and which junctions, despite increased demand continue to experience no significant congestion.

The tests were repeated at the end of the matrix estimation process with the following results.

Table 68 Stress Test Summary Results

	AM Peak		PM Peak	
	Final Model	10% Flow Increase	Final Model	10% Flow Increase
Iterations to convergence	38	57	63	73
Total Travel time Simulation network (pcu hrs-hr)	24,479	27,925 (+14%)	24,937	28,036 (+12%)
Average speed (simulation network (kmh)	57.6	53.8 (-7%)	55.5	51.8 (-7%)
Transient queues (pcu)	4,220.2	5,138.7 (+22%)	4,595.5	5,616.3 (+22%)

Delay difference plots are provided in Appendix I. From the final stress tests it was concluded that the key areas of congestion in the network are identified appropriately by the model.

7.4.6 Scheme Testing

A test has also been carried out using a notional highway improvement scheme in order to check how the model responds. The key features of this test were:

- VDM assignments undertaken for both 2026 and 2036;
- Demand derived from NTEM 7.2 growth factors; and
- Assessment of both a Do Minimum and a Do Something option.

The Do Minimum network assumed the inclusion of the following committed schemes:

- M62 Junction 8 Improvements Scheme;
- Omega Local Highway Improvements Scheme;
- Omega Zones 3-6 Junction Improvements Scheme;
- Warrington East Phase 2 Scheme; and
- Centre Park Link.

The Do Something network then added a generic option for an additional crossing for the Ship Canal and the Mersey, relieving congestion within the town centre and providing additional options for traffic between North and South Warrington.

The model outputs were reviewed to identify the changes in trip patterns between the Do Minimum and Do Something. Results for the test are included in Appendix K.

7.5 Highway Calibration Assignment Results

We have reported the results against a number of criteria in order to show how close the model is to meeting WebTAG acceptability guidelines (as presented earlier in Section 3.4 and 3.5). The results of this assessment is described below.

The use of a flow and journey time dashboard to record and present the model outputs against the observed data is provided in Appendix I.

7.5.1 Comparison of Modelled Flows – Screenlines and Cordons

Chapter 4 presented the locations of the count sites used in the calibration and validation of the highway model and those which have been used on a screenline or cordon.

Summaries of the screenline performance are shown in Table 70 to Table 72 for each modelled time period. Cordon summaries for both the inner and outer cordon are presented in Table 73 to Table 75 and on Figure 96 to Figure 101

The overall statistics of how well the calibration screenlines or cordons met WebTAG actability criteria is shown in Table 69 where 16 screenlines, and 4 cordons have been assessed.

Table 69 Screenline and Cordon Overall Summary

Criteria	Time Period	Pass	Near*	Fail
Percentage of Screenlines or Cordons where the Flow Difference < 5%	AM	90%	10%	-
	IP	85%	10%	5%
	PM	95%	5%	-
Percentage of Screenlines or Cordons where GEH < 4	AM	100%	-	-
	IP	95%	5%	-
	PM	95%	5%	-

*Definition of ‘Near’ and ‘Fail’ categories – for flow difference this is a percentage between 5% and 10%, for GEH, this is a vale between 5 and 7.5. Fail represents GEH > 10 and flow difference > 10%

In the AM, 2 screenlines fall outside the 5% flow target but by less than 1% at 5.3% and 5.6%. In the Inter-peak, 2 screenlines fall outside the 5% flow target, and one screenline outside of the 10% target. The maximum reported flow difference percentage for the Inter-peak is 10.1% across a screenline. In the PM, only 1 site falls outside the 5% target and this is only 6.3%. All 3 time periods report an 85% ‘pass rate’ or higher.

Table 70 AM Screenline Calibration Summary

Screenline	Direction	Observed			Modelled			Difference			% Difference			GEH			TOTAL Flow Diff Meeting WebTAG
		Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	
A49 North / South	Northbound	2,754	110	2,864	2,764	100	2,864	10	-10	0	0%	-9%	0.0%	0.20	0.99	0.00	YES
	Southbound	3,061	84	3,145	2,896	83	2,979	-165	-1	-166	-5%	-1%	-5.3%	3.03	0.09	3.00	NO
West of A49	Eastbound	3,358	177	3,535	3,281	128	3,409	-77	-49	-126	-2%	-28%	-3.6%	1.34	3.99	2.15	YES
	Westbound	4,439	160	4,599	4,432	116	4,549	-7	-44	-50	0%	-27%	-1.1%	0.10	3.71	0.74	YES
East of A49	Eastbound	3,686	156	3,842	3,636	127	3,763	-50	-29	-79	-1%	-19%	-2.1%	0.82	2.47	1.28	YES
	Westbound	5,023	144	5,167	5,103	126	5,229	80	-18	62	2%	-13%	1.2%	1.12	1.58	0.85	YES
Birchwood	Northbound	4,019	251	4,270	3,835	197	4,032	-184	-54	-238	-5%	-22%	-5.6%	2.93	3.61	3.69	NO
	Southbound	3,947	186	4,133	3,778	186	3,964	-169	-0	-169	-4%	0%	-4.1%	2.71	0.00	2.65	YES
Canal	Northbound	3,565	40	3,605	3,668	93	3,761	102	53	155	3%	133%	4.3%	1.70	6.51	2.56	YES
	Southbound	3,152	63	3,215	3,173	88	3,261	21	25	46	1%	40%	1.4%	0.37	2.89	0.80	YES
Rail East / West	Eastbound	2,050	75	2,125	2,050	55	2,104	-0	-20	-21	0%	-27%	-1.0%	0.01	2.50	0.45	YES
	Westbound	1,565	57	1,622	1,578	59	1,638	13	2	16	1%	4%	1.0%	0.34	0.32	0.39	YES
Rail North / South	Northbound	5,114	119	5,233	4,895	100	4,994	-219	-19	-239	-4%	-16%	-4.6%	3.10	1.84	3.34	YES
	Southbound	4,473	136	4,609	4,415	131	4,546	-58	-5	-63	-1%	-4%	-1.4%	0.87	0.42	0.92	YES

The AM calibration results indicate that the model is reflecting base conditions well against the observed results at a screenline level. The maximum observed percentage difference is a 5.6% underestimation of demand across the northbound screenline at Birchwood. The maximum reported GEH across a screenline is also low at 6.51 heading northbound across the Canal screenline where the model is reporting an additional 155 trips compared to the observed.

Table 71 IP Screenline Calibration Summary

Screenline	Direction	Observed			Modelled			Difference			% Difference			GEH			TOTAL Flow Diff Meeting WebTAG
		Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	
A49 North / South	Northbound	1,883	92	1,975	1,917	75	1,993	34	-17	18	2%	-18%	0.9%	0.79	1.81	0.40	YES
	Southbound	2,086	91	2,177	1,883	75	1,957	-203	-16	-220	-10%	-18%	-10.1%	4.57	1.81	4.84	NO
West of A49	Eastbound	2,575	140	2,715	2,589	111	2,700	14	-29	-15	1%	-21%	-0.6%	0.28	2.60	0.29	YES
	Westbound	2,597	129	2,726	2,596	111	2,708	-1	-18	-18	0%	-14%	-0.7%	0.01	1.60	0.35	YES
East of A49	Eastbound	2,767	113	2,880	2,919	106	3,025	152	-7	145	5%	-6%	5.0%	2.84	0.65	2.66	YES
	Westbound	2,957	113	3,070	3,006	102	3,108	49	-11	38	2%	-9%	1.2%	0.89	1.03	0.69	YES
Birchwood	Northbound	2,364	216	2,580	2,417	217	2,634	53	1	54	2%	0%	2.1%	1.09	0.06	1.06	YES
	Southbound	2,149	215	2,364	2,205	232	2,438	56	17	74	3%	8%	3.1%	1.21	1.17	1.51	YES
Canal	Northbound	2,642	29	2,671	2,718	75	2,793	75	46	122	3%	160%	4.6%	1.45	6.43	2.33	YES
	Southbound	2,847	59	2,905	2,843	70	2,913	-4	11	8	0%	19%	0.3%	0.07	1.39	0.14	YES
Rail East / West	Eastbound	1,735	67	1,802	1,735	50	1,785	-0	-17	-17	0%	-25%	-0.9%	0.01	2.18	0.40	YES
	Westbound	1,689	62	1,751	1,690	62	1,753	1	0	2	0%	0%	0.1%	0.04	0.02	0.04	YES
Rail North / South	Northbound	3,343	114	3,457	3,386	109	3,495	43	-5	38	1%	-4%	1.1%	0.74	0.46	0.65	YES
	Southbound	3,259	102	3,361	3,278	109	3,387	19	7	26	1%	7%	0.8%	0.33	0.70	0.45	YES

The Inter peak calibration results also indicate that the model is reflecting observed conditions well although there is one screenline with a percentage difference of 10.1%. 5 of the 8 sites that make up this screenline are underestimating demand between 20-40 trips. It is the cumulative effect of this that is driving the overall difference compared to the observed. The GEH value for this screenline however is less than 5 indicating that this is within tolerance and still a good reflection of observed conditions overall.

The Canal screenline southbound and the outer cordon outbound both are within the 5% tolerance range indicating that the overall volume travelling across the screenline and cordon in this area is reflecting observed conditions well. It is likely that there are not enough localised trips in the area of the A49 north-south screenline that could be affecting the volume of demand.

Table 72 PM Screenline Calibration Summary

Screenline	Direction	Observed			Modelled			Difference			% Difference			GEH			TOTAL Flow Diff Meeting WebTAG
		Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	
A49 North / South	Northbound	2,738	108	2,846	2,800	51	2,851	62	-57	5	2%	-53%	0.2%	1.18	6.46	0.09	YES
	Southbound	2,699	57	2,756	2,684	47	2,731	-15	-10	-25	-1%	-18%	-0.9%	0.30	1.41	0.49	YES
West of A49	Eastbound	4,734	68	4,802	4,669	63	4,732	-65	-5	-70	-1%	-7%	-1.5%	0.95	0.59	1.01	YES
	Westbound	3,454	67	3,521	3,461	67	3,528	7	0	7	0%	0%	0.2%	0.12	0.01	0.12	YES
East of A49	Eastbound	5,055	63	5,118	5,042	66	5,108	-13	3	-10	0%	4%	-0.2%	0.18	0.34	0.14	YES
	Westbound	4,306	54	4,360	4,295	52	4,347	-11	-2	-13	0%	-4%	-0.3%	0.16	0.28	0.19	YES
Birchwood	Northbound	4,410	132	4,542	4,386	136	4,521	-24	4	-21	-1%	3%	-0.5%	0.37	0.31	0.31	YES
	Southbound	3,341	148	3,489	3,462	149	3,612	121	1	123	4%	1%	3.5%	2.08	0.11	2.06	YES
Canal	Northbound	3,315	35	3,350	3,335	47	3,382	20	12	32	1%	33%	1.0%	0.35	1.83	0.55	YES
	Southbound	3,572	63	3,635	3,560	51	3,611	-12	-12	-24	0%	-19%	-0.7%	0.20	1.57	0.40	YES
Rail East / West	Eastbound	2,004	52	2,056	2,005	52	2,056	1	-0	0	0%	-1%	0.0%	0.01	0.05	0.01	YES
	Westbound	2,076	51	2,127	2,103	47	2,150	27	-4	23	1%	-8%	1.1%	0.59	0.56	0.50	YES
Rail North / South	Northbound	4,838	78	4,916	4,737	85	4,821	-101	7	-95	-2%	9%	-1.9%	1.47	0.75	1.36	YES
	Southbound	5,140	93	5,233	4,930	93	5,023	-210	0	-210	-4%	0%	-4.0%	2.96	0.03	2.93	YES

In the PM model, no screenline falls outside the 5% target. The maximum recorded GEH in the PM is 6.46 for HGVs on the A49 north-south screenline where the model is underestimating HGV demand by approximately 60 trips. The total demand overall is well within GEH and percentage flow difference.

Of the 12 reported cordon results shown in Table 73 to Table 75, only two; inner cordon outbound in the Inter peak model is outside the 5% flow difference target at 6% and a GEH of 5.22, and inner cordon inbound in the PM model is outside the 5% flow difference target at 6.3% and a GEH of 5.42 All light vehicles report a GEH less than 5 with 5 HGV results showings a GEH >5. In most instances, the model is underestimating HGV demand across the cordons. Only the outer cordon (inbound direction) is reporting positive demand in all time periods, indicating that the right volume overall is entering the borough and it is likely that localised routing is having an effect. Overall, the cordon results for all three time periods are reflecting observed data well with model results within acceptable tolerances.

Table 73 AM Cordon Calibration Summary

Screenline	Direction	Observed			Modelled			Difference			% Difference			GEH			TOTAL Flow Diff Meeting WebTAG
		Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	
Outer Cordon	Inbound	12,262	674	12,936	12,128	749	12,877	-134	75	-59	-1%	11%	0%	1.21	2.79	0.52	YES
	Outbound	13,156	713	13,869	12,728	618	13,346	-428	-95	-523	-3%	-13%	-4%	3.76	3.67	4.48	YES
Inner Cordon	Inbound	8,327	449	8,776	8,532	302	8,834	205	-147	58	2%	-33%	1%	2.23	7.58	0.62	YES
	Outbound	5,993	275	6,268	5,844	248	6,092	-149	-27	-176	-2%	-10%	-3%	1.94	1.67	2.24	YES

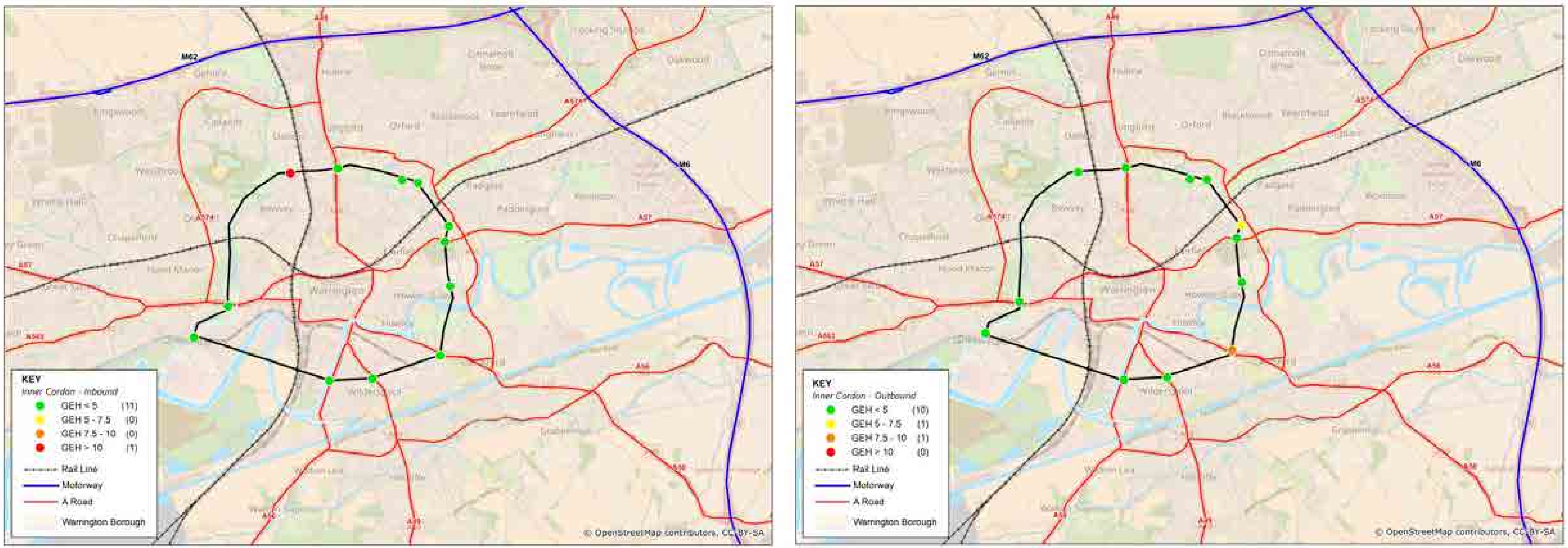
Table 74 IP Cordon Calibration Summary

Screenline	Direction	Observed			Modelled			Difference			% Difference			GEH			TOTAL Flow Diff Meeting WebTAG
		Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	
Outer Cordon	Inbound	8,711	690	9,401	8,722	794	9,517	11	104	116	0%	15%	1%	0.12	3.83	1.19	YES
	Outbound	8,834	700	9,534	8,867	659	9,526	33	-41	-8	0%	-6%	0%	0.35	1.56	0.08	YES
Inner Cordon	Inbound	6,441	383	6,824	6,437	233	6,669	-4	-150	-155	0%	-39%	-2%	0.05	8.56	1.88	YES
	Outbound	6,615	319	6,934	6,286	220	6,506	-329	-99	-428	-5%	-31%	-6%	4.10	6.03	5.22	NO

Table 75 PM Cordon Calibration Summary

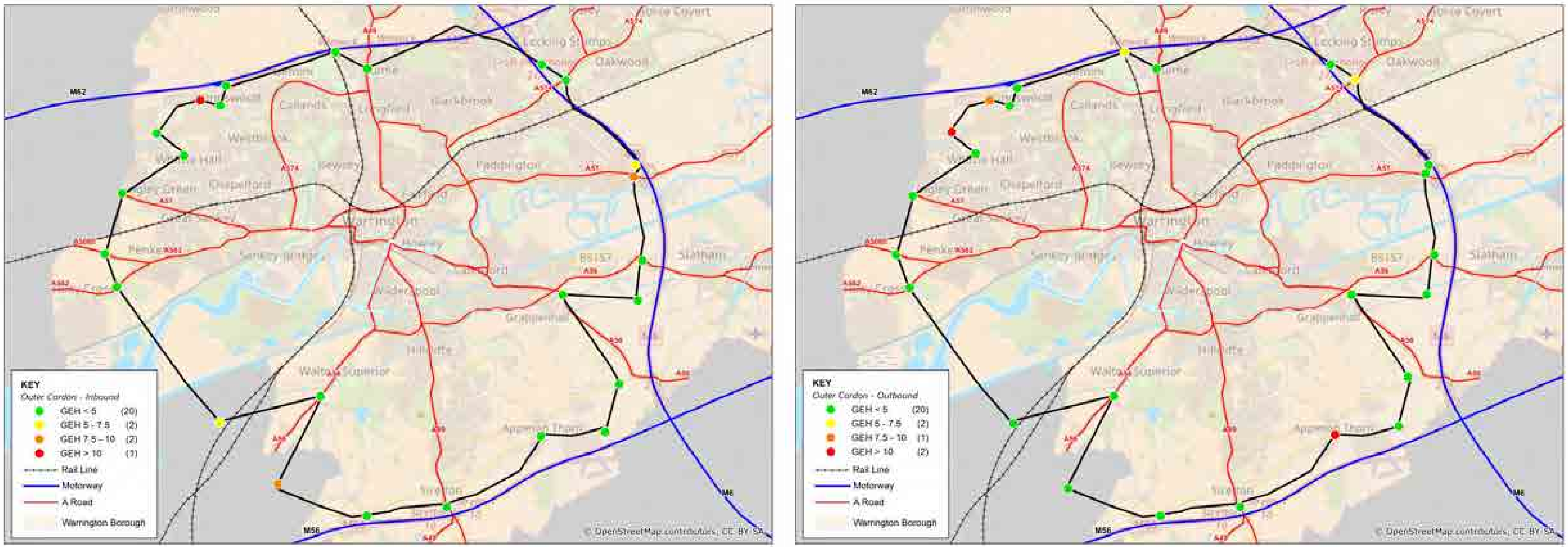
Screenline	Direction	Observed			Modelled			Difference			% Difference			GEH			TOTAL Flow Diff Meeting WebTAG
		Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	
Outer Cordon	Inbound	13,345	538	13,883	13,270	547	13,818	-75	9	-65	-1%	2%	0%	0.65	0.41	0.56	YES
	Outbound	13,154	514	13,668	12,798	450	13,248	-356	-64	-420	-3%	-12%	-3%	3.12	2.92	3.62	YES
Inner Cordon	Inbound	6,919	271	7,190	6,614	123	6,738	-305	-148	-452	-4%	-55%	-6.3%	3.70	10.52	5.42	NO
	Outbound	8,986	249	9,235	9,063	135	9,198	77	-114	-37	1%	-46%	0%	0.81	8.24	0.39	YES

Figure 96 AM Inner Cordon GEH Results – Inbound (left), Outbound (right)



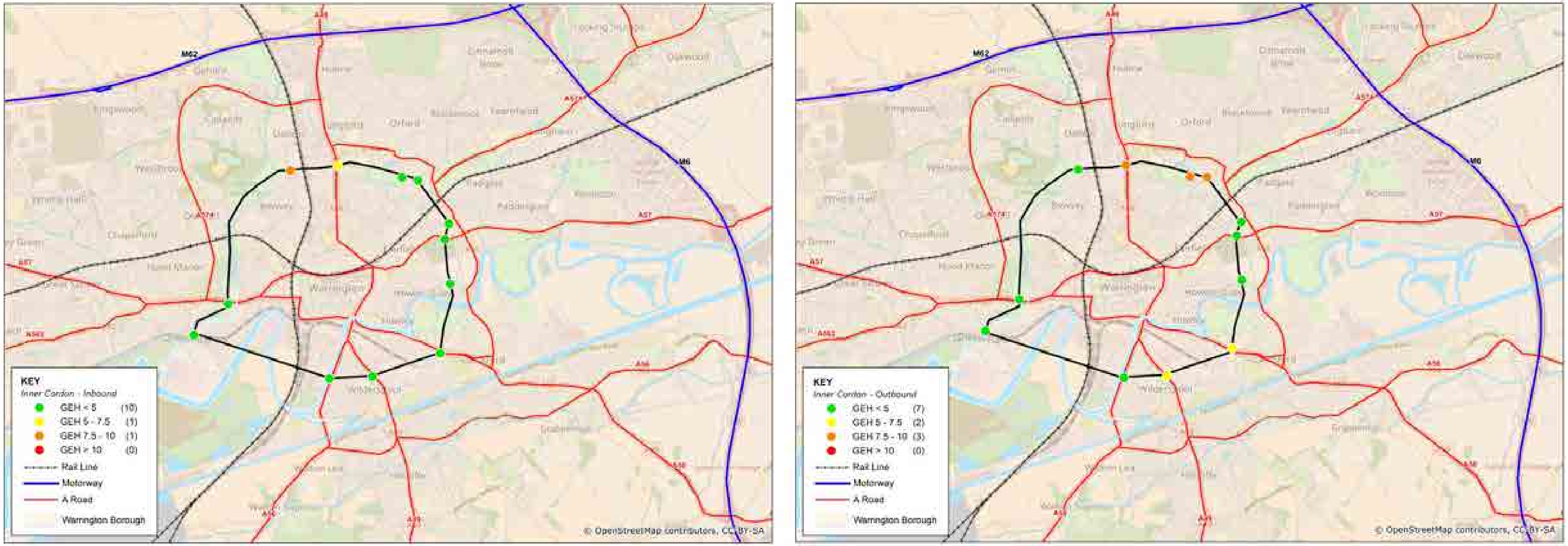
In the AM for both directions, at least 10 out of the 12 individual sites on the inner cordon return a GEH value of less than 5. Only one site in the inbound direction has a GEH greater than 10. This is site ATC_126 on Longshaw Street which has a GEH value of 11.09. This site is reporting an underestimation of trips. However, in this instance, the adjacent site on A49 Winwick Road is reporting a corresponding over-estimation in the number of trips along this link but is reporting a GEH just less than 5 at 4.97. Overall, the volume of trips crossing the inner cordon is accurate, however the site specific results show some minor variability.

Figure 97 AM Outer Cordon GEH Results – Inbound (left), Outbound (right)



Comparing the outer cordon results, again the model is reflecting observed conditions well. In both directions, 20 out of the 25 individual sites report a GEH < 5, with only 3 out the 50 greater than 5; one in the inbound direction, and two in the outbound direction. The maximum recorded GEH is 18.6 along Omega Boulevard in the outbound direction where the model is underestimating car demand by 200. Some of this variance is accounted for at the adjacent site along Skyline drive which is over-estimating car demand by 100 (and reporting a GEH of 7.6). It is likely that this is a result of using simplified zone loading points in the area and demand alternating between routes during the assignment.

Figure 98 Inter Peak Inner Cordon GEH Results – Inbound (left), Outbound (right)



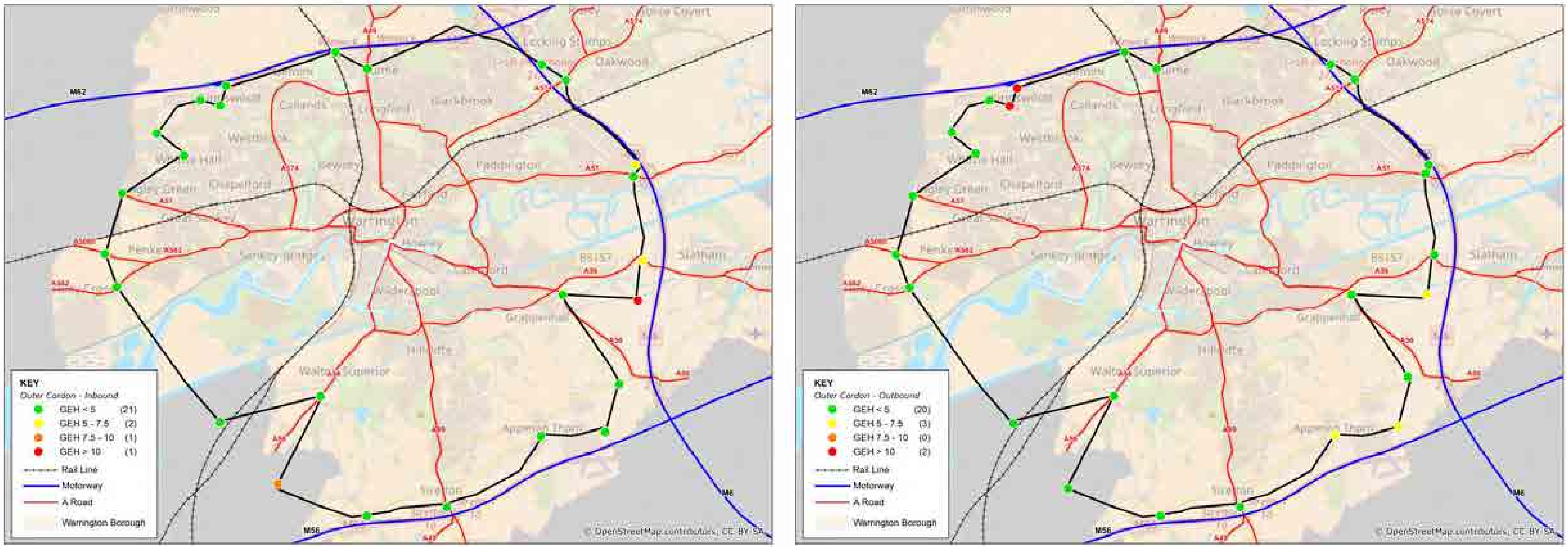
In the Inter peak, the Longshaw St site is now over-estimating demand and the A49 is under-estimating demand. Both sites in the inbound direction return GEH values between 5-10 at 7.82 and 5.77 respectively. Overall, 10 out of the 12 sites report GEH values of less than 5.

In the outbound direction, there is more variability, with 7 out of 12 sites reporting a GEH less than 5, with 5 sites reporting a GEH between 5 – 10. Performance across this screenline is still positive relative to observed data but there are 2 instances where parallel routing and route choice are affecting individual site performance;

- Hallfields Road and Smith Drive – GEH of 8.47 and 9.42 respectively but Hallfields Road is under estimating the number of trips by 120 whilst Smith Drive is over estimating demand by approximately 140 trips; and
- Knutsford Road and Wilderspool Causeway – GEH of 6.10 and 5.19 respectively. Here, Knutsford Road is reporting 150 fewer trips, whilst Wilderspool Causeway is 130 too many.

These examples indicate that the number of trips and overall volume crossing the cordon is reflecting observed data well, there is some variability at the individual site level.

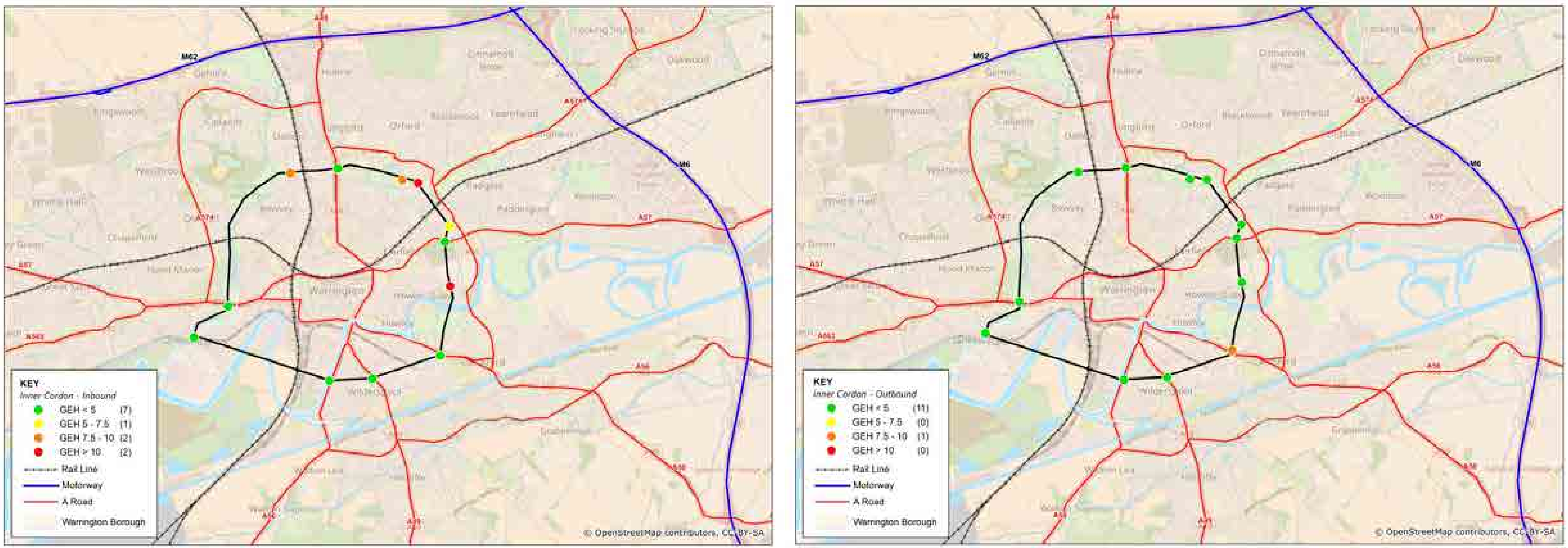
Figure 99 Inter Peak Outer Cordon GEH Results – Inbound (left), Outbound (right)



Across the outer cordon, 41 of the 50 sites all report a GEH less than 5. As in the AM, only 3 out of the 50 sites return a GEH greater than 10. The maximum reported GEH in the Inter peak is 14.03 along Charon Way heading outbound. The adjacent site along Burtonwood Road also reports a GEH greater than 10 in the outbound direction (10.07). Again, here we are seeing parallel route choice affecting flow. The Charon Way site is under estimating demand by roughly the same volume that is being overestimated along Burtonwood Road.

Similarly, in the inbound direction, Weaste Lane returns a GEH of 11.59 whilst the adjacent site on Stockport Road returns a GEH of 7.07. The Weaste Lane site has approximately 100 too many trips whilst Stockport Road is under estimating demand by 120.

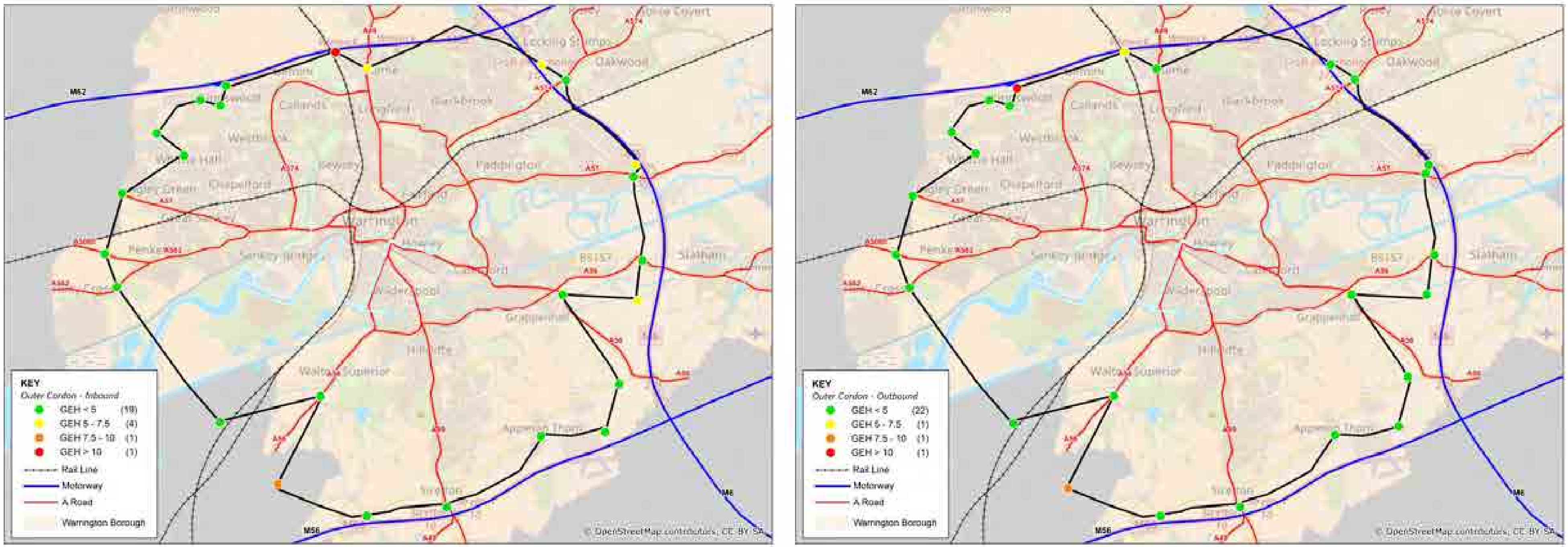
Figure 100 PM Inner Cordon GEH Results – Inbound (left), Outbound (right)



In the PM model, the inner cordon inbound has the most instances of parallel route choice affecting headline performance. 2 out of the 12 sites have a GEH greater than 10 and the maximum reported GEH is 11.71 along Farrell Street. Here, the poorly performing sites are impacted by parallel route choice; with Smith Drive reporting too many trips relative to the observed data and Hallfields Road under reporting the number of trips relative to the observed data. The same trend along Longshaw Street and A49 Winwick Road is also noted in the PM.

In the outbound direction, all sites report a GEH of less than 10. Only 1 site out of the 12 has a GEH greater than 5; Knutsford Rd at 8.09 . Again, this site is being impacted by parallel route choice but the overall volumes crossing the cordons in the PM are accurate to observed data.

Figure 101 PM Outer Cordon GEH Results – Inbound (left), Outbound (right)



Across the outer cordon, only 2 sites out of the 50 return a GEH greater than 10; Mill Lane inbound, and Charon Way outbound. Mill Lane is affected by A49 Winwick Road attracting a higher number of trips compared to the observed, whilst Charon Way is again affected by demand along Burtonwood Road and Mill Lane north.

Overall, the number of individual sites returning a GEH greater than 5 across both cordons is low. Out of a possible 74 sites in a given time period and across both the inner and outer cordons:

- In the AM - 4 sites have a GEH > 10 – 3 on the outer cordon, 1 on the inner cordon;
- In the Inter peak – 3 sites have a GEH > 10 – all 3 are found on the outer cordon; and
- In the PM – 4 sites have a GEH > 10 – 2 on the outer cordon, 2 on the inner cordon.

In each instance where GEH performance for an individual site is > 5, the reason for the variance is primarily due to parallel route choice affecting site-specific volume.

7.5.2 Comparison of Modelled Flows – Count Sites

In addition to assessing the performance of the model at a screenline and cordon level, individual count sites have also been analysed. A summary of the overall performance by time period is shown in Table 76. This table presents results for all counts sites used either for calibration or validation. A summary for sites used for calibration-only is shown in Table 77.

Table 76 Individual Count Site Summary – Calibration and Validation Sites

Criteria	Time Period	Pass	Near*	Fail
Percentage of Individual Counts where GEH < 5	AM	82%	8%	10%
	IP	83%	10%	8%
	PM	81%	10%	9%
Percentage of Individual Count Sites meeting Flow Criteria	AM	81%	n/a	19%
	IP	86%	n/a	14%
	PM	83%	n/a	17%
Percentage of individual Count Sites meeting either FLOW or GEH criteria	**AM**	**85%**	n/a	15%
	IP	**87%**	n/a	13%
	PM	**85%**	n/a	15%

*Definition of 'Near' and 'Fail' categories – for GEH, this is a value between 5 and 7.5, Fail is for sites where GEH >10

Table 77 Individual Count Site Summary – Calibration Sites Only

Criteria	Time Period	Pass	Near*	Fail
Percentage of Individual Counts where GEH < 5	AM	85%	6%	8%
	IP	86%	8%	5%
	PM	83%	9%	8%
Percentage of Individual Count Sites meeting Flow Criteria	AM	85%	n/a	15%
	IP	90%	n/a	10%
	PM	86%	n/a	14%
Percentage of individual Count Sites meeting either FLOW or GEH criteria	**AM**	**88%**	n/a	12%
	IP	**90%**	n/a	10%
	PM	**87%**	n/a	13%

*Definition of 'Near' and 'Fail' categories – for GEH, this is a value between 5 and 7.5, Fail is for sites where GEH >10

Figure 102 to Figure 104 present the GEH results for each count site by time period. Table summaries of individual count site results can be found in Sections 3 & 4 of the Highway Dashboard (Appendix I). Figure 105 to Figure 107 show the same GEH summaries but only for sites used in calibration.

The results illustrate the geographic spread of sites used in the model calibration exercise, with all areas of the borough assessed. Of the 389 individual sites assessed, in any given time period, between 314 and 322 have a GEH of less than 5 (this is a minimum of 80% of individual sites) and there are no obvious clusters of poor performance.

Only 18 sites recorded a GEH greater than 5 in all 3 time periods and 10 of these sites are junction turning link counts or one-day MCC counts where the reliability of the observed data is lower due to the short duration.

Figure 102 AM GEH Summary - Total Vehicles, All Count Sites

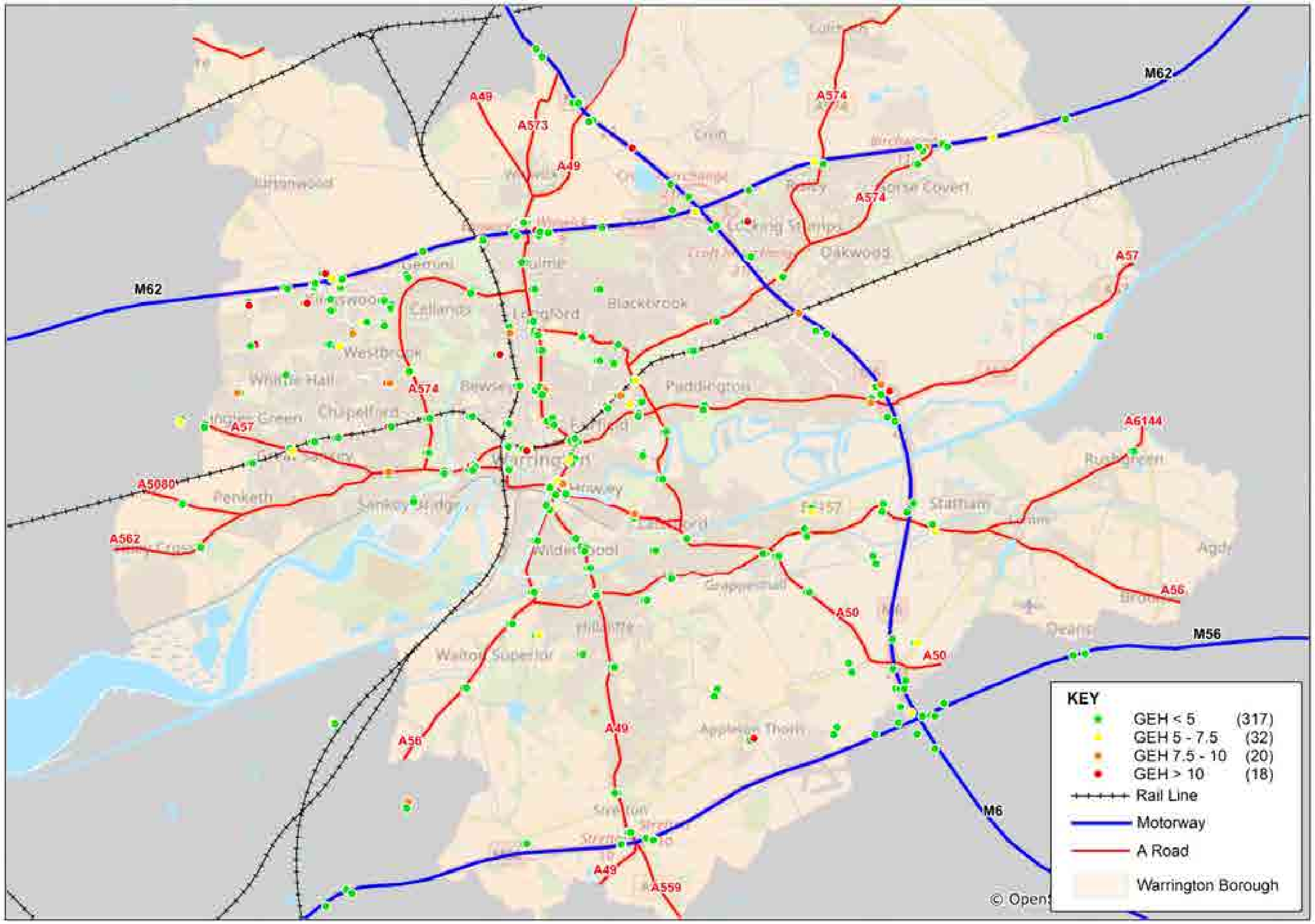


Figure 103 Inter Peak GEH Summary - Total Vehicles, All Count Sites

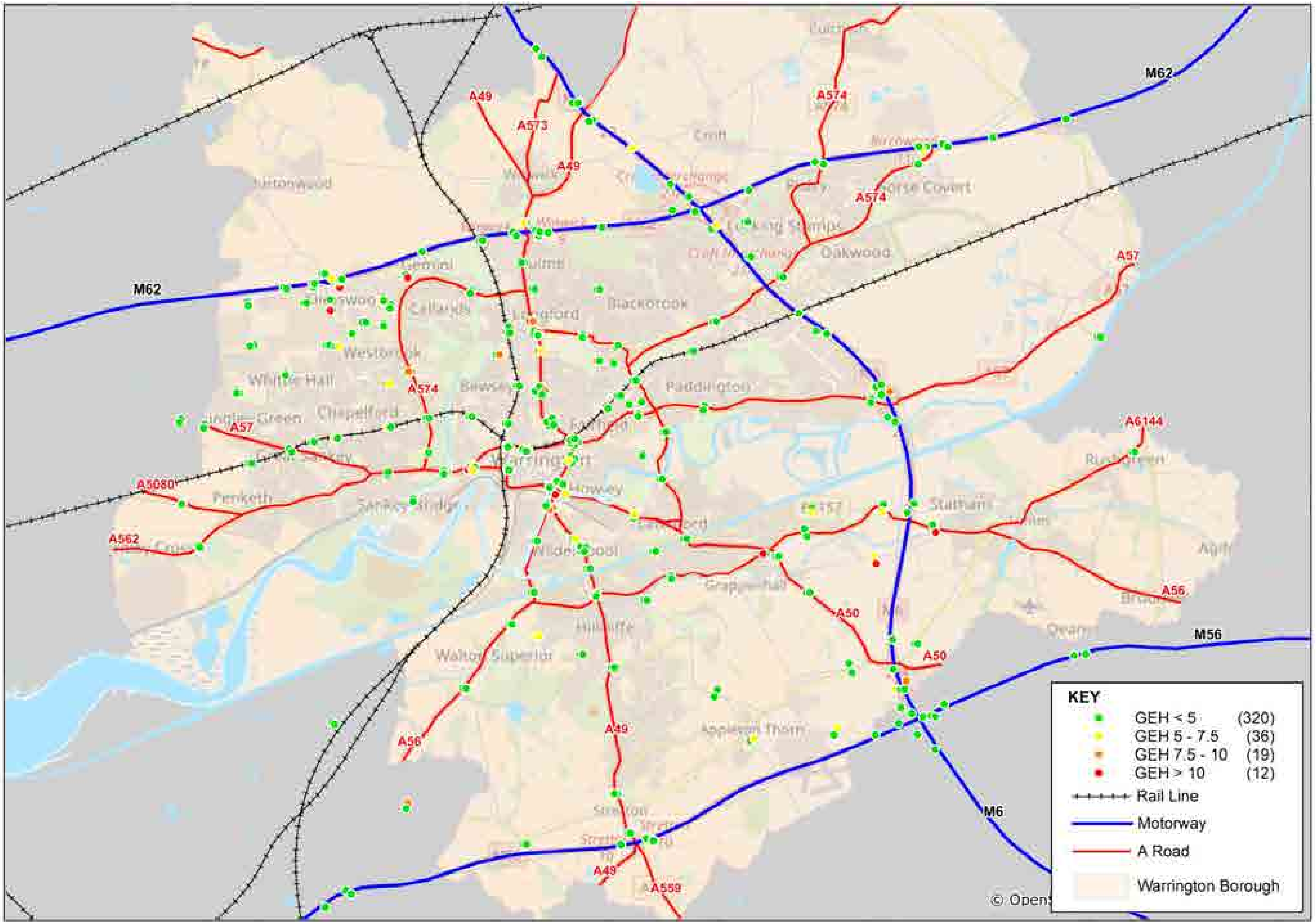


Figure 104 PM GEH Summary - Total Vehicles, All Count Sites

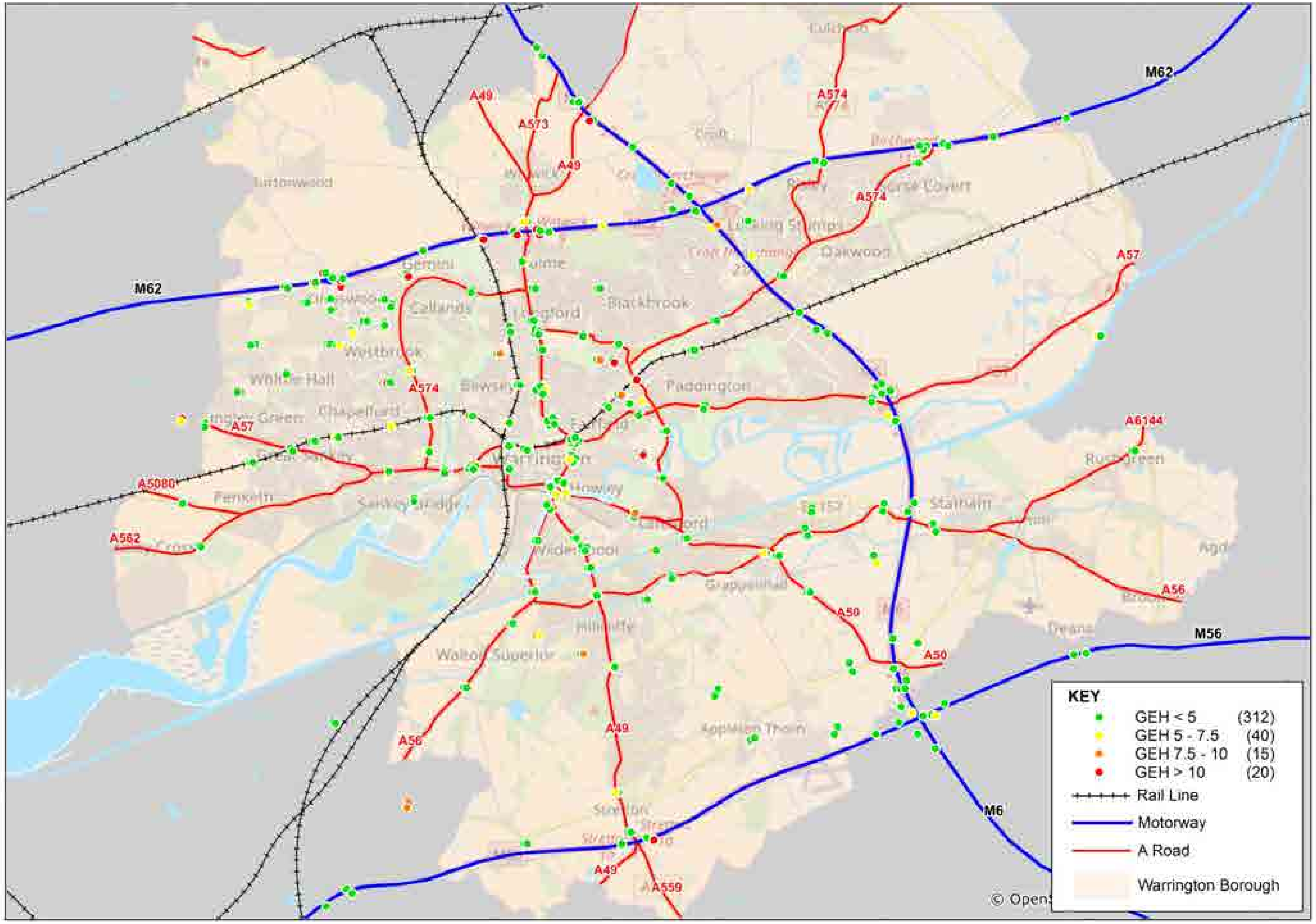


Figure 105 AM GEH Summary - Total Vehicles, Calibration Only Sites

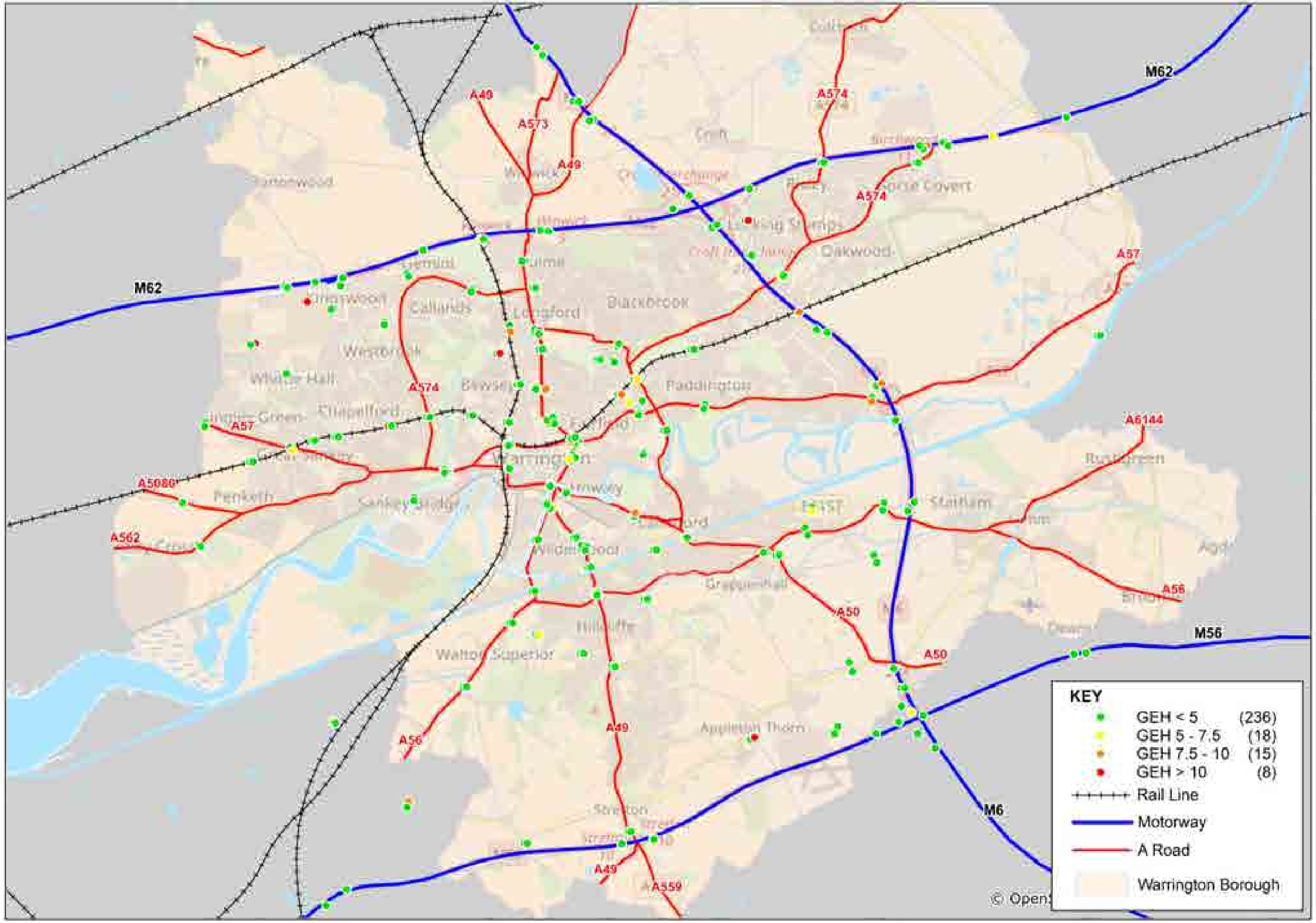


Figure 106 Inter Peak GEH Summary - Total Vehicles, Calibration Only Sites

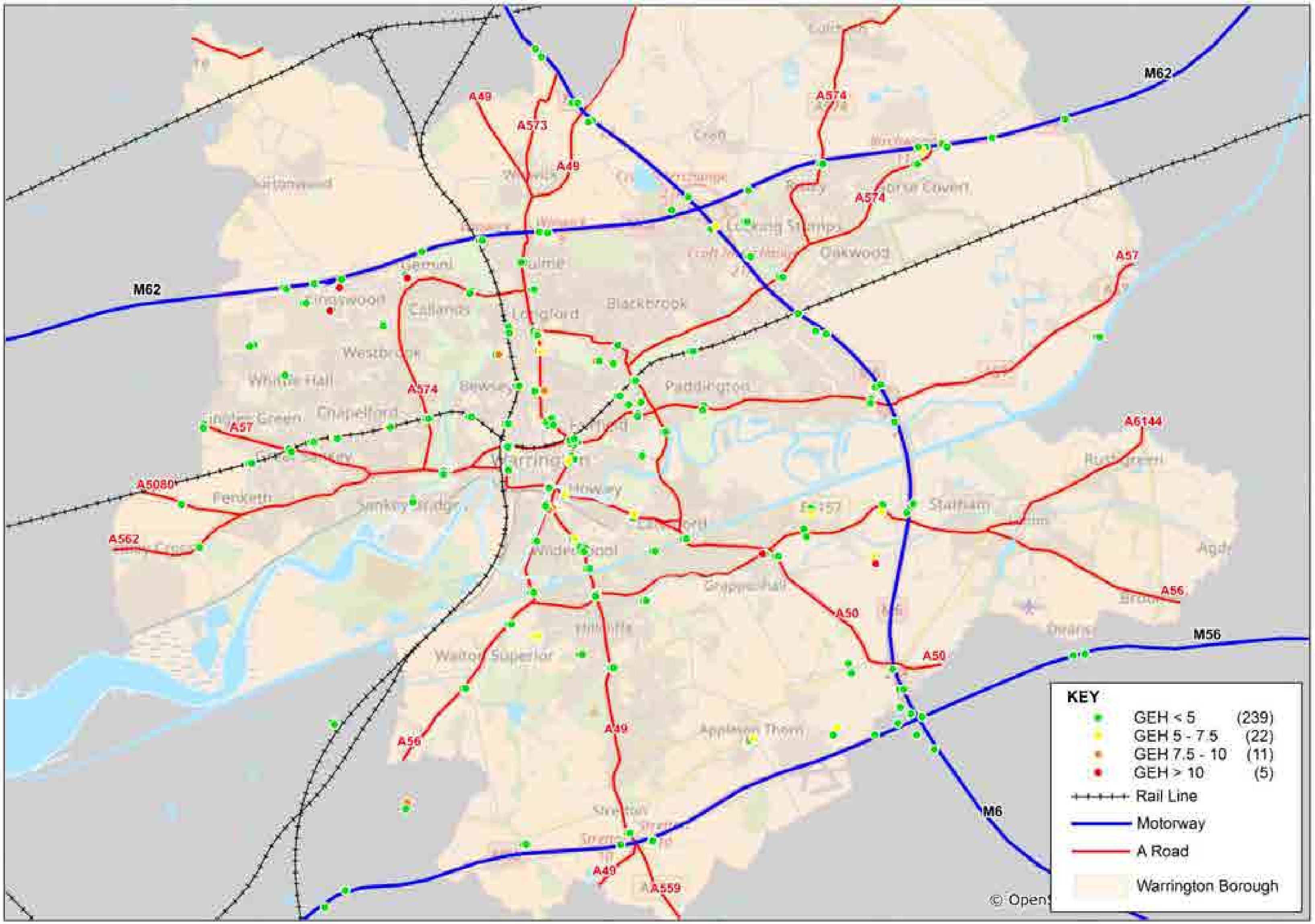
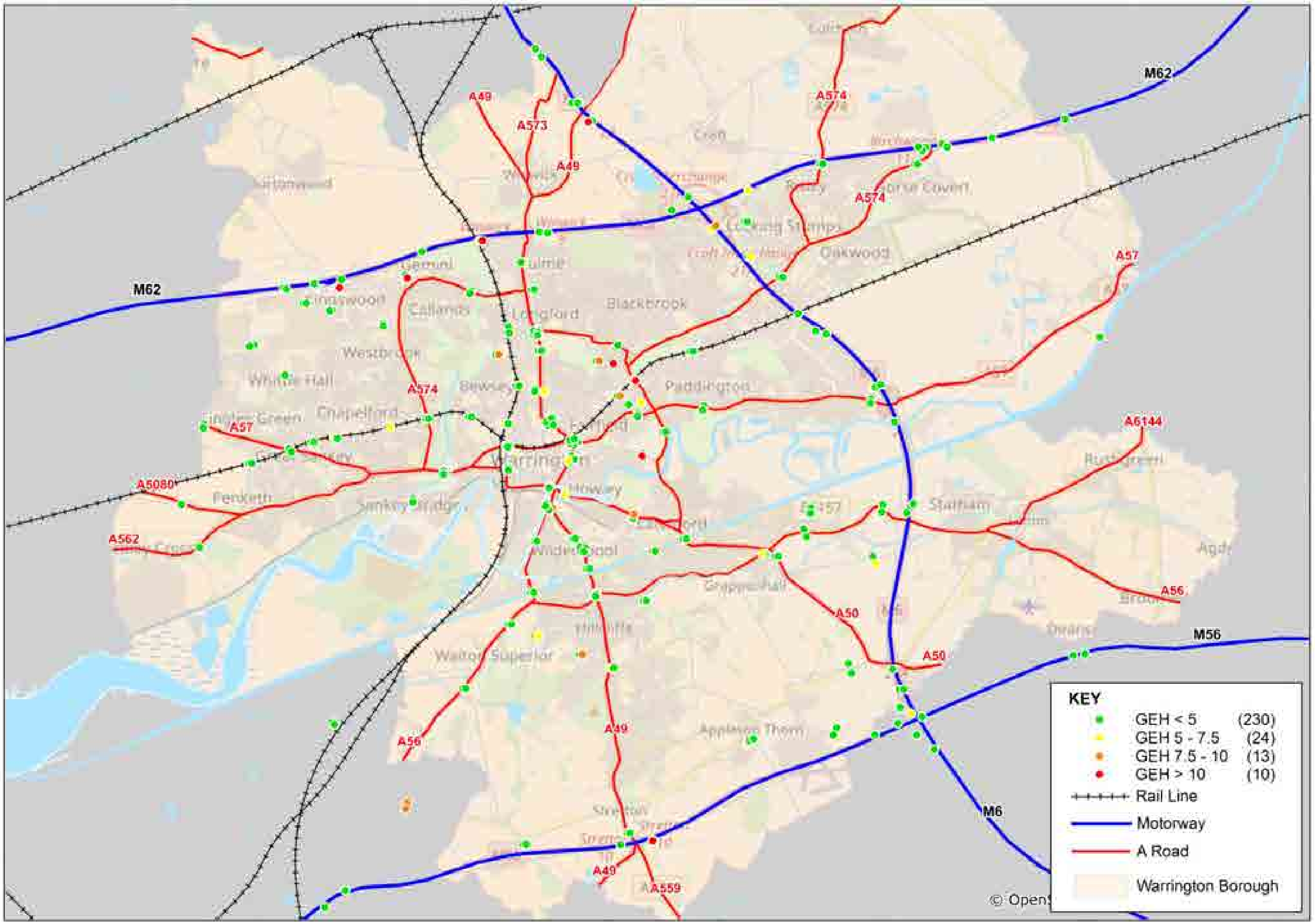


Figure 107 PM GEH Summary - Total Vehicles, Calibration Only Sites



7.5.3 Comparison of Modelled and Observed Journey Times

Section 4.2.6 presented the 19 journey time routes (each route analysed by direction) that have been identified and agreed with WBC covering:

- 3 motorways surrounding Warrington;
- 4 'cross-town' routes covering the key A roads across Warrington and motorway-to-motorway connections; and
- 12 local routes covering other key movements in and around the town.

The overall performance of the routes meeting the WebTAG acceptability criteria is presented in Table 78.

Table 78 Journey Time Routes Meeting Acceptability Criteria

Route Type	AM	IP	PM
Motorway Routes (6)	67%	67%	83%
Cross-Town Routes (8)	100%	100%	100%
Other Local Routes (24)	79%	83%	75%
TOTAL (38)	**82%**	**84%**	**82%**

A breakdown of the individual journey time results by each route and time period are presented in Table 79 to Table 81 for the 3 motorway routes, and Table 82 to Table 84 for the 4 cross-town routes, and the 12 local Warrington routes. In the Inter peak, the only route that does not meet the acceptability criteria is the M6 northbound, where the model is estimating a journey time over 2.5 minutes longer than observed.

Table 79 Observed AM Journey Times for Motorway Routes (in minutes)

ID	Route Direction		Length (km)	AM Time OBS	AM Time MOD	Difference (Mins)	% Difference	WebTAG Compliant
MR 1	M6 – Between Junction 19 and 23	NB	23.3	14.6	17.7	3.1	21%	NO
		SB	24.5	17.9	18.2	0.3	1%	YES
MR 2	M62 – Between Junction 6 and 12	EB	28.6	22.3	19.8	-2.5	-11%	YES
		WB	30.4	17.8	21.9	4.1	23%	NO
MR 3	M56 – Between Junction 7 and 12	EB	22.3	13.6	13.8	0.2	2%	YES
		WB	21.6	12.2	13.9	1.7	14%	YES

In the AM, the two routes that fall outside of the acceptability criteria are both showing longer journey times compared to the observed; over 3 minutes additional time along the M6 northbound, and 4 additional minutes along the M62 westbound. Along the M6 northbound, over half of the additional delay is being generated along the section between Junction 19 (Knutsford) and the Thelwall Viaduct, with a further additional minute to travel over the viaduct up to Junction 21. Along the M62 Westbound, 3 of the 4 additional minutes of delay are being generated between the M60 and Junction 11 at Birchwood.

Both of these routes are highly variable in terms of journey time.

Table 80 Observed Inter Peak Journey Times for Motorway Routes (in minutes)

ID	Route	Direction	Length (km)	IP Time OBS	IP Time MOD	Difference (Mins)	% Difference	WebTAG Compliant
MR 1	M6 – Between Junction 19 and 23	NB	23.3	13.7	16.3	2.6	19%	NO
		SB	24.5	14.0	16.3	2.2	16%	NO
MR 2	M62 – Between Junction 6 and 12	EB	28.6	17.4	19.3	1.9	11%	YES
		WB	30.4	17.6	19.3	1.7	10%	YES
MR 3	M56 – Between Junction 7 and 12	EB	22.3	12.5	13.2	0.8	6%	YES
		WB	21.6	12.0	12.4	0.4	4%	YES

In the Inter peak, the only route that does not meet the acceptability criteria is the M6, where the model is estimating a journey time over 2 minutes longer than what has been observed in each direction. This delay is being generated along the section between J19 at Knutsford and J21.

Table 81 Observed PM Journey Times for Motorway Routes (in minutes)

ID	Route	Direction	Length (km)	PM Time OBS	PM Time MOD	Difference (Mins)	% Difference	WebTAG Compliant
MR 1	M6 – Between Junction 19 and 23	NB	23.3	27.0	20.4	-6.5	-24%	NO
		SB	24.5	15.7	16.7	1.0	6%	YES
MR 2	M62 – Between Junction 6 and 12	EB	28.6	25.2	23.3	-1.9	-7%	YES
		WB	30.4	22.2	23.8	1.6	7%	YES
MR 3	M56 – Between Junction 7 and 12	EB	22.3	14.1	13.5	-0.6	-4%	YES
		WB	21.6	12.9	13.1	0.1	1%	YES

In the PM model, the M6 northbound trend seen in the AM and IP models, is reversed. In this time period, this route is being modelled over 6 minutes quicker than observed times. 5 minutes of this is along the section between J19 and the Thelwall Viaduct.

We have not sought to have time period specific adjustments to the networks and therefore there is a compromise to be reached in the performance by time period. The motorway network is volatile in this context and the results presented above reflect a good compromise overall given the software and data constraints.

Table 82 Observed AM Journey Times for Non-Motorway Routes (in minutes)

ID	Route		Length (km)	AM Time OBS	AM Time MOD	Difference (mins)	% Difference	WebTAG Compliant
XT 1	Cross Town – Via A49	NB	16.5	23.3	23.2	-0.1	0%	YES
		SB	16.2	28.6	27.3	-1.3	-4%	YES
XT 2	Cross Town – Via A57/A50	EB	17.8	30.9	31.1	0.2	1%	YES
		WB	17.5	31.3	27.5	-3.9	-12%	YES
XT 3	Cross Town – Widnes / M6	EB	12.9	15.4	16.6	1.2	8%	YES
		WB	12.7	15.3	15.2	0.0	0%	YES
XT 4	Cross Town – M56 to M62	NB	15.9	25.7	26.9	1.2	5%	YES
		SB	16.7	26.2	26.4	0.1	0%	YES
Wton 1	M56 J11 – Runcorn Bridge – M62 J7	NB	18.5	18.8	17.7	-1.1	-6%	YES
		SB	18.5	18.5	18.1	-0.4	-2%	YES
Wton 2	Cromwell Avenue to Chester Road	CW	13.5	31.6	28.5	-3.1	-10%	YES
		ACW	13.7	31.5	29.0	-2.5	-8%	YES
Wton 3	M6 J21 to M6 J23 via local route	NB	13.3	22.8	20.9	-1.9	-8%	YES
		SB	13.6	19.7	22.0	2.4	12%	YES
Wton 4	Burtonwood to Winwick	SB	5.8	7.2	8.6	1.5	21%	NO
		NB	5.8	8.6	9.3	0.7	8%	YES
Wton 5	A580 to Birchwood	SB	8.3	13.6	10.6	-2.9	-22%	NO
		NB	8.3	13.9	10.4	-3.6	-26%	NO
Wton 6	A56 to M56 J7	EB	16.1	21.4	22.0	-2.1	-9%	YES
		WB	16.1	24.8	23.1	1.0	4%	YES
Wton 7	Burtonwood to Whittle Ave	SB	7.0	11.6	11.4	-0.2	-2%	YES
		NB	7.0	10.2	10.2	0.0	0%	YES
Wton 8	Lovely Lane to Marsh House Lane	EB	3.5	8.2	8.1	-0.2	-2%	YES
		WB	3.5	9.6	9.8	0.2	2%	YES
Wton 9	M6 J21 to Thellwall New Road	CW	13.7	23.1	21.4	-1.7	-7%	YES
		ACW	13.7	19.7	20.8	1.1	5%	YES
Wton 10	Lymm to Daresbury	WB	10.4	16.8	19.7	2.9	18%	NO
		EB	10.3	14.1	16.8	2.7	19%	NO
Wton 11	A580 to M6 J20	SB	24.2	32.7	33.8	1.1	3%	YES
		NB	24.2	32.4	32.9	0.5	2%	YES
Wton 12	Charon Way to Lingley Green	SB	4.9	7.6	8.3	0.7	9%	YES
		NB	5.0	7.9	8.1	0.2	2%	YES

Table 83 Observed Inter Peak Journey Times for Non-Motorway Routes (in minutes)

ID	Route		Length (km)	IP Time OBS	IP Time MOD	Difference (Mins)	% Difference	WebTAG Compliant
XT 1	Cross Town – Via A49	NB	16.5	23.2	22.4	-0.8	-3%	YES
		SB	16.2	19.0	20.9	1.9	10%	YES
XT 2	Cross Town – Via A57/A50	EB	17.8	27.0	28.4	1.4	5%	YES
		WB	17.5	25.1	25.1	0.0	0%	YES
XT 3	Cross Town – Widnes / M6	EB	12.9	14.1	15.6	1.5	10%	YES
		WB	12.7	13.2	14.0	0.8	6%	YES
XT 4	Cross Town – M56 to M62	NB	15.9	22.2	23.6	1.5	7%	YES
		SB	16.7	21.2	24.4	3.2	15%	YES
Wton 1	M56 J11 – Runcorn Bridge – M62 J7	NB	18.5	18.1	15.8	-2.3	-13%	YES
		SB	18.5	15.7	17.6	1.9	12%	YES
Wton 2	Cromwell Avenue to Chester Road	CW	13.5	24.9	25.9	1.0	4%	YES
		ACW	13.7	28.2	26.2	-2.0	-7%	YES
Wton 3	M6 J21 to M6 J23 via local route	NB	13.3	17.4	18.9	1.5	8%	YES
		SB	13.6	17.2	18.2	1.0	6%	YES
Wton 4	Burtonwood to Winwick	SB	5.8	6.5	8.6	2.1	32%	NO
		NB	5.8	7.3	9.3	1.9	26%	NO
Wton 5	A580 to Birchwood	SB	8.3	11.7	10.3	-1.4	-12%	YES
		NB	8.3	11.5	10.3	-1.2	-10%	YES
Wton 6	A56 to M56 J7	EB	16.1	19.1	21.7	-0.9	-4%	YES
		WB	16.1	25.6	22.8	0.7	3%	YES
Wton 7	Burtonwood to Whittle Ave	SB	7.0	10.6	11.8	1.2	11%	YES
		NB	7.0	10.0	10.2	0.2	2%	YES
Wton 8	Lovely Lane to Marsh House Lane	EB	3.5	8.1	7.4	-0.7	-8%	YES
		WB	3.5	8.7	8.4	-0.3	-4%	YES
Wton 9	M6 J21 to Thellwall New Road	CW	13.7	19.5	21.1	1.6	8%	YES
		ACW	13.7	18.7	20.8	2.1	11%	YES
Wton 10	Lymm to Daresbury	WB	10.4	13.9	19.0	5.0	36%	NO
		EB	10.3	12.4	16.3	3.9	31%	NO
Wton 11	A580 to M6 J20	SB	24.2	30.0	33.8	3.8	13%	YES
		NB	24.2	30.0	33.1	3.1	10%	YES
Wton 12	Charon Way to Lingley Green	SB	4.9	7.7	8.2	0.5	6%	YES
		NB	5.0	8.1	7.9	-0.2	-2%	YES

Table 84 Observed PM Journey Times for Non-Motorway Routes (in minute)

ID	Route		Length (km)	PM Time OBS	PM Time MOD	Difference (Mins)	% Difference	WebTAG Compliant
XT 1	Cross Town – Via A49	NB	16.5	28.3	25.4	-2.9	-10%	YES
		SB	16.2	26.1	25.4	-0.7	-3%	YES
XT 2	Cross Town – Via A57/A50	EB	17.8	32.3	31.3	-1.1	-3%	YES
		WB	17.5	35.0	32.2	-2.8	-8%	YES
XT 3	Cross Town – Widnes / M6	EB	12.9	16.2	17.0	0.8	5%	YES
		WB	12.7	15.5	17.8	2.3	15%	YES
XT 4	Cross Town – M56 to M62	NB	15.9	27.5	26.3	-1.2	-5%	YES
		SB	16.7	31.4	30.7	-0.7	-2%	YES
Wton 1	M56 J11 – Runcorn Bridge – M62 J7	NB	18.5	24.4	22.9	-1.5	-6%	YES
		SB	18.5	16.2	18.5	2.2	14%	YES
Wton 2	Cromwell Avenue to Chester Road	CW	13.5	31.6	28.8	-2.9	-9%	YES
		ACW	13.7	34.7	33.3	-1.3	-4%	YES
Wton 3	M6 J21 to M6 J23 via local route	NB	13.3	20.1	24.4	4.3	21%	NO
		SB	13.6	20.3	20.8	0.5	3%	YES
Wton 4	Burtonwood to Winwick	SB	5.8	6.8	7.6	0.8	11%	YES
		NB	5.8	8.7	10.3	1.6	18%	NO
Wton 5	A580 to Birchwood	SB	8.3	17.6	10.3	-7.3	-42%	NO
		NB	8.3	14.0	10.6	-3.4	-24%	NO
Wton 6	A56 to M56 J7	EB	16.1	20.0	22.1	-1.3	-5%	YES
		WB	16.1	27.2	22.1	-1.8	-8%	YES
Wton 7	Burtonwood to Whittle Ave	SB	7.0	11.2	12.1	0.9	8%	YES
		NB	7.0	10.4	10.0	-0.4	-4%	YES
Wton 8	Lovely Lane to Marsh House Lane	EB	3.5	9.3	8.8	-0.5	-5%	YES
		WB	3.5	11.8	9.2	-2.6	-22%	NO
Wton 9	M6 J21 to Thellwall New Road	CW	13.7	21.5	22.8	1.3	6%	YES
		ACW	13.7	23.9	20.9	-3.0	-13%	YES
Wton 10	Lymm to Daresbury	WB	10.4	17.2	17.9	0.7	4%	YES
		EB	10.3	14.0	15.7	1.8	13%	YES
Wton 11	A580 to M6 J20	SB	24.2	34.8	35.1	0.3	1%	YES
		NB	24.2	41.5	33.9	-7.6	-18%	NO
Wton 12	Charon Way to Lingley Green	SB	4.9	8.1	9.3	1.2	14%	YES
		NB	5.0	10.0	9.0	-1.0	-10%	YES

7.5.4 Convergence

As identified in Section 3.5, the WebTAG convergence criteria and acceptability guidelines are set out in Table 11. To summarise:

- % Gap for final 4 iterations to be < 0.1%; and
- Percentage of link flows changing by < 1% to be > 98% of cases (in final 4 iterations).

A summary of the convergence performance for each modelled time period is shown in Table 86 whilst Table 85 presents the assignment results for the 4 preceding loops before convergence is reached. The results indicate a stable model that meets convergence criteria for all 3 time periods.

Table 85 Final Four Assignment Loops before Convergence Reached

Time Period	Criteria	Iteration 4	Iteration 3	Iteration 2	Iteration 1
AM assignment loops 34-37	*No. Loops*	*34 / 200*	*35 / 200*	*36 / 200*	*37 / 200*
	% Delays that change <1%	*99.4*	*99.6*	*99.6*	*99.7*
	% Flows that change < 1%	98.3	99.4	98.7	99.6
	% GAP (< 0.1)	0.0012	0.0015	0.00097	0.0014
IP assignment loops 13-16	*No. Loops*	*13 / 200*	*14 / 200*	*15 / 200*	*16 / 200*
	% Delays that change <1%	*99.8*	*99.7*	*99.7*	*99.7*
	% Flows that change < 1%	98.3	98.9	98.9	99.0
	% GAP (< 0.1)	0.0034	0.0023	0.0039	0.0018
PM assignment loops 59-62	*No. Loops*	*59 / 200*	*60 / 200*	*61 / 200*	*62 / 200*
	% Delays that change <1%	*99.4*	*99.4*	*99.5*	*99.5*
	% Flows that change < 1%	98.4	98.7	98.9	99.1
	% GAP (< 0.1)	0.0034	0.0028	0.0028	0.0032

Table 86 Model Convergence Statistics – Final Assignment Converged Loop

Criteria	AM	IP	PM
No. Loops	*38 / 200*	*17 / 200*	*63 / 200*
% Delays that change <1%	*99.6*	*99.7*	*99.5*
% Flows that change < 1%	98.6	99.0	99.1
% GAP (< 0.1)	0	0.002	0.002

The convergence statistics reported in Table 86 show that each model reaches convergence within 70 iterations (well within the 200 assignment limit set). The results comply with WebTAG criteria set out in Unit M3.1.

8. PT Model

8.1 Context

This chapter outlines the development of the WMMTM16 PT Model and the calibration / validation guidelines against which the model was assessed.

8.2 PT Model Key Guidance and Parameters

The WMMTM16 PT Model has been developed in accordance with the DfT's WebTAG guidance which provides detailed information on the development of transport models, validation criteria and acceptability guidelines and assessment of fitness-for-purpose with specific emphasis on Web*TAG Unit M3.2: Public Transport Assignment Modelling (January 2014)* during the development of the PT model.

8.2.1 Validation Criteria and Acceptability Criteria

Observed data have been collected and collated from a number of different sources and relate to both bus and rail demand and travel time as detailed previously in Section 4.2.7. For full details on the data collection exercise, please refer to the AECOM report *"Warrington Transport Model: Data Collection Report (MDCR), January 2017"* for more information relating to the methodology, collection and analysis of existing data and the additional data collection exercise undertaken in June/July 2016

The differences between modelled and observed data need to be quantified against criteria that enable an assessment to be made to determine the acceptability of the model performance with respect for its intended use. WebTAG unit M3.2 Section 7 provides a set of acceptability guidelines against which model performance should be assessed; these criteria and guidelines have been adopted.

There are three main criteria detailed in WebTAG M3.2 Section 7 that have been applied to the WMMTM16 PT Model.

Guidance WebTAG M3.2 Sections 7.1.2 - 7.1.5

The validation of a public transport assignment model should include comparisons of the following:

*Validation of the **trip matrix** should involve comparisons of assigned and counted passengers across complete screenlines and cordons (as opposed to individual services).*

*Validation of the **network** should involve checks on the accuracy of the coded geometry and times/speeds in the model (i.e. for in-vehicle, access and interchange times).*

*Validation of the **services** should involve comparing the modelled flows of public transport vehicles with counts (as well as other features such as stopping patterns for rail, etc.).*

*Validation of the **assignment** should involve comparing modelled and observed:*

- *Passenger flows across screenlines and cordons, usually by public transport mode and sometimes at the level of individual bus or train services; and*
- *Passengers boarding and alighting in urban centres.*

WebTAG unit M3.2 details a set of criteria that have been adopted in the model calibration and validation process, which are reproduced in Table 87.

Table 87 WebTAG Validation Measures

Measure	WebTAG M3.2 Criteria	Acceptability Guideline
Trip Matrix Validation	Difference between assigned and counted flows across complete screenlines or cordons should be less than 15% of the counts	> 95% of cases
Assignment Screenline Validation	Difference between assigned and counted flows across screenlines should be less than 15% of the counts	All cases
Assignment Individual Link Validation	Difference between assigned and counted flows at individual links should be less than 25% of the counts	All cases, except where observed flows are less than 150 passengers per hour

Source: WebTAG M3.2 Sections 7.1.2 and 7.1.6

8.2.2 Convergence Criteria and Standards

Assessment of the levels of demand and capacity on the bus and rail networks within Warrington has not identified crowding as a problem on any services. Therefore the public transport model does not assess the impacts of crowding and no crowding function has been incorporated.

On this basis, a single assignment iteration loads the demand onto the network, and no convergence criteria are required.

8.2.3 Time Periods Modelled

Three periods are separately modelled as recommended by WebTAG M3.1 Section 2.5.2. Specifically, the model represents an average Monday-Thursday ‘typical’ weekday in 2016. The peak periods along with the inter-peak modelled represent a single average hour of the respective periods:

- AM peak period average hour representing 07:00 – 10:00;
- Inter-peak period average hour representing 10:00 – 16:00; and
- PM peak period average hour representing 16:00 – 18:00.

The modelled time periods have been altered for the PT model to best suit the survey data collected, as the sample rates for the bus and rail surveys using the highway model specified time periods were too low to provide a robust dataset. To aid with the transferability between the PT, highway and demand models the following factors were developed using the bus occupancy counts and rail stations ingress and egress counts:

Table 88 PT model time periods conversion factors

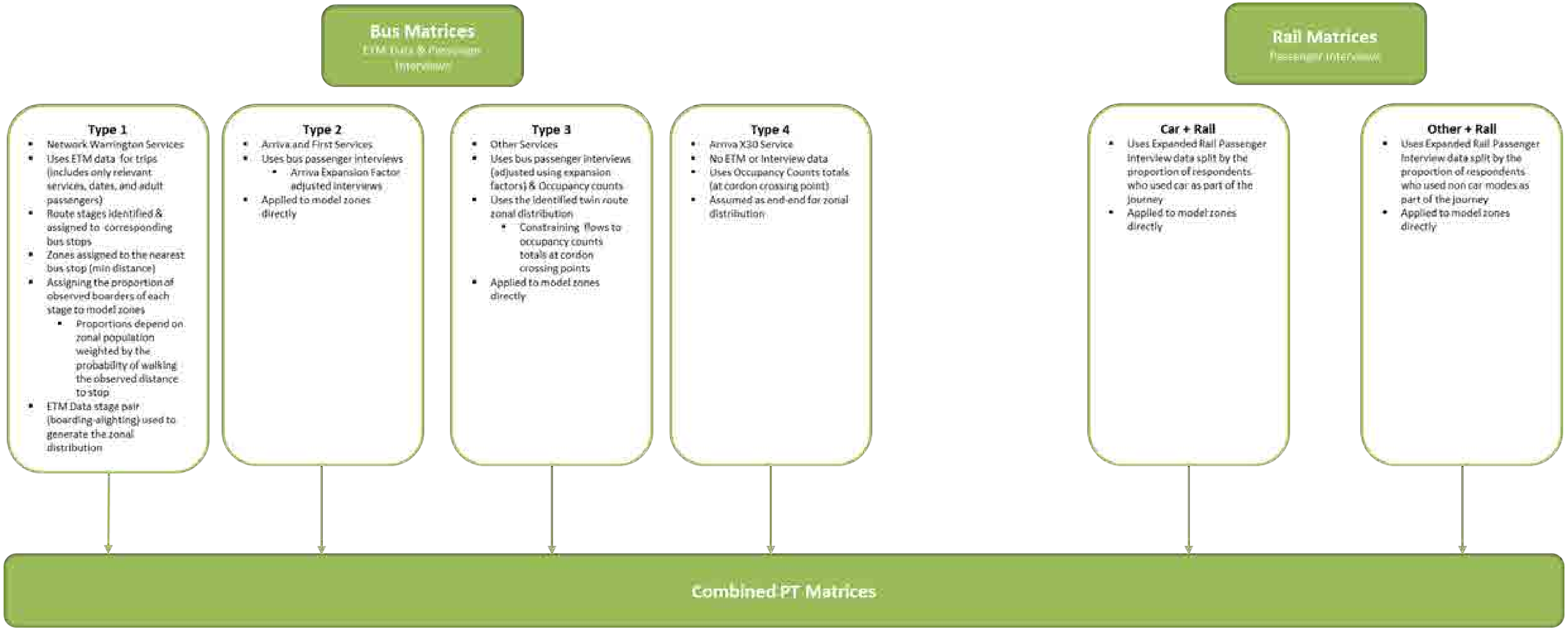
Time Period	Factor*
AM Period	1.39
IP Period	1.00
PM Period	1.59

** The same factors are used for both bus and rail matrices*

8.3 Trip Matrix Development

While the PT model ultimately deals with a combined bus and rail trip matrix, each respective mode trip matrix was developed separately. Figure 108 provides a summary of the PT modes matrix build-up process. Both sets of matrices use the expanded sets of passenger interviews, as described in section 4.2.7, during the build-up process.

Figure 108 Summary of data and processes used to develop WMMTM16 PT Model Matrices



Bus Matrices
ETM Data & Passenger Interviews

Rail Matrices
Passenger Interviews

Type 1
- Network Warrington Services
- Uses ETM data for trips (includes only relevant services, dates, and adult passengers)
- Route stages identified & assigned to corresponding bus stops
- Zones assigned to the nearest bus stop (min distance)
- Assigning the proportion of observed boarders of each stage to model zones
    - Proportions depend on zonal population weighted by the probability of walking the observed distance to stop
- ETM Data stage pair (boarding-alighting) used to generate the zonal distribution

Type 2
- Arriva and First Services
- Uses bus passenger interviews
    - Arriva Expansion Factor adjusted interviews
- Applied to model zones directly

Type 3
- Other Services
- Uses bus passenger interviews (adjusted using expansion factors) & Occupancy counts
- Uses the identified twin route zonal distribution
    - Constraining flows to occupancy counts totals at cordon crossing points
- Applied to model zones directly

Type 4
- Arriva X30 Service
- No ETM or Interview data
- Uses Occupancy Counts totals (at cordon crossing point)
- Assumed as end-end for zonal distribution

Car + Rail
- Uses Expanded Rail Passenger Interview data split by the proportion of respondents who used car as part of the journey
- Applied to model zones directly

Other + Rail
- Uses Expanded Rail Passenger Interview data split by the proportion of respondents who used non car modes as part of the journey
- Applied to model zones directly

Combined PT Matrices

As shown in Figure 108, the bus trip matrix consisted of four sub-matrices that vary in terms of the database and subsequent steps used to develop them.

Across each of the types, child tickets and school buses have been removed from the trip generation as identified in the specification.

8.3.1 Bus Type 1 Sub-Matrix

Services included

Type 1 constitutes nearly 86% (on average across all time periods) of the total bus trips matrix. It includes all Network Warrington operated bus services and uses the Network Warrington ETM database as a basis for the volume of bus trips.

Demand generation

The ETM database utilises a stage-based ticketing system rather than by individual bus stops. The corresponding bus stops have been identified by matching the stage names and the bus stop. This list was independently reviewed and sense checked during its generation and during the course of the matrix development.

The ETM data is then proportionally assigned to the zones which sit within / adjacent to the stage bus stops. The zonal proportions depend on the zonal populations, inversely weighted by the walking the observed distance to the assigned bus stop. As zonal population increase the associated bus stop will have a larger share of the stage demand, but if the zone centroid is far away from the bus route / stop, a smaller proportion will be willing to walk and therefore it will have a smaller share of the stage demand.

Each model zone has been assigned to a single bus stop, with zones being sufficiently disaggregated. The walk distance likelihood is based up a distribution derived from the passenger survey data.

8.3.2 Bus Type 2 Sub-Matrix

Services included

Type 2 constitutes approximately 7% (on average across all time periods) of the total bus trips matrix. The Type 2 matrix includes the trips made using the following Arriva and First bus services:

- Service 7;
- Service 100;
- Service 110;
- Service 360; and
- Service 329.

Demand generation

Arriva ETM data was provided as a database in a similar form to that as the Network Warrington data. However, the database only recorded the origin stage, not the destination and was therefore of limited application.

Therefore, where available, expanded bus passengers’ interview records were used to develop the majority of the Arriva matrix, utilizing the provided origin and destination addresses and/or postcodes to identify the respective zone pairs of the trips.

8.3.3 Bus Type 3 Sub-Matrix

Services included

Type 3 constitutes approximately 6% (on average across all time periods) of the total bus trips matrix.

The Type 3 matrix includes trips made using the following bus services by Link Network and Halton:

- Service 62; and
- Service 110.

Demand generation

For these services there was no ticket data, nor any passenger interviews. However, these services have routes similar to other routes which are included in Type 1 or Type 2, having the same service number.

Therefore the distribution was taken from the associated Type 1 or Type 2 corresponding route and calibrated to the cordon crossing values for the respective services, which recorded passenger numbers for every service.

8.3.4 Bus Type 4 Sub-Matrix

Services included

Type 4 constitutes approximately 1% (on average across all time periods) of the total bus trips matrix. The Type 4 matrix includes trips made by the Arriva X30 bus service.

Demand generation

As there was no ETM data or bus interviews for this service, the cordon totals at the crossing points were identified and the matrix was developed by assuming the service as an end-to-end service and assigned to the respective zones.

While this type employs the greater degree of uncertainty, for completeness of the model, it along with the other three types, were included in the overall demand generation.

8.3.5 Rail Matrix

The rail trip matrices have been separated into ‘car+rail’ matrices and ‘other+rail’ matrices, as some of the passengers interviewed indicated that they used a car as travel mode during a part of the surveyed trip and had distinctly different characteristics as a sub-group compared to the non-car users. The ‘other’ modes comprised of primarily access by foot, wheelchair, pedal cycle, or bus.

A separate rail matrix was developed for these car user trips and this demand split was assigned separately from the main public transport demand. The car-rail demand was provided with additional connectors to/from the identified zones to stations, to represent the car access element of their trip. These connectors were not accessible to the non-car users. The number of identified car-bus trips was marginal based upon passenger interviews, to the point that no similar disaggregation was deemed necessary for those travellers.

Both types of rail matrices we generated by factoring the passenger survey responses in line with the observed station boarding and alighting counts, with expansion factors being low, as identified in the data collection report.

The ‘car+rail’ matrix comprised approximately 48% of the total rail trips and ‘other+rail’ comprised approximately 52%.

8.3.6 Combined PT Matrix

The bus (non-car element) and rail matrices were combined and assigned as a joint ‘public transport only’ matrix. The car-rail matrix was assigned separately and the two sets of assigned flows aggregated within EMME automatically.

8.3.7 Prior Matrix Adjustments

Bus Matrix

Within the Network Warrington ETM dataset, a significantly larger number of same stage origin to destination trips were identified in the IP and PM peak compared to the AM peak. This was due to most second leg return trips and concessionary trip movements being identified only with the boarding stage, with the same stage being repeated as the destination.

Alternative methods to account for the approximate distribution of these trips were investigated, including reversing the AM trip distribution for return trips or simply factoring up specific services. The anomalous data did not necessarily follow the same trip patterns as the known data though.

The most balanced outturn approach was identified to be a combination of factoring up the individual services which contained the anomalous data entries by 25%, followed by an overall matrix sector-sector adjustment. The second part of this adjustment involved splitting the zones into 3 broad sectors (based on the validation count cordons) and making sector-to-sector level adjustments to bring the overall level of demand in line on a cordon basis.

This two-stage approach countered the ‘missing’ concessionary ticket data, while making changes in a structured manner.

The offsetting of concessionary tickets resulted in a net increase of non-same stage to stage data trips of approximately 5% in the AM peak, 74% in the IP and 17% in the PM peak, compared to the unadjusted matrix. The 74% in the IP period is reflective of the high proportion of concessionary travellers in that period in particular.

Rail Matrix

At a broad level, the amount of rail users assigned in the model was found to be too large when initially assigned collectively along with bus. The cause for this was identified as being primarily a result of double counting bus-rail trips generated from the two sets of bus and rail data.

To counter this effect, an 8% reduction was applied to each of the three rail matrix time periods.

Rail boarding’s at the two primary stations of Warrington Bank Quay and Warrington Central were identified as having a consistent over-modelling of boarding’s and alighting’s, further to sensitivity testing of assignment parameters. The primary component behind this was identified as being a particular level of double counting at these locations from the demand generation. This is in terms of passengers that initially board at other modelled stations and then cross the town centre to access either Warrington Bank Quay or Warrington Central, and also a larger propensity for bus-rail double counting at these stations.

To counter the impact of this, expansion factors for these two stations were reduced consistently by 22% for each of the three time periods.

8.4 Network Review

The public transport network has been reviewed to verify that it is a realistic representation of the bus and rail services as indicated in TAG Unit M3.2. This review was also required to ensure that the model calibration and validation is not affected by routeing issues that can result in an incorrect balance of public transport demand by corridor or access point. The network checks in this phase comprised; a review of the zone connectors, public transport links and walk routes used by passengers to access the transit network.

A review of zone connectors focused on ensuring that the access to the model network was adequate for a public transport model. Whilst car users generally park close to their origin and destination, public transport users often access and egress the public transport stop by a different mode (car, taxi, cycle, walking). The area of influence or catchment of transit stops increases in size with the level of service and attractiveness of the stop. TAG Unit A4.2 establishes that the typical catchment of a bus stop is about 400 metres. The TAG unit also explains that rail stations attract passengers from a larger catchment of at least 800 metres around the station (major stations tend to have an even larger catchment area).

In this context, and based on observed trip patterns, adjustments of connectors during the network validation stage were required, for example at Birchwood rail station through provision of additional walk-only connector links to the network to facilitate accessing trips to/from the station.

The model links have also been reviewed to prevent excessively long walking distances on the network, as well as any missing walk links from the Highway Model. This exercise focused mainly on incorporating links that were relevant for the accessibility of the public transport network and that were not included initially in the model. Figure 109 provides an example of a number of walk only links, such as 2112-10002, 2764-1004 and 1003-2283, that were identified while developing the PT model, which were not previously coded in the SATURN highway model. Likewise Figure 110 provides an example of the walk-only link added to provide connectivity between the rail stations within the FMA and the nearest bus stop or network node.

Figure 109 Example of walk-only links in Warrington Town Centre

Figure 110 Example of walk-only connectors for rail stations (Warrington Bank Quay Station)

From the rail passenger surveys, station access movements by car were identified and based on this, zone-to-station car access links were added as a final element. These were included as a separate set of links for transparency and provided an additional means by which the car-rail demand could access stations, but which the non-car-rail demand were prohibited from using.

As part of the model calibration, visual sense checks of the links were conducted, and any unrealistic or unrepresentative movements which impacted on model assignment were removed.

8.4.1 Service Review

TAG Unit M3.2 indicates that the validation of a public transport model should involve service checks. Visual checks of the route followed by each coded service in the model were undertaken to ensure that it reflects the existing public transport network as outlined previously in Section 5.4. Service headway by bus and rail service was also benchmarked against the timetables and survey data to ensure consistency and prevent potential demand routing issues.

8.5 Assignment Calibration and Validation

8.5.1 Assignment Calibration

Initial assignment parameters were presented in Section 2.3.9.2. This section details the refinement of these parameters during the calibration process to improve model performance and ensure that it fits the observed data in line with WebTAG guidance.

8.5.2 Trip Matrix Estimation

While the prior matrix adjustments approximate the demand matrices overall, it incorporated a number of broad assumptions in part of the service demand distribution and in accounting for some of the anomalous ETM data.

Therefore, it was necessary to make some minor modifications on a specific zone basis during the calibration process. This was done by factoring zones net origins or destination movements up / down by a maximum of 50%.

Zone specific adjustments were made only to the bus component when greater localised uncertainty occurred, whilst no corresponding rail component changes were required.

Across the time periods, of the 586 zones, the number of zones adjusted was as follows;

Table 89 Quantity of Zones Adjusted During Calibration

Time Period	Origin	Destination
AM	21	18
IP	20	21
PM	19	15

This represents approximately three to four percent of the zone origins and destinations which required some adjustment. The net matrix total changes were as follows;

- AM -3.1%;
- IP -2.7%; and
- PM -3.6%.

This reduces some of the prior matrix adjustment increases which offset ‘missing’ concessionary ticket, but by a relative small margin and with a greater level of specification, appropriate to serve its calibration purpose.

Comparing the resultant R^2 values from the prior and post matrix estimation for bus, each time period maintains an R^2 value of approximately 0.99 for both origin and destination totals.

Figure 111 AM Peak Origin Zone Demand Comparison Between Prior and Post Calibration

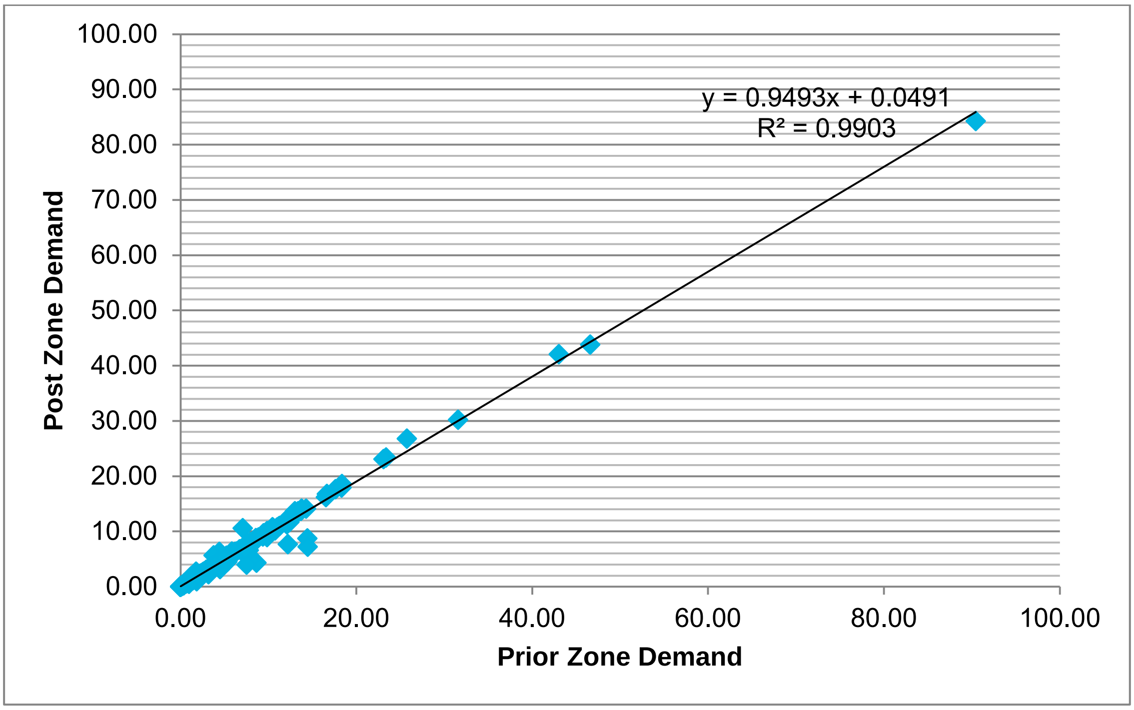


Figure 112 Inter Peak Origin Zone Demand Comparison Between Prior and Post Calibration

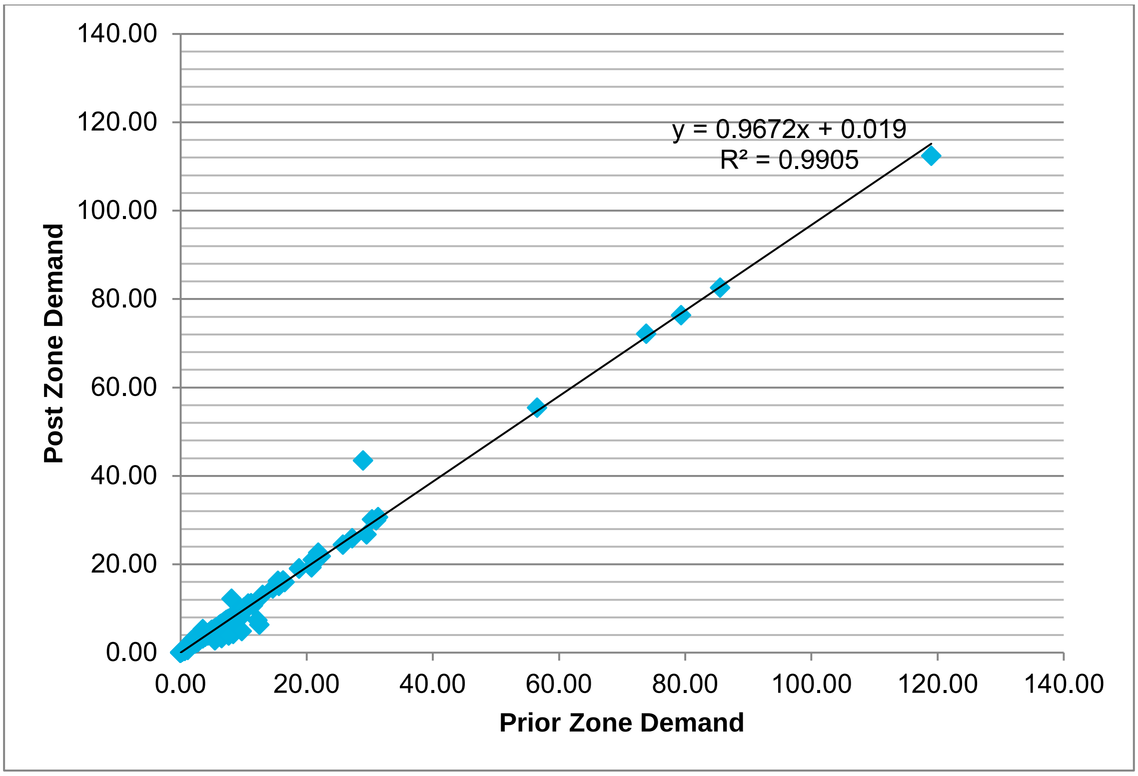


Figure 113 PM Peak Origin Zone Demand Comparison Between Prior and Post Calibration

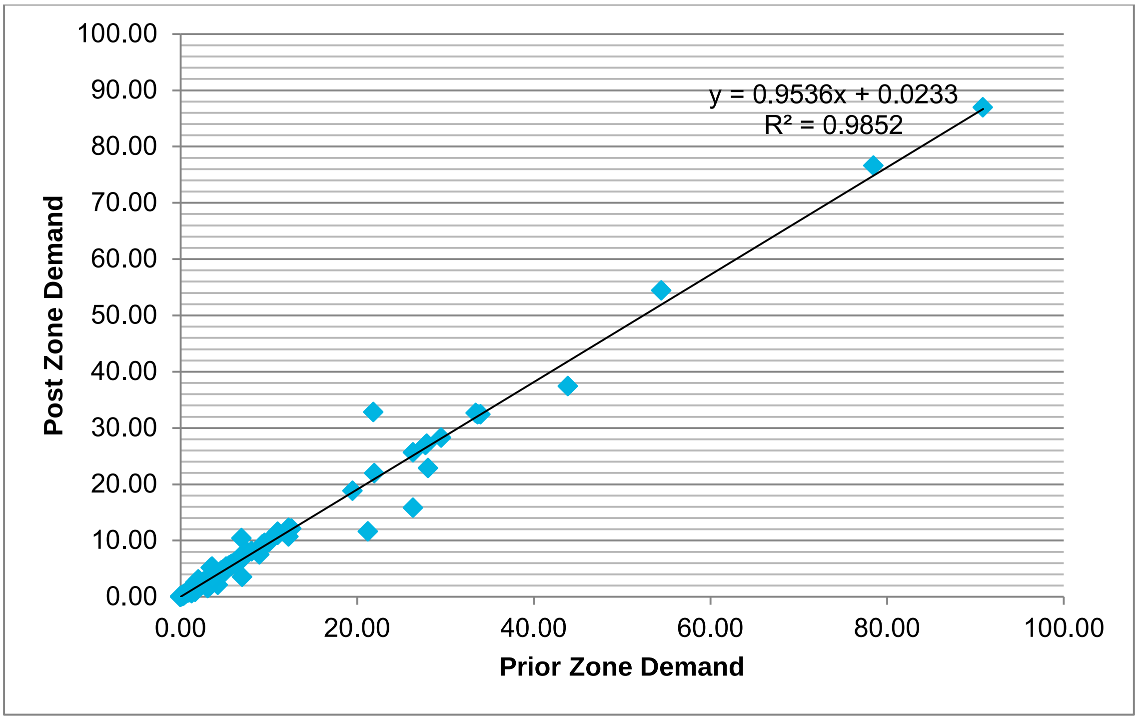


Figure 114 AM Peak Destination Zone Demand Comparison Between Prior and Post Calibration

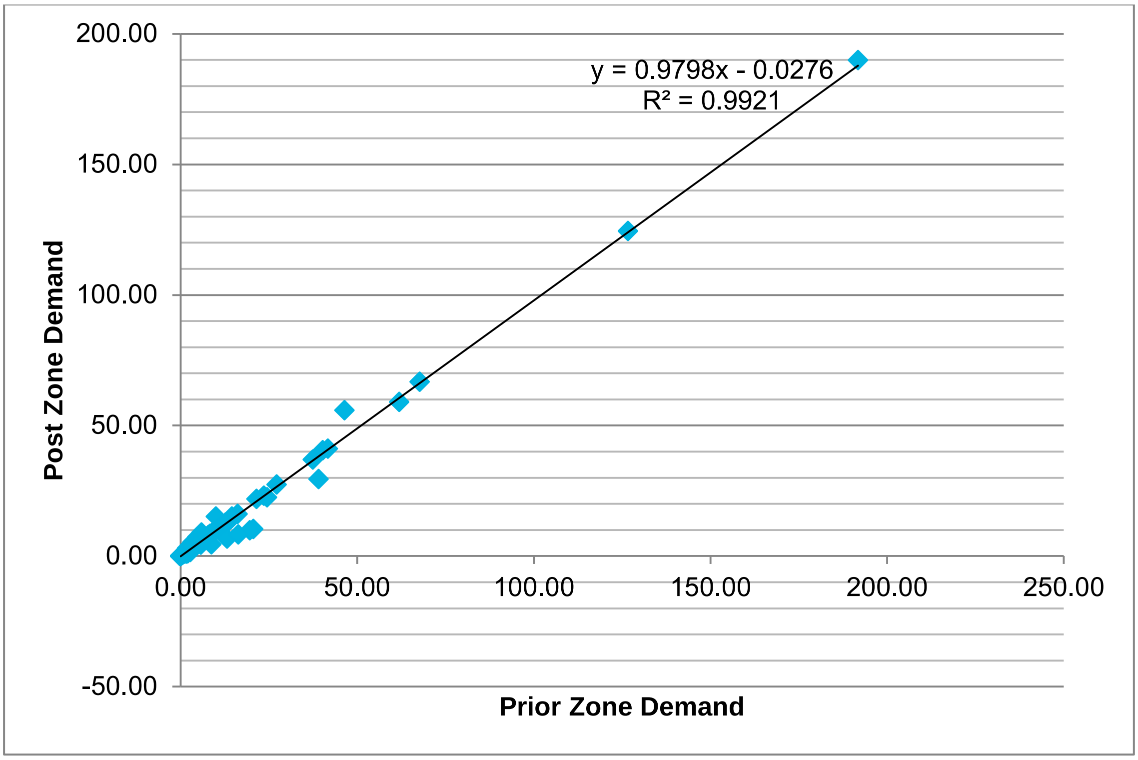


Figure 115 Inter Peak Destination Zone Demand Comparison Between Prior and Post Calibration

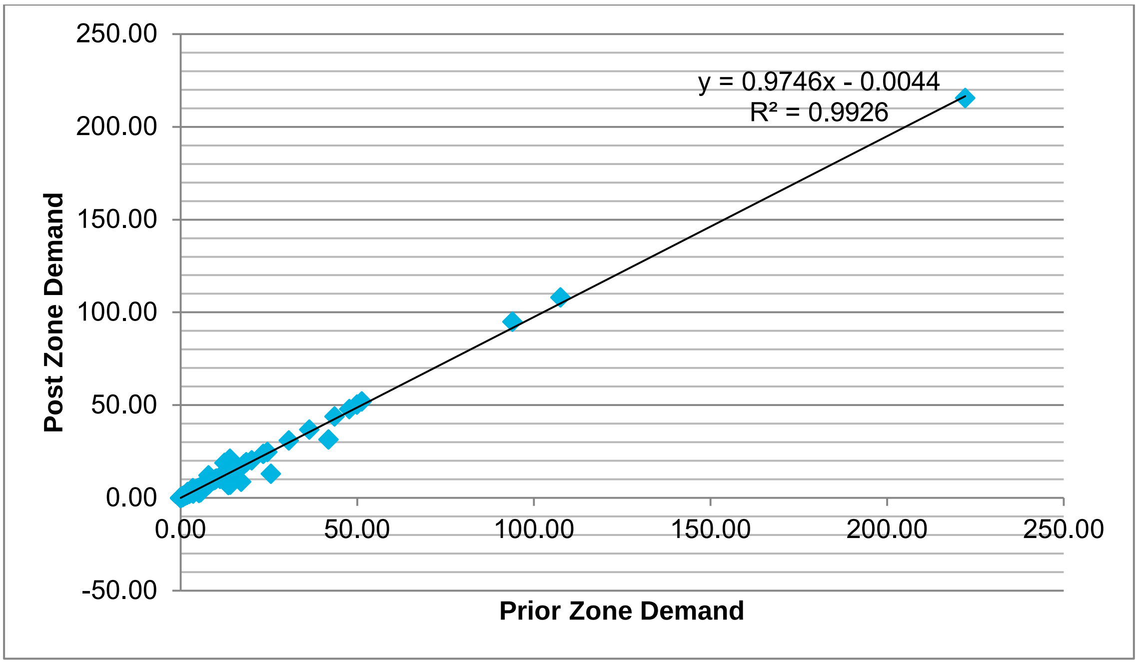
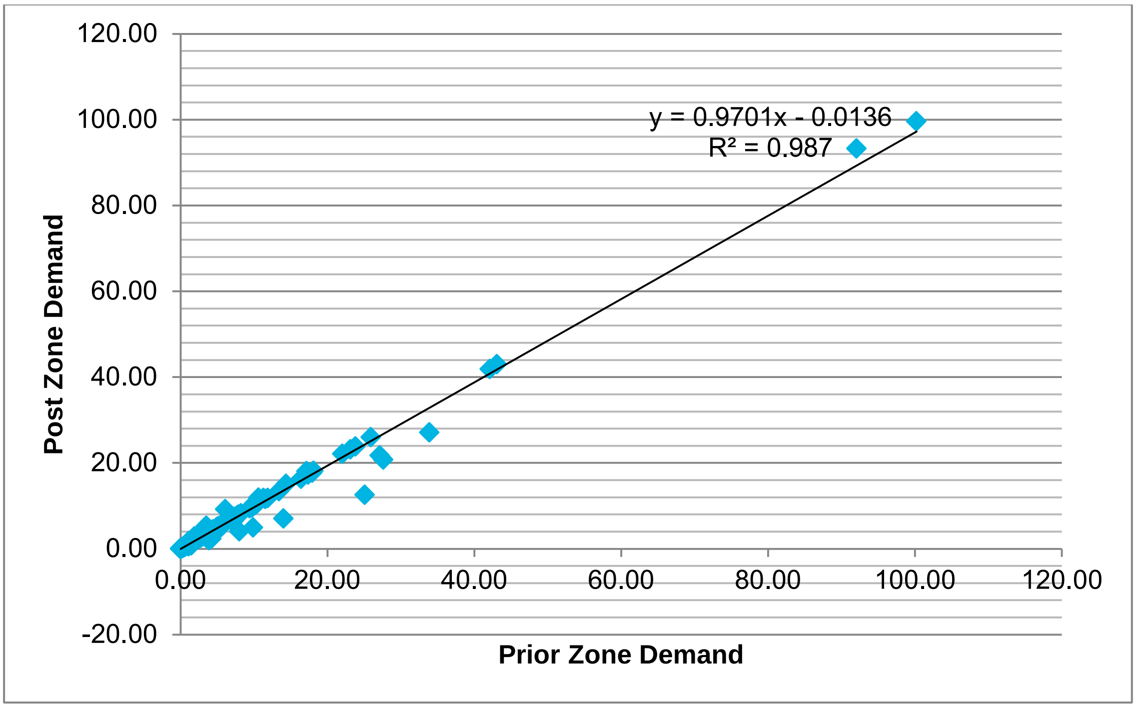


Figure 116 PM Peak Destination Zone Demand Comparison Between Prior and Post Calibration



8.5.3 Assignment Validation

8.5.3.1 Flow Validation

Guidance on validation standards was set out in Section 8.2.1. However, due to the relatively low patronage of the bus network in Warrington, many of the links and screenlines used in the WMMTM16 PT Model have flows below 150 passengers per hour threshold for which WebTAG defined a link based criterion. The validation has therefore been undertaken by applying a more stringent link based criterion that +/- 25% of 150 passengers, i.e. +/- 38 passengers per hour, should also be satisfied for all individual links including those below 150 passengers per hour.

Screenlines are defined by a collection of links, and implicitly the WebTAG criterion relates to flows that would be considerably in excess of a single link. We have assumed the same link based tolerance of +/-38 passengers, where screenline flows are below 150 passengers.

The validation points and screenlines used for the PT model validation have been defined in Section 4.2.7. During the model calibration and validation however, the two bus trips cordons were further split into mini screenlines to better analyse trip movements and provide a more robust model. Table 90 outlines the new definitions of the bus screenlines and the points they contain.

Table 90 PT – Bus Trips Matrices Mini Screenlines Validation Points

Screenline ID	Survey Point ID
Inner Cordon	
Inner North	2_1
	2_2
	2_3
	2_4
Inner South	2_5
	2_6
	2_7
	2_8

Screenline ID	Survey Point ID
Outer Cordon	
Outer North East	3_1
	3_2
	3_3
	3_4
	3_5
	3_6
Outer South	3_7
	3_8
	3_9
	3_10
	3_11
	2_12
	3_13
Outer North West	3_14
	3_15
	3_16
	3_17
	3_18

Table 91 and Table 92 set out the observed and modelled values for the AM Peak period, whilst Figure 117 presents this analysis in graphical form, including the upper and lower bounds of acceptability. Table 93 and Table 94 and Figure 118 then present this same analysis for the Inter-Peak period, whilst Table 95 and Table 96 and Figure 119 cover the PM Peak period. Meanwhile Table 97 provides a statistical summary of the PT model validation.

As can be seen from these results, all cordon and link based flows are within both the WebTAG criteria and the additional criteria we have adopted for lower flow corridors. We have reviewed the largest deviations between modelled flows and counts and judge that these modest variations are consistent with residual uncertainties in the demand data and routeing parameters.

Table 91 AM Peak Period PT Validation Summary – Bus Trips

Fully Modelled Area Cordon			**AM PEAK**									
			Inbound					**Outbound**				
Roadname	**Inbound Direction**	**Outbound Direction**	**Observed**	**Modelled**	**Flow Difference**	**Percent Difference**	**GEH**	**Observed**	**Modelled**	**Flow Difference**	**Percent Difference**	**GEH**
Inner North Screenline												
A49 Lythgoes Lane_Owen Street	South	North	126	139	13	10%	🟢 1.13	77	45	-32	-41%	🟢 4.06
Orford Lane_Clegge Street	West	East	51	32	-19	-38%	🟢 3.00	7	9	2	23%	🟢 0.58
Battersby Lane_The Albion	South	North	79	69	-10	-13%	🟢 1.20	34	25	-9	-26%	🟢 1.66
Chrurch Street_Parish Church	West	East	113	122	9	8%	🟢 0.83	46	60	14	30%	🟢 1.92
		Total	**370**	**362**	**-8**	**-2%**	🟢 **0.40**	**164**	**139**	**-25**	**-15%**	🟢 **2.03**
Inner South Screenline												
Knutsford Road_Cenotaph	West	East	40	39	-1	-3%	🟢 0.16	16	2	-14	-88%	🟢 4.73
Wilderspool Causeway_St James' Court	North	South	74	92	18	25%	🟢 2.01	67	72	5	7%	🟢 0.60
A5060 Chester Road_Brian Bevan Island	North	South	17	4	-13	-76%	🟢 4.01	16	5	-11	-68%	🟢 3.32
A5061 Liverpool Road_Crosfields	East	West	254	279	25	10%	🟢 1.51	137	171	34	25%	🟢 2.77
		Total	**385**	**414**	**29**	**8%**	🟢 **1.45**	**236**	**250**	**14**	**6%**	🟢 **0.92**
Inner Cordon Total			**755**	**776**	**21**	**3%**	🟢 **0.77**	**400**	**389**	**-11**	**-3%**	🟢 **0.54**
Outer North East Screenline												
A49 Winwick Road_Sandy Lane West	South	North	102	111	9	8%	🟢 0.84	26	37	11	44%	🟢 2.02
Northway_Locker Avenue	West	East	47	31	-16	-34%	🟢 2.51	8	1	-7	-88%	🟢 3.39
Fisher Avenue_Cossack Avenue	South	North	32	46	14	42%	🟢 2.18	14	18	4	26%	🟢 0.91
Poplars Avenue_Derek Avenue	South	North	53	34	-19	-35%	🟢 2.84	12	8	-4	-35%	🟢 1.36
Hilden Road_Hilden Place	West	East	45	33	-12	-27%	🟢 1.97	27	31	4	13%	🟢 0.68
Padgate Lane_Mason Avenue	West	East	39	24	-15	-39%	🟢 2.72	23	47	24	107%	🟢 4.12
A57 Manchester Road_Dog & Partridge	West	East	57	63	6	11%	🟢 0.77	24	28	4	17%	🟢 0.78
		Total	**376**	**342**	**-34**	**-9%**	🟢 **1.78**	**135**	**170**	**35**	**26%**	🟢 **2.86**
Outer North West Screenline												
A562 Penketh Road_Brookside Avenue	East	West	78	93	15	19%	🟢 1.58	53	38	-15	-28%	🟢 2.22
A57 Liverpool Road_Highfield Avenue	East	West	26	30	4	14%	🟢 0.69	84	51	-33	-39%	🟢 3.98
Lingley Green Avenue_Post Office Sorting Centre	East	West	5	1	-4	-79%	🟢 2.18	18	10	-8	-45%	🟢 2.21
Whittle Avenue_Thatch Cottage	South	North	14	17	3	21%	🟢 0.76	5	2	-3	-57%	🟢 1.46
A574 Cromwell Avenue_Ladywood	South	North	39	32	-7	-17%	🟢 1.12	31	46	15	48%	🟢 2.42
		Total	**162**	**173**	**11**	**7%**	🟢 **0.85**	**191**	**147**	**-44**	**-23%**	🟢 **3.36**
Outer South Screenline												
A50 Knutsford Road_Dog & Dart	West	East	26	30	4	17%	🟢 0.82	49	31	-18	-37%	🟢 2.85
A56 Chester Road_Euclid Avenue	West	East	5	4	-1	-20%	🟢 0.47	14	4	-10	-71%	🟢 3.25
Lumb Brook Road_Grappenhall Lodge	South	North	3	3	0	-10%	🟢 0.19	4	0	-4	-100%	🟢 2.71
Bridge Lane_Epsom Gardens	North	South	0	0	0	CHECK		0	0	0	CHECK	
A49 London Road_Lyon's Lane	North	South	9	3	-6	-68%	🟢 2.55	7	12	5	71%	🟢 1.62
A56 Chester Road_Stag Inn	North	South	27	15	-12	-45%	🟢 2.68	16	10	-6	-36%	🟢 1.58
		Total	**71**	**55**	**-16**	**-22%**	🟢 **1.98**	**89**	**57**	**-32**	**-36%**	🟢 **3.75**
Outer Cordon Total			**608**	**570**	**-38**	**-6%**	🟢 **1.58**	**414**	**374**	**-40**	**-10%**	🟢 **2.03**
Fully Modelled Area BUS Total			**1363**	**1346**	**-17**	**-1%**	🟢 **0.46**	**534**	**559**	**25**	**5%**	🟢 **1.05**
Other (Birchwood) Screenline												
Southworth Lane_Southworth Lane	West	East	28	27	-1	-2%	🟢 0.13	12	18	6	46%	🟢 1.46
Locking Stumps Lane_Golf Club	South	North	17	19	2	14%	🟢 0.55	36	32	-4	-12%	🟢 0.74
A574 Birchwood Way_Roberts Fold	West	East	20	19	-1	-5%	🟢 0.23	35	71	36	103%	🟢 4.94
		Total	**64**	**65**	**1**	**1%**	🟢 **0.08**	**84**	**121**	**37**	**45%**	🟢 **3.69**

Table 92 AM Peak Period PT Validation Summary – Rail Trips

			Inbound					Outbound				
Rail Stations	**Inbound Direction**	**Outbound Direction**	**Observed**	**Modelled**	**Flow Difference**	**Percent Difference**	**GEH**	**Observed**	**Modelled**	**Flow Difference**	**Percent Difference**	**GEH**
Birchwood	Entry	Exit	139	121	-18	-13%	● 1.54	179	179	0	0%	● 0.01
Glazebrook	Entry	Exit	11	10	-1	-9%	● 0.31	1	4	3	500%	● 2.18
Newton-le-Willows	Entry	Exit	169	163	-6	-3%	● 0.44	9	12	4	41%	● 1.09
Padgate	Entry	Exit	54	35	-19	-35%	● 2.85	12	7	-5	-39%	● 1.48
Sankey for Penketh	Entry	Exit	48	21	-27	-56%	● 4.60	8	4	-4	-51%	● 1.69
Warrington Bank Quay	Entry	Exit	202	195	-7	-3%	● 0.49	177	201	24	13%	● 1.72
Warrington Central	Entry	Exit	308	334	26	9%	● 1.47	193	174	-19	-10%	● 1.39
Fully Modelled Area RAIL Total			**930**	**879**	**-51**	**-5%**	● **1.68**	**578**	**581**	**3**	**1%**	● **0.13**

Fully Modelled Area Both Modes Total			**2293**	**2225**	**-68**	**-3%**	● **1.42**	**1112**	**1140**	**28**	**3%**	● **0.83**

Figure 117 AM Peak Period PT Validation – Graphical representation of individual counts

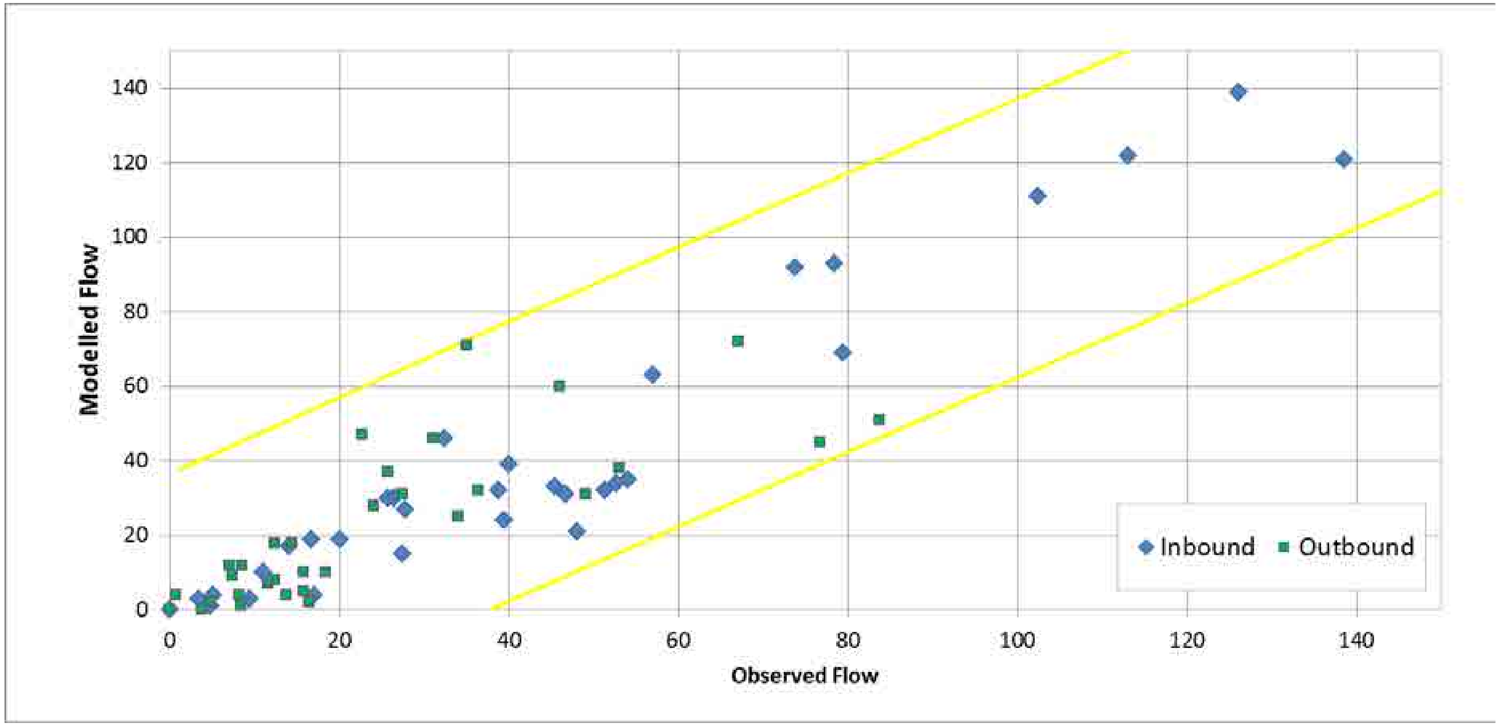


Table 93 Inter-Peak Period PT Validation Summary – Bus Trips

Fully Modelled Area Cordon			**Inbound**					**Outbound**				
Roadname	**Inbound Direction**	**Outbound Direction**	**Observed**	**Modelled**	**Flow Difference**	**Percent Difference**	**GEH**	**Observed**	**Modelled**	**Flow Difference**	**Percent Difference**	**GEH**
Inner North Screenline												
A49 Lythgoes Lane_Owen Street	South	North	155	163	8	5%	🟢 0.62	120	89	-31	-26%	🟢 3.02
Orford Lane_Clegge Street	West	East	45	32	-13	-28%	🟢 2.05	57	34	-23	-40%	🟢 3.37
Battersby Lane_The Albion	South	North	69	46	-23	-33%	🟢 2.97	90	58	-32	-36%	🟢 3.75
Chrurch Street_Parish Church	West	East	93	93	0	0%	🟢 0.02	99	88	-11	-11%	🟢 1.09
		Total	**361**	**334**	**-27**	**-8%**	🟢 **1.46**	**365**	**269**	**-96**	**-26%**	🟡 **5.41**
Inner South Screenline												
Knutsford Road_Cenotaph	West	East	34	32	-2	-6%	🟢 0.38	28	15	-13	-47%	🟢 2.83
Wilderspool Causeway_St James' Court	North	South	94	117	23	25%	🟢 2.27	95	132	37	39%	🟢 3.46
A5060 Chester Road_Brian Bevan Island	North	South	34	13	-21	-62%	🟢 4.33	27	7	-20	-74%	🟢 4.79
A5061 Liverpool Road_Crosfields	East	West	248	264	16	7%	🟢 1.01	254	258	4	1%	🟢 0.23
		Total	**410**	**426**	**16**	**4%**	🟢 **0.80**	**404**	**412**	**8**	**2%**	🟢 **0.38**
Inner Cordon Total			**771**	**760**	**-11**	**-1%**	🟢 **0.39**	**770**	**681**	**-89**	**-12%**	🟢 **3.29**
Outer North East Screenline												
A49 Winwick Road_Sandy Lane West	South	North	79	102	23	29%	🟢 2.42	70	63	-7	-10%	🟢 0.86
Northway_Locker Avenue	West	East	45	25	-20	-44%	🟢 3.38	30	8	-22	-74%	🟡 5.10
Fisher Avenue_Cossack Avenue	South	North	18	15	-3	-17%	🟢 0.78	23	33	10	41%	🟢 1.82
Poplars Avenue_Derek Avenue	South	North	35	40	5	15%	🟢 0.84	49	27	-22	-45%	🟢 3.52
Hilden Road_Hilden Place	West	East	37	40	3	9%	🟢 0.51	40	31	-9	-22%	🟢 1.48
Padgate Lane_Mason Avenue	West	East	32	37	5	14%	🟢 0.79	36	35	-1	-3%	🟢 0.20
A57 Manchester Road_Dog & Partridge	West	East	28	33	5	16%	🟢 0.84	41	36	-5	-13%	🟢 0.86
		Total	**275**	**292**	**18**	**6%**	🟢 **1.04**	**290**	**233**	**-57**	**-20%**	🟢 **3.51**
Outer North West Screenline												
A562 Penketh Road_Brookside Avenue	East	West	82	87	5	6%	🟢 0.56	75	84	9	12%	🟢 0.97
A57 Liverpool Road_Highfield Avenue	East	West	27	26	-1	-3%	🟢 0.13	28	12	-16	-57%	🟢 3.52
Lingley Green Avenue_Post Office Sorting Centre	East	West	16	1	-15	-94%	🟡 5.08	4	2	-2	-54%	🟢 1.31
Whittle Avenue_Thatch Cottage	South	North	9	6	-3	-35%	🟢 1.15	14	3	-11	-79%	🟢 3.77
A574 Cromwell Avenue_Ladywood	South	North	33	29	-4	-11%	🟢 0.66	32	59	27	83%	🟢 3.97
		Total	**166**	**149**	**-17**	**-10%**	🟢 **1.35**	**154**	**160**	**7**	**4%**	🟢 **0.52**
Outer South Screenline												
A50 Knutsford Road_Dog & Dart	West	East	51	38	-13	-25%	🟢 1.90	22	45	23	101%	🟢 3.91
A56 Chester Road_Euclid Avenue	West	East	12	4	-8	-66%	🟢 2.78	7	7	0	5%	🟢 0.13
Lumb Brook Road_Grappenhall Lodge	South	North	4	7	3	68%	🟢 1.20	3	4	1	41%	🟢 0.63
Bridge Lane_Epsom Gardens	North	South	3	0	-3	-100%	🟢 2.24	3	3	0	6%	🟢 0.10
A49 London Road_Lyon's Lane	North	South	14	13	-1	-8%	🟢 0.32	19	22	3	18%	🟢 0.74
A56 Chester Road_Stag Inn	North	South	20	6	-14	-70%	🟢 3.95	22	27	5	21%	🟢 0.94
		Total	**104**	**68**	**-36**	**-34%**	🟢 **3.85**	**76**	**108**	**32**	**43%**	🟢 **3.37**
Outer Cordon Total			**544**	**509**	**-35**	**-6%**	🟢 **1.53**	**519**	**501**	**-18**	**-3%**	🟢 **0.79**
Fully Modelled Area BUS Total			**1315**	**1269**	**-46**	**-3%**	🟢 **1.28**	**1289**	**1182**	**-107**	**-8%**	🟢 **3.03**
Other (Birchwood) Screenline												
Southworth Lane_Southworth Lane	West	East	17	26	9	50%	🟢 1.86	17	12	-5	-28%	🟢 1.23
Locking Stumps Lane_Golf Club	South	North	24	8	-16	-67%	🟢 4.00	17	37	21	124%	🟢 3.96
A574 Birchwood Way_Roberts Fold	West	East	27	31	4	16%	🟢 0.81	21	41	20	98%	🟢 3.66
		Total	**68**	**65**	**-3**	**-4%**	🟢 **0.37**	**54**	**90**	**36**	**67%**	🟢 **4.26**

Table 94 Inter-Peak Period PT Validation Summary – Rail Trips

Rail Stations	Inbound Direction	Outbound Direction	Inbound Observed	Inbound Modelled	Inbound Flow Difference	Inbound Percent Difference	Inbound GEH	Outbound Observed	Outbound Modelled	Outbound Flow Difference	Outbound Percent Difference	Outbound GEH
Birchwood	Entry	Exit	69	87	18	26%	● 2.02	48	38	-10	-21%	● 1.50
Glazebrook	Entry	Exit	2	3	1	80%	● 0.87	1	4	3	336%	● 1.97
Newton-le-Willows	Entry	Exit	30	26	-4	-13%	● 0.74	17	21	4	25%	● 0.98
Padgate	Entry	Exit	20	15	-5	-24%	● 1.12	8	8	0	2%	● 0.06
Sankey for Penketh	Entry	Exit	17	6	-11	-64%	● 3.17	10	13	3	31%	● 0.91
Warrington Bank Quay	Entry	Exit	97	113	16	17%	● 1.58	107	132	25	23%	● 2.25
Warrington Central	Entry	Exit	117	130	13	11%	● 1.15	130	153	23	18%	● 1.96
Fully Modelled Area RAIL Total			**351**	**380**	**29**	**8%**	● **1.51**	**320**	**369**	**49**	**15%**	● **2.62**

Fully Modelled Area Both Modes Total	**1666**	**1649**	**-17**	**-1%**	● **0.42**	**1609**	**1551**	**-58**	**-4%**	● **1.46**

Figure 118 Inter-Peak Period PT Validation – Graphical representation of individual counts

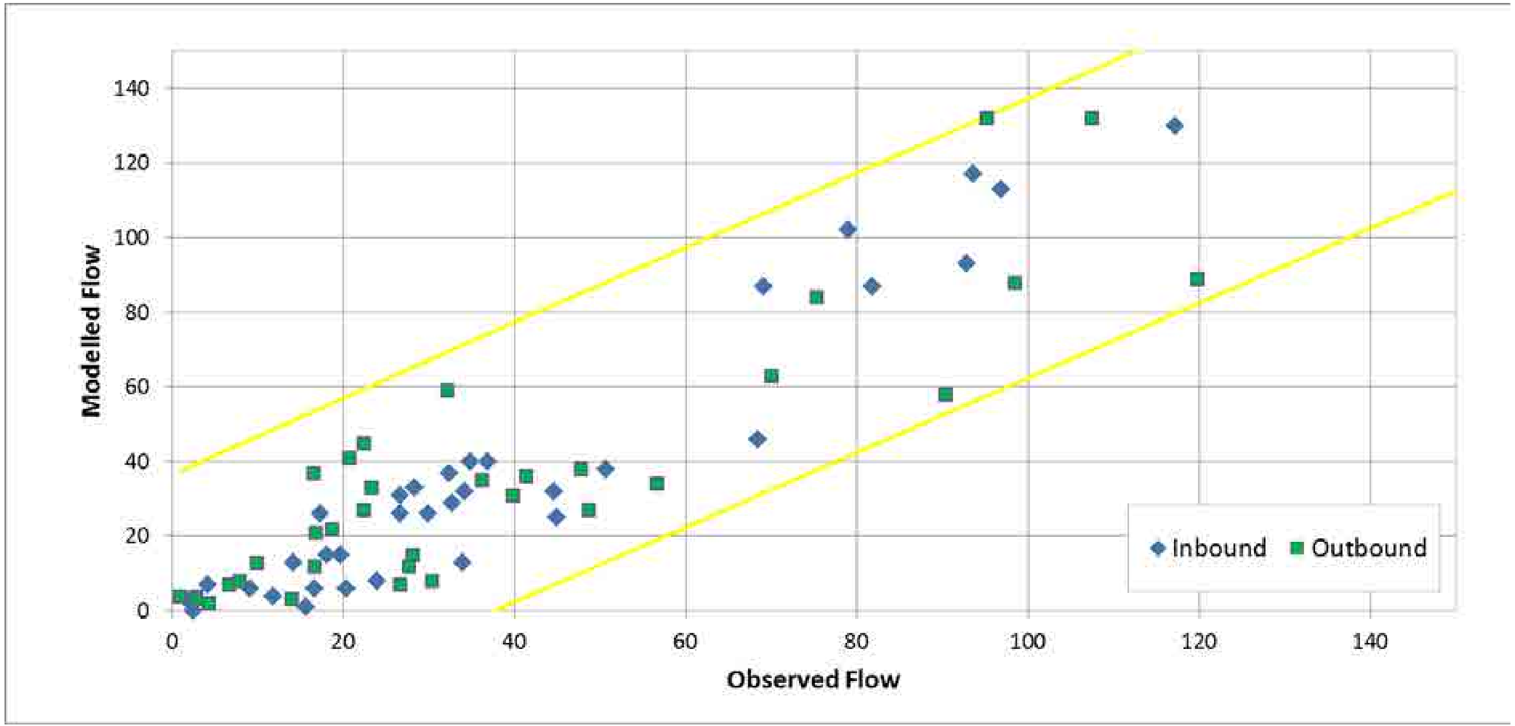


Table 95 PM Peak Period PT Validation Summary – Bus Trips

Fully Modelled Area Cordon			Inbound					Outbound				
Roadname	**Inbound Direction**	**Outbound Direction**	**Observed**	**Modelled**	**Flow Difference**	**Percent Difference**	**GEH**	**Observed**	**Modelled**	**Flow Difference**	**Percent Difference**	**GEH**
Inner North Screenline												
A49 Lythgoes Lane_Owen Street	South	North	75	84	9	13%	● 1.05	124	100	-24	-20%	● 2.30
Orford Lane_Clegge Street	West	East	12	7	-5	-42%	● 1.62	39	17	-22	-56%	● 4.16
Battersby Lane_The Albion	South	North	46	27	-19	-42%	● 3.19	60	42	-18	-30%	● 2.56
Chrurch Street_Parish Church	West	East	49	50	1	3%	● 0.19	85	89	4	4%	● 0.39
		Total	**182**	**168**	**-14**	**-8%**	● **1.03**	**309**	**248**	**-61**	**-20%**	● **3.66**
Inner South Screenline												
Knutsford Road_Cenotaph	West	East	17	8	-9	-52%	● 2.47	36	27	-9	-25%	● 1.60
Wilderspool Causeway_St James' Court	North	South	58	76	18	31%	● 2.20	77	101	24	31%	● 2.54
A5060 Chester Road_Brian Bevan Island	North	South	13	1	-12	-92%	● 4.54	14	5	-9	-64%	● 2.92
A5061 Liverpool Road_Crosfields	East	West	134	148	14	10%	● 1.15	234	257	23	10%	● 1.47
		Total	**222**	**233**	**11**	**5%**	● **0.73**	**361**	**390**	**29**	**8%**	● **1.50**
Inner Cordon Total			**404**	**401**	**-3**	**-1%**	● **0.13**	**670**	**638**	**-32**	**-5%**	● **1.25**
Outer North East Screenline												
A49 Winwick Road_Sandy Lane West	South	North	41	70	29	72%	● 3.94	71	94	23	32%	● 2.49
Northway_Locker Avenue	West	East	12	3	-9	-75%	● 3.29	27	7	-20	-74%	● 4.91
Fisher Avenue_Cossack Avenue	South	North	22	23	1	6%	● 0.28	24	26	2	10%	● 0.47
Poplars Avenue_Derek Avenue	South	North	13	8	-5	-38%	● 1.54	33	16	-17	-52%	● 3.43
Hilden Road_Hilden Place	West	East	27	22	-5	-18%	● 0.95	28	26	-2	-8%	● 0.45
Padgate Lane_Mason Avenue	West	East	27	19	-8	-30%	● 1.67	24	18	-6	-25%	● 1.31
A57 Manchester Road_Dog & Partridge	West	East	28	30	2	8%	● 0.43	30	47	17	55%	● 2.68
		Total	**169**	**175**	**6**	**4%**	● **0.48**	**238**	**234**	**-4**	**-2%**	● **0.26**
Outer North West Screenline												
A562 Penketh Road_Brookside Avenue	East	West	41	26	-15	-37%	● 2.59	94	100	6	6%	● 0.61
A57 Liverpool Road_Highfield Avenue	East	West	41	39	-2	-4%	● 0.26	25	31	6	22%	● 1.07
Lingley Green Avenue_Post Office Sorting Centre	East	West	7	4	-3	-43%	● 1.28	5	2	-3	-57%	● 1.46
Whittle Avenue_Thatch Cottage	South	North	7	6	-1	-14%	● 0.39	7	6	-1	-18%	● 0.52
A574 Cromwell Avenue_Ladywood	South	North	30	32	2	7%	● 0.36	31	53	22	73%	● 3.45
		Total	**126**	**107**	**-19**	**-15%**	● **1.73**	**162**	**192**	**30**	**19%**	● **2.25**
Outer South Screenline												
A50 Knutsford Road_Dog & Dart	West	East	19	24	5	26%	● 1.08	17	43	26	158%	● 4.82
A56 Chester Road_Euclid Avenue	West	East	2	3	1	50%	● 0.63	5	7	2	50%	● 0.97
Lumb Brook Road_Grappenhall Lodge	South	North	5	4	-1	-14%	● 0.32	3	2	-1	-25%	● 0.44
Bridge Lane_Epsom Gardens	North	South	0	0	0	CHECK		1	0	-1	-100%	● 1.63
A49 London Road_Lyon's Lane	North	South	5	11	6	136%	● 2.26	8	8	0	4%	● 0.12
A56 Chester Road_Stag Inn	North	South	16	20	4	22%	● 0.86	30	9	-21	-70%	● 4.70
		Total	**47**	**62**	**15**	**33%**	**2.08**	**63**	**69**	**6**	**10%**	● **0.78**
Outer Cordon Total			**341**	**344**	**3**	**1%**	● **0.16**	**463**	**495**	**32**	**7%**	● **1.48**
Fully Modelled Area BUS Total			**745**	**745**	**0**	**0%**	● **0.01**	**1133**	**1133**	**0**	**0%**	● **0.01**
Other (Birchwood) Screenline												
Southworth Lane_Southworth Lane	West	East	10	21	11	117%	● 2.89	19	20	1	3%	● 0.15
Locking Stumps Lane_Golf Club	South	North	28	25	-3	-10%	● 0.52	12	28	16	140%	● 3.67
A574 Birchwood Way_Roberts Fold	West	East	31	25	-6	-18%	● 1.07	18	23	5	25%	● 1.03
		Total	**68**	**71**	**3**	**4%**	● **0.36**	**49**	**71**	**22**	**44%**	● **2.79**

Table 96 PM Peak Period PT Validation Summary – Rail Trips

			Inbound					Outbound				
Rail Stations	**Inbound Direction**	**Outbound Direction**	**Observed**	**Modelled**	**Flow Difference**	**Percent Difference**	**GEH**	**Observed**	**Modelled**	**Flow Difference**	**Percent Difference**	**GEH**
Birchwood	Entry	Exit	192	198	6	3%	● 0.42	147	133	-14	-10%	● 1.21
Glazebrook	Entry	Exit	4	4	0	0%	● 0.00	14	11	-3	-21%	● 0.85
Newton-le-Willows	Entry	Exit	31	26	-5	-16%	● 0.94	201	182	-19	-9%	● 1.34
Padgate	Entry	Exit	26	10	-16	-61%	● 3.68	49	52	3	6%	● 0.40
Sankey for Penketh	Entry	Exit	14	12	-2	-11%	● 0.42	48	41	-7	-14%	● 1.03
Warrington Bank Quay	Entry	Exit	160	193	33	21%	● 2.51	226	197	-29	-13%	● 1.97
Warrington Central	Entry	Exit	191	199	8	4%	● 0.57	332	360	28	8%	● 1.50
Fully Modelled Area RAIL Total			**617**	**642**	**25**	**4%**	● **1.00**	**1017**	**976**	**-41**	**-4%**	● **1.29**

Fully Modelled Area Both Modes Total	**1362**	**1387**	**26**	**2%**	● **0.69**	**2149**	**2109**	**-40**	**-2%**	● **0.87**

Figure 119 PM Peak Period PT Validation – Graphical representation of individual counts

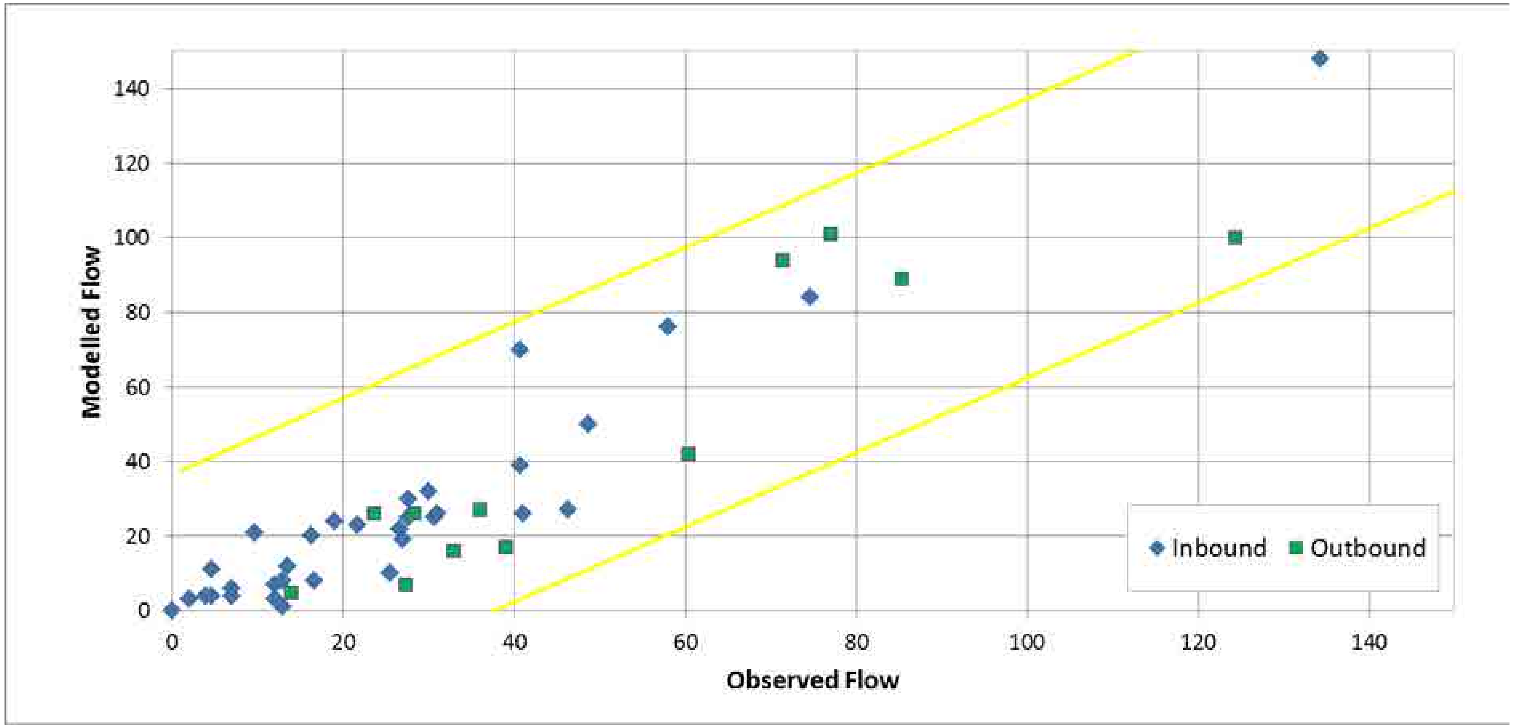


Table 97 PT Model Validation Summary Statistics

Failing Flow Validation Criteria (No of Counts/Screenlines/Cordon per Passenger Flow Category)

Inbound Trips

		AM						IP						PM					
	Passengers	<50	50-100	100-150	>150	**SubTot**	**Total**	<50	50-100	100-150	>150	**SubTot**	**Total**	<50	50-100	100-150	>150	**SubTot**	**Total**
Bus	Counts	0	0	0	0	**0**	**29**	0	0	0	0	**0**	**29**	0	0	0	0	**0**	**29**
	Screenlines	0	1	0	0	**1**	**6**	0	0	1	0	**1**	**6**	1	0	0	0	**1**	**6**
	Cordons	0	0	0	0	**0**	**2**	0	0	0	0	**0**	**2**	0	0	0	0	**0**	**2**
Rail	Counts	0	0	0	0	**0**	**7**	0	0	0	0	**0**	**7**	0	0	0	0	**0**	**7**
	Cordon	0	0	0	0	**0**	**1**	0	0	0	0	**0**	**1**	0	0	0	0	**0**	**1**

Outbound Trips

		AM						IP						PM					
	Passengers	<50	50-100	100-150	>150	**SubTot**	**Total**	<50	50-100	100-150	>150	**SubTot**	**Total**	<50	50-100	100-150	>150	**SubTot**	**Total**
Bus	Counts	0	0	0	0	**0**	**29**	0	0	0	0	**0**	**29**	0	0	0	0	**0**	**29**
	Screenlines	0	2	1	2	**5**	**6**	0	2	0	2	**4**	**6**	1	0	0	2	**3**	**6**
	Cordons	0	0	0	0	**0**	**2**	0	0	0	0	**0**	**2**	0	0	0	0	**0**	**2**
Rail	Counts	0	0	0	0	**0**	**7**	0	0	0	0	**0**	**7**	0	0	0	0	**0**	**7**
	Cordon	0	0	0	0	**0**	**1**	0	0	0	1	**1**	**1**	0	0	0	0	**0**	**1**

Passing Flow Validation Criteria (No of Counts/Screenlines/Cordon per Passenger Flow Category)

Inbound Trips

		AM						IP						PM					
	Passengers	<50	50-100	100-150	>150	**SubTot**	**Total**	<50	50-100	100-150	>150	**SubTot**	**Total**	<50	50-100	100-150	>150	**SubTot**	**Total**
Bus	Counts	19	6	3	1	**29**	**29**	21	6	0	2	**29**	**29**	26	2	1	0	**29**	**29**
	Screenlines	0	1	0	4	**5**	**6**	0	1	0	4	**5**	**6**	0	1	1	3	**5**	**6**
	Cordons	0	0	0	2	**2**	**2**	0	0	0	2	**2**	**2**	0	0	0	2	**2**	**2**
Rail	Counts	2	1	1	3	**7**	**7**	4	2	1	0	**7**	**7**	4	0	0	3	**7**	**7**
	Cordon	0	0	0	1	**1**	**1**	0	0	0	1	**1**	**1**	0	0	0	1	**1**	**1**

Outbound Trips

		AM						IP						PM					
	Passengers	<50	50-100	100-150	>150	**SubTot**	**Total**	<50	50-100	100-150	>150	**SubTot**	**Total**	<50	50-100	100-150	>150	**SubTot**	**Total**
Bus	Counts	24	4	1	0	**29**	**29**	21	6	1	1	**29**	**29**	22	5	1	1	**29**	**29**
	Screenlines	0	0	0	1	**1**	**6**	0	0	0	2	**2**	**6**	0	1	0	2	**3**	**6**
	Cordons	0	0	0	2	**2**	**2**	0	0	0	2	**2**	**2**	0	0	0	2	**2**	**2**
Rail	Counts	4	0	0	3	**7**	**7**	5	0	2	0	**7**	**7**	3	0	1	3	**7**	**7**
	Cordon	0	0	0	1	**1**	**1**	0	0	0	0	**0**	**1**	0	0	0	1	**1**	**1**

8.5.3.2 PT Routing Checks

As an initial sense check, the component PT matrices (‘bus only’, ‘non-car rail’ and ‘car-rail’) were assigned individually. This enabled a high level confirmation that in general the appropriate modes and routes were being used, such as rail services for long distance trips to London and that car access to station was only being used by that part of the demand. These high level checks confirmed at a broad level the appropriateness of the respective demand modes.

Further to the flow checks, specific routing checks were made, focusing on areas of potential query. This was conducted using the full assignment, one of the main demand components identified above, or specific groups of zones either side of a screen line, such as Birchwood. Using an increasingly refined level of analysis, specific movements to and from zones were reviewed in this manner as part of the calibration / validation process.

Finally, as confirmation of the final set of assignments for each of the time periods, a selection of origins and destinations covering a spread of local and long distance trips, were chosen to check the operation of the model, including;

- Warrington centre
- Penketh (west Warrington)
- Omega (north west Warrington)
- Stockton heath medical centre (South Warrington)
- Woolston (east Warrington)
- Warrington collegiate (north Warrington)
- Thellwall
- Birchwood
- London
- Liverpool
- Altrincham
- Runcorn
- Manchester

For each of these routes the proportional split of routes was output through EMME, including the PT service(s) used, for example, from Warrington to Penketh (zone 8009), 72% were proportioned to bus service 110, 25% to bus service 7 and 3% to bus service 32A.

These service proportions have been sense checked by comparing routes which reported substantial proportions, in terms of the directness of the route between the origin and destination in the model (Figure 120). Further, a comparison against ‘Google Maps’ route suggestion was made as a sense check.

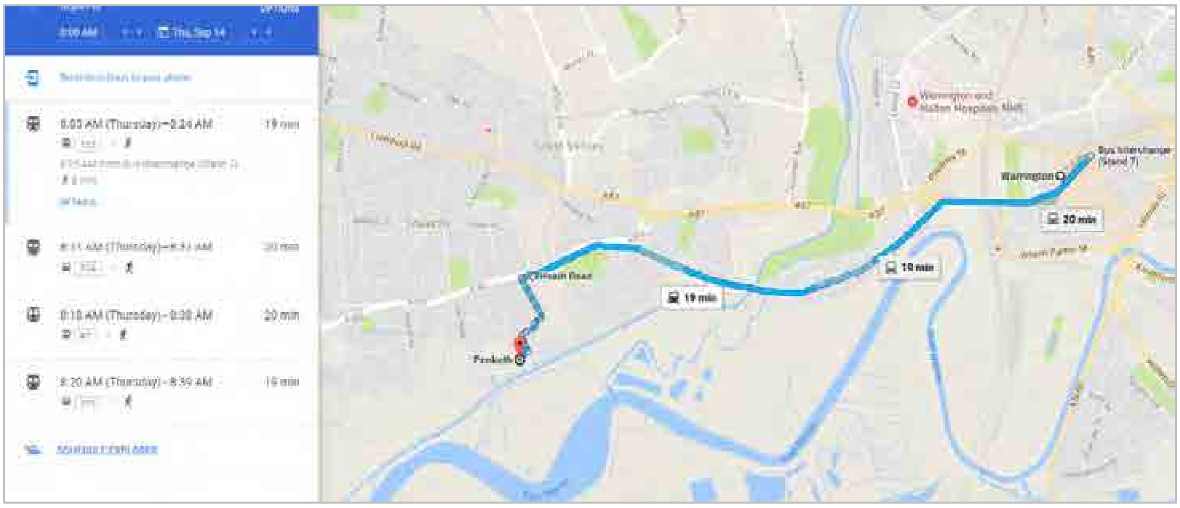
In addition to the proportional splits to and from Warrington for the identified sample locations, an EMME output was generated for the cross movements between each of the locations, for the route options with the highest proportion.

The above analysis suggests that the routing is operating sensibly, with some spread of services used between locations, but primarily the most direct service options being used. Cross checks against ‘Google Maps’ highlighted no anomalies. Being a fairly radial system into Warrington, there was little interchange required to / from Warrington itself, but a transfer more apparent between locations such as Woolston and Penketh - with people interchanging between bus services previously identified to / from Warrington at the Interchange in this example.

With no particular anomalies identified during these checks, the routing is considered to be operating sensibly within the model.

Figure 120 Example of primary assigned route service

Figure 121 Example of comparative ‘Google Maps’ suggested route options



8:05 AM (Thursday)—8:24 AM 19 min

8:11 AM (Thursday)—8:31 AM 20 min

8:18 AM (Thursday)–8:38 AM 20 min

8:20 AM (Thursday)–8:39 AM 19 min

9. Validation Assignment Results

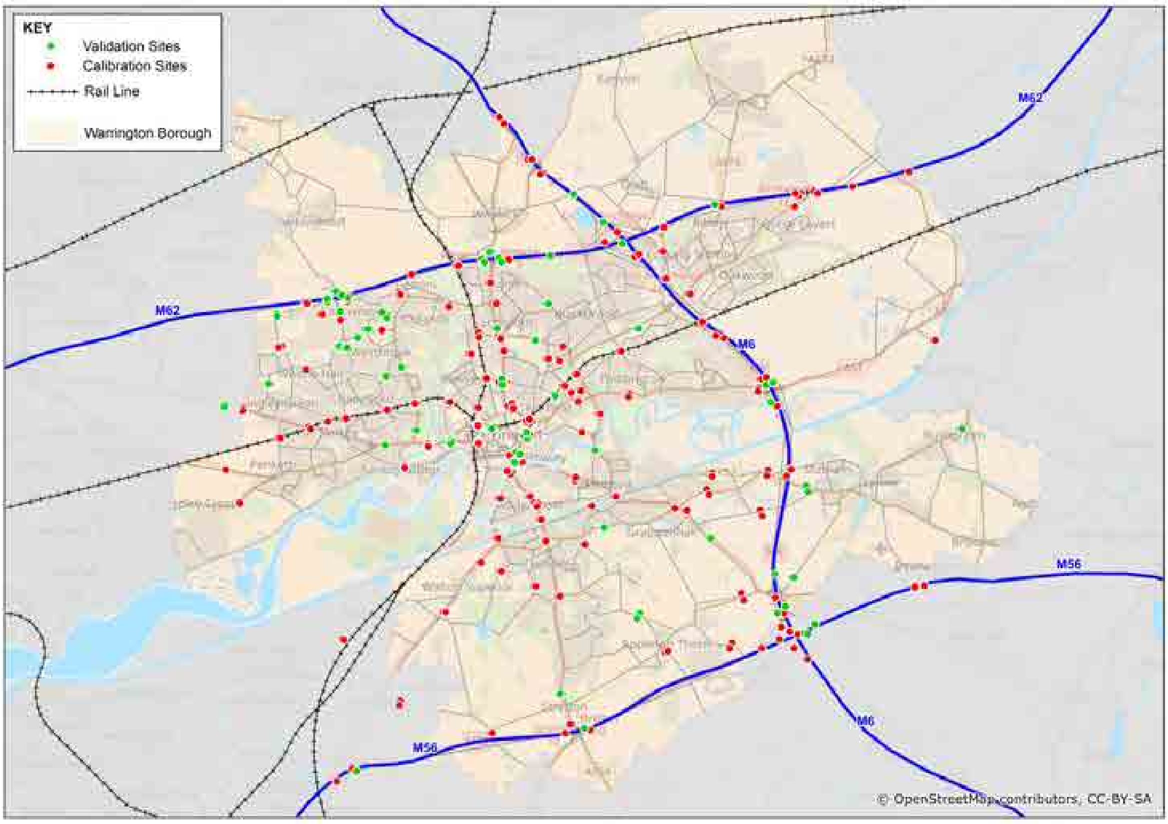
9.1 Introduction

The 389 sites used in calibration and validation of the WMMTM16 have been split by:

- 277 sites used for calibration; and
- 112 for validation (a 71% versus 29% split).

The distribution of this split is shown in Figure 122.

Figure 122 Count Sites Used in Calibration / Validation



9.2 Comparison of Modelled Flows – Screenline

Of the 112 sites used for independent validation, 46 were assigned to a screenline.

Summaries of the screenline performance are shown in Table 99 to Table 101 for each modelled time period. 5 screenlines have been used for independent validation of the WMMTM16. The sites and screenlines used for validation are shown in Figure 123.

The overall statistics of how well these validation screenlines meet WebTAG actability criteria is shown in Table 98.

Figure 123 Validation Sites on a Validation Screenline

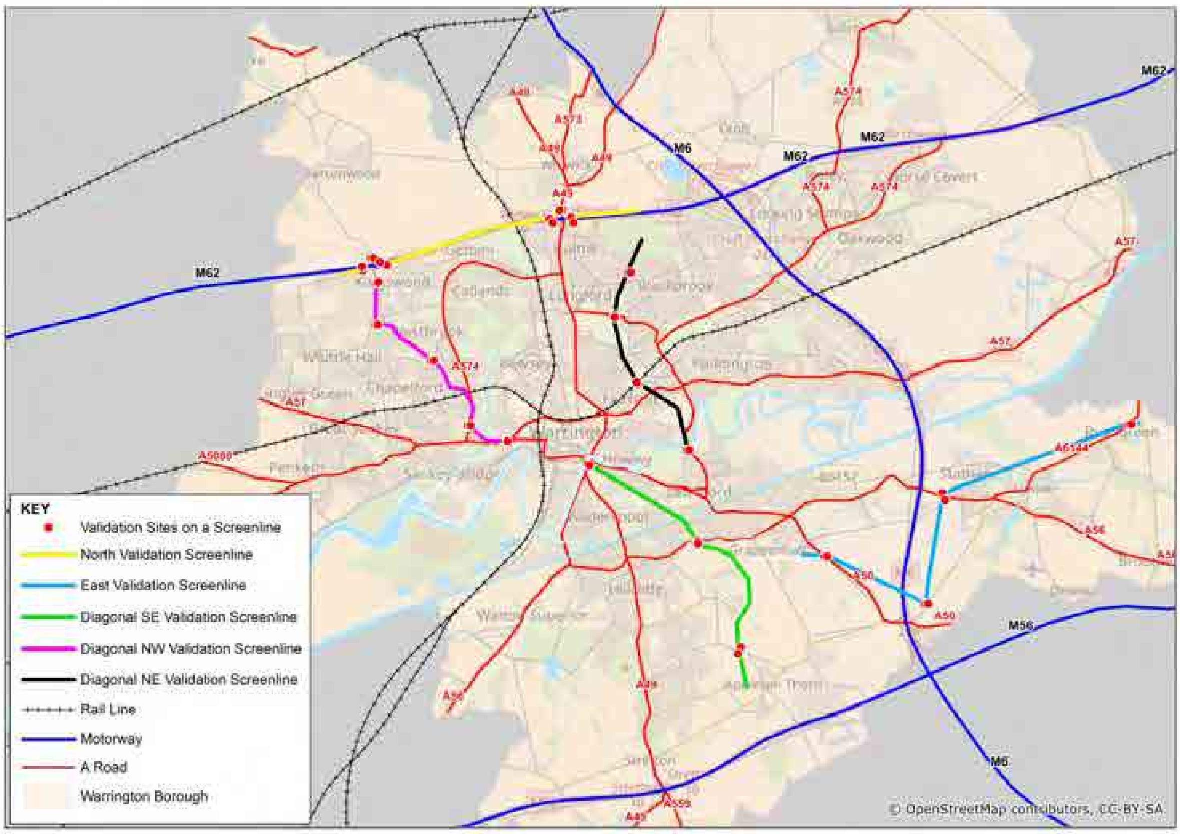


Table 98 Screenline Overall Summary, Validation Sites Only

Criteria	Time Period	Pass	Near*	Fail
Percentage of Screenlines or Cordons where the Flow Difference < 5%	AM	70%	20%	10%
	IP	20%	50%	30%
	PM	50%	20%	30%
Percentage of Screenlines or Cordons where GEH < 4	AM	90%	10%	0%
	IP	50%	30%	20%
	PM	70%	0%	30%

*Definition of ‘Near’ and ‘Fail’ categories – for flow difference this is a percentage between 5% and 10%, for GEH, this is a value between 5 and 7.5. ‘Fail’ represents GEH > 10 and flow difference > 10%

Although the performance of the validation screenlines is lower compared to those used in calibration, there is a large proportion of screenlines that fall within the ‘near’ category indicating that the results are very close to targets being aimed at, for example, in the AM, 2 screenlines achieve a flow difference of 5.9% and 5.8% and therefore fall within the ‘near’ category. The greatest flow difference achieved on the validation screenlines for each time period is as follows:

- AM – 16%;
- IP – 23%; and
- PM – 22%.

The maximum GEH recorded for a screenline in each time period is as follows:

- AM – 7.50;
- IP – 8.72; and
- PM – 17.69.

Of the 46 sites that are allocated to a validation screenline:

- In the AM – 36 sites have a GEH < 5, and only 4 sites have a GEH> 10;
- In the IP – 35 sites have a GEH < 5, and only 5 sites have a GEH > 10; and
- In the PM – 33sites have a GEH < 5, and 7 sites have a GEH > 10.

Table 99 AM Screenline Validation Summary

Screenline	Direction	Observed			Modelled			Difference			% Difference			GEH			TOTAL Flow Diff Meets WebTAG Criteria
		Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	
Diagonal NW	Northbound	5,047	68	5,115	4,782	119	4,902	-265	51	-213	-5%	75%	-4%	3.78	5.29	3.02	YES
	Southbound	3,541	72	3,613	3,312	154	3,467	-229	82	-146	-6%	114%	-4%	3.91	7.74	2.46	YES
Diagonal NE	Northbound	2,157	13	2,170	2,090	18	2,108	-67	5	-62	-3%	41%	-3%	1.45	1.35	1.33	YES
	Southbound	2,524	31	2,555	2,432	38	2,470	-92	7	-85	-4%	22%	-3%	1.84	1.18	1.69	YES
North	Inbound	4,862	455	5,318	4,567	436	5,003	-295	-19	-314	-6%	-4%	-5.9%	4.30	0.90	4.38	NO
	Outbound	3,825	465	4,290	3,788	414	4,201	-37	-51	-89	-1%	-11%	-2%	0.61	2.44	1.36	YES
East	Inbound	2,046	74	2,120	1,704	85	1,789	-342	11	-331	-17%	15%	-16%	7.91	1.24	7.50	NO
	Outbound	1,713	65	1,778	1,709	86	1,795	-4	21	17	0%	33%	1%	0.09	2.45	0.41	YES
Diagonal SE	Eastbound	2,805	89	2,894	2,757	65	2,822	-48	-24	-72	-2%	-27%	-2%	0.91	2.79	1.35	YES
	Westbound	2,393	56	2,449	2,253	55	2,307	-140	-1	-142	-6%	-2%	-5.8%	2.91	0.19	2.91	NO

Table 100 IP Screenline Validation Summary

Screenline	Direction	Observed			Modelled			Difference			% Difference			GEH			TOTAL Flow Diff Meets WebTAG Criteria
		Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	
Diagonal NW	Northbound	3,242	62	3,304	3,448	89	3,537	206	27	233	6%	44%	7%	3.57	3.12	3.99	NO
	Southbound	2,814	53	2,867	3,050	93	3,143	236	40	276	8%	76%	10%	4.36	4.71	5.04	NO
Diagonal NE	Northbound	1,936	14	1,950	1,853	25	1,879	-83	11	-71	-4%	81%	-4%	1.90	2.57	1.62	YES
	Southbound	2,005	19	2,024	1,969	29	1,998	-36	10	-26	-2%	55%	-1%	0.81	2.12	0.57	YES
North	Inbound	3,645	489	4,134	3,335	421	3,756	-310	-68	-378	-9%	-14%	-9%	5.25	3.18	6.01	NO
	Outbound	3,606	561	4,167	3,240	436	3,676	-366	-124	-491	-10%	-22%	-12%	6.26	5.56	7.83	NO
East	Inbound	1,217	67	1,284	888	102	990	-329	35	-294	-27%	52%	-23%	10.13	3.80	8.72	NO
	Outbound	1,255	63	1,318	1,322	80	1,402	67	17	84	5%	28%	6%	1.86	2.05	2.28	NO
Diagonal SE	Eastbound	1,634	61	1,695	1,857	56	1,913	223	-5	218	14%	-8%	13%	5.35	0.64	5.14	NO
	Westbound	1,526	48	1,574	1,617	39	1,656	91	-9	82	6%	-19%	5%	2.29	1.35	2.03	YES

Table 101 PM Screenline Validation Summary

Screenline	Direction	Observed			Modelled			Difference			% Difference			GEH			TOTAL Flow Diff Meets WebTAG Criteria
		Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	Lights	HGV	Total	
Diagonal NW	Northbound	3,995	32	4,027	3,894	49	3,943	-101	17	-84	-3%	53%	-2%	1.61	2.65	1.33	YES
	Southbound	5,636	55	5,691	5,514	60	5,574	-122	5	-117	-2%	9%	-2%	1.63	0.65	1.56	YES
Diagonal NE	Northbound	2,562	12	2,574	2,172	19	2,191	-390	7	-383	-15%	60%	-15%	8.01	1.82	7.84	NO
	Southbound	2,535	25	2,560	2,470	27	2,497	-65	2	-63	-3%	7%	-2%	1.29	0.35	1.25	YES
North	Inbound	5,146	320	5,466	4,342	338	4,680	-804	18	-786	-16%	6%	-14%	11.67	0.99	11.04	NO
	Outbound	5,508	408	5,916	4,336	295	4,631	-1,172	-113	-1,285	-21%	-28%	-22%	16.71	6.01	17.69	NO
East	Inbound	1,918	54	1,972	1,730	59	1,789	-188	5	-183	-10%	9%	-9%	4.40	0.64	4.23	NO
	Outbound	1,799	44	1,843	1,825	68	1,893	26	24	50	1%	56%	3%	0.61	3.27	1.16	YES
Diagonal SE	Eastbound	2,524	23	2,547	2,652	24	2,676	128	1	129	5%	3%	5%	2.51	0.12	2.52	YES
	Westbound	2,693	35	2,728	2,683	30	2,714	-10	-5	-14	0%	-13%	-1%	0.19	0.79	0.27	YES

9.3 Comparison of Modelled Flows – Count Sites

The remaining 66 sites not assigned to a screenline have been used as independent validation sites. A summary of the overall performance by time period is shown in Table 102. This table presents results for all counts sites used for validation (both on a screenline or independent).

Figure 124 to Figure 126 present the GEH results for each count site by time period for validation sites only. Table summaries of individual count site results can be found in Section 5 of the Highway Dashboard (Appendix I).

Table 102 Individual Count Site Summary – Validation Sites Only

Criteria	Time Period	Pass	Near*	Fail
Percentage of Individual Counts where GEH < 5	AM	73%	13%	13%
	IP	74%	13%	13%
	PM	75%	14%	11%
Percentage of Individual Count Sites meeting Flow Criteria	AM	71%	n/a	29%
	IP	75%	n/a	25%
	PM	75%	n/a	25%
Percentage of individual Count Sites meeting either FLOW or GEH criteria	AM	77%	n/a	23%
	IP	79%	n/a	21%
	PM	79%	n/a	21%

*Definition of ‘Near’ and ‘Fail’ categories – for GEH, this is a vale between 5 and 7.5, Fail is for sites where GEH >10

Again, this performance is lower than the calibration dataset but still a strong performance given the scale of data being assessed.

Figure 124 AM GEH Summary - Total Vehicles, Validation Only Sites

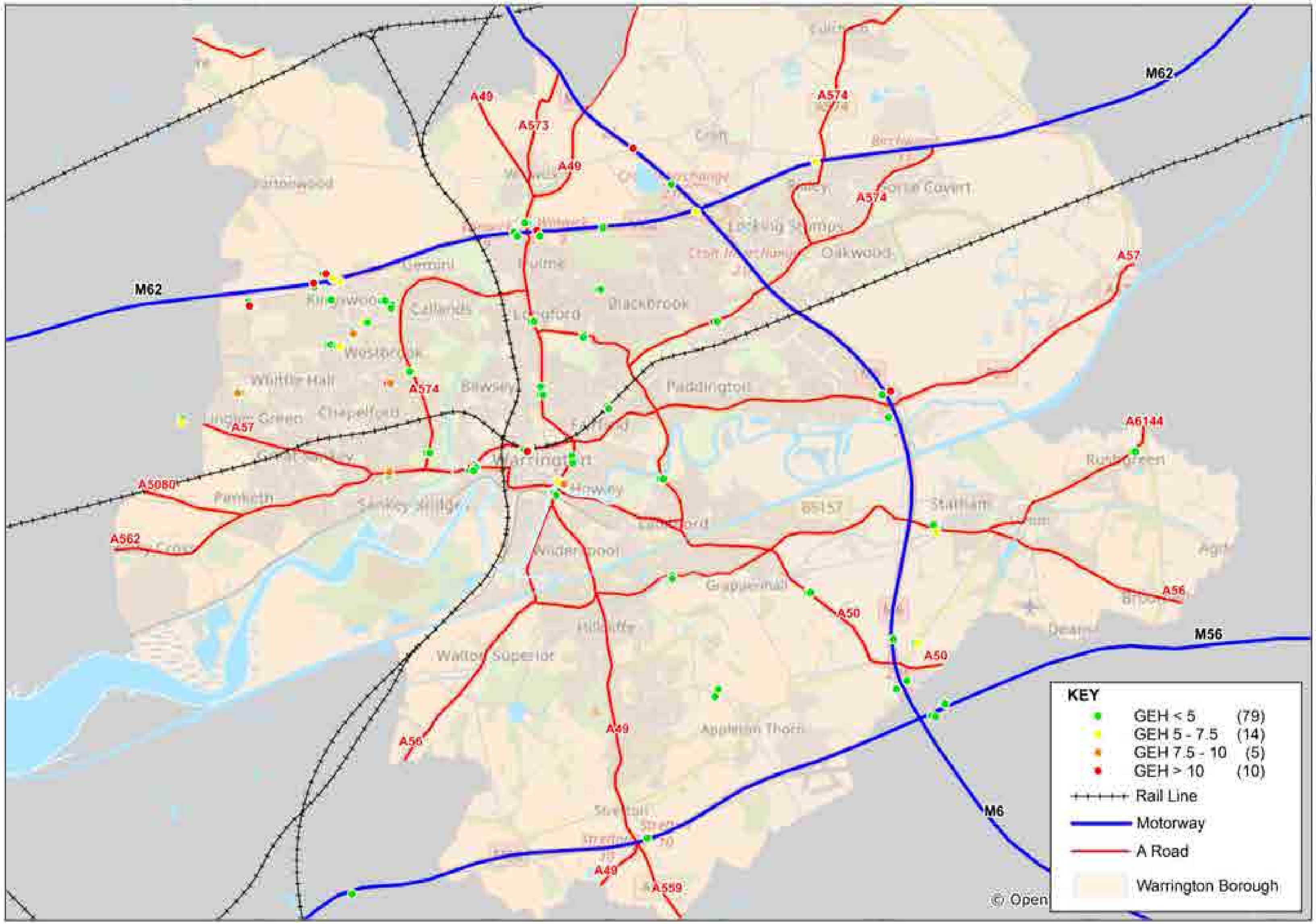


Figure 125 Inter Peak GEH Summary - Total Vehicles, Validation Only Sites

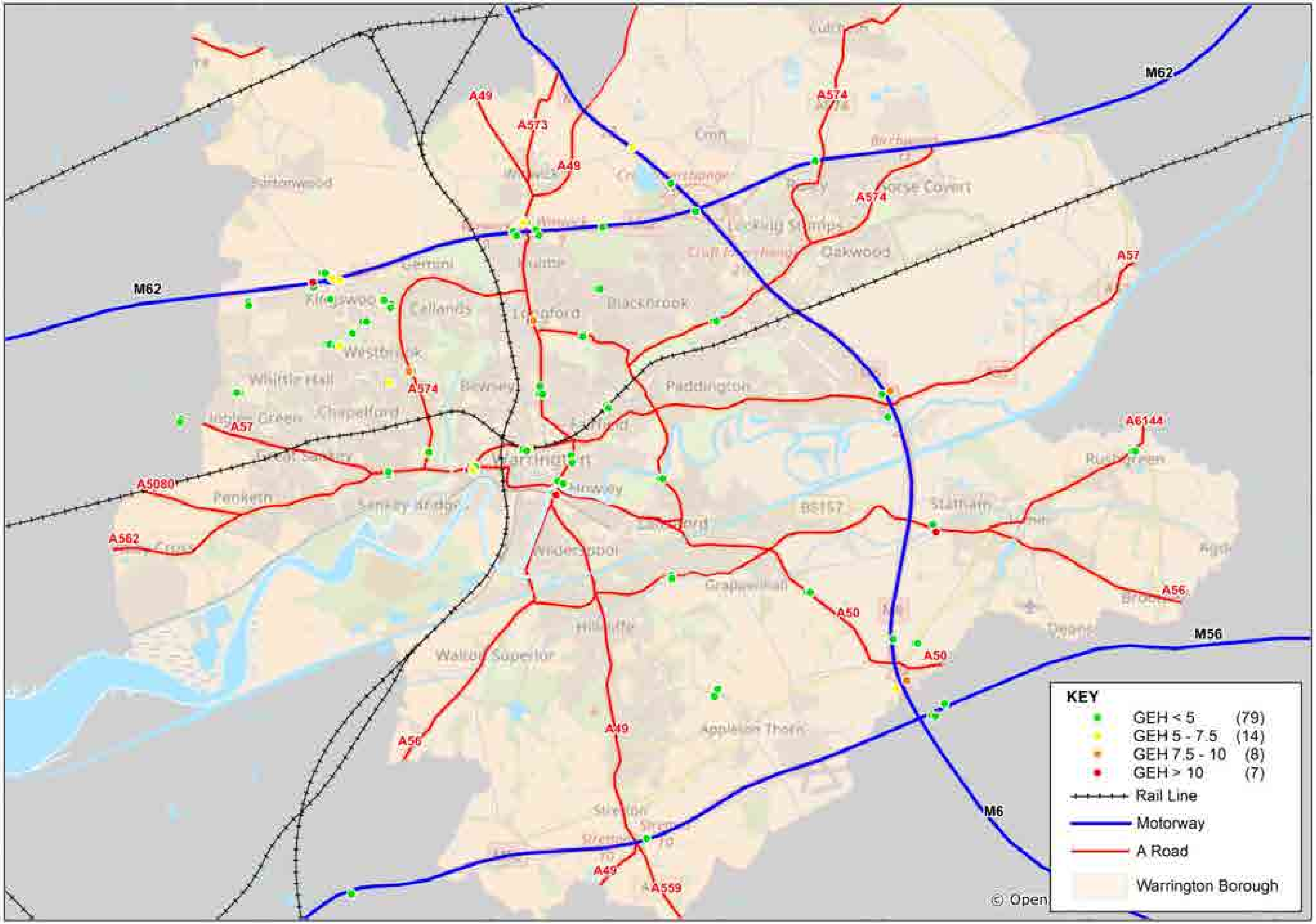
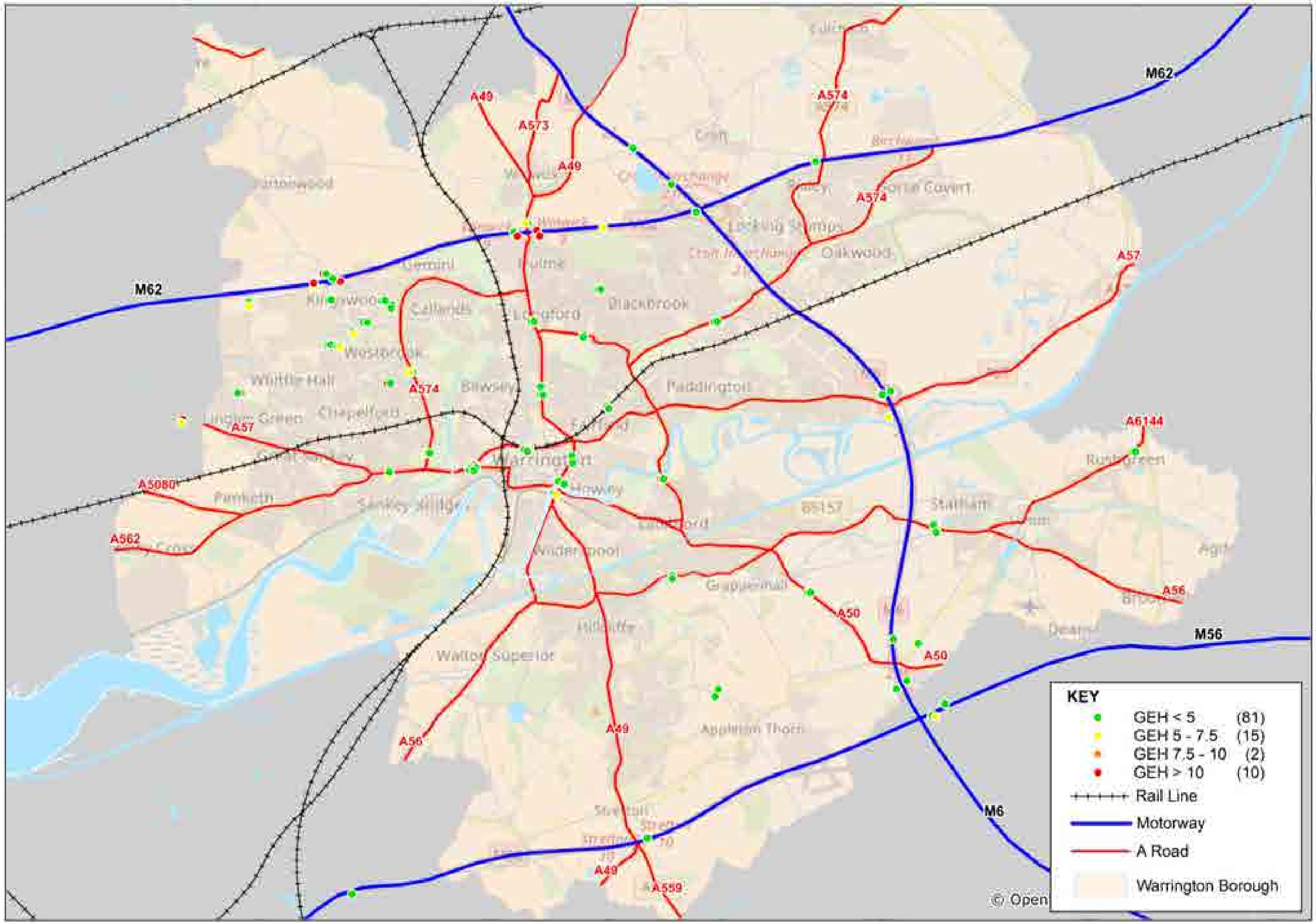


Figure 126 PM GEH Summary - Total Vehicles, Validation Only Sites



9.4 Overall Model Performance

Although the performance of the independent validation dataset is lower than the calibration dataset, the overall model robustness and performance is judged on the combined results. These are presented in the remainder of this section.

Figure 127, Figure 129, and Figure 131 present a summary of the performance statistics for each time period.

Figure 128, Figure 130, and Figure 132 show the majority proportion of model links meeting GEH acceptability criteria in each time period. Over 310 links (out of 389) in each modelled time period return a GEH result of less than 5.

Figure 127 AM Model Summary Performance Statistics

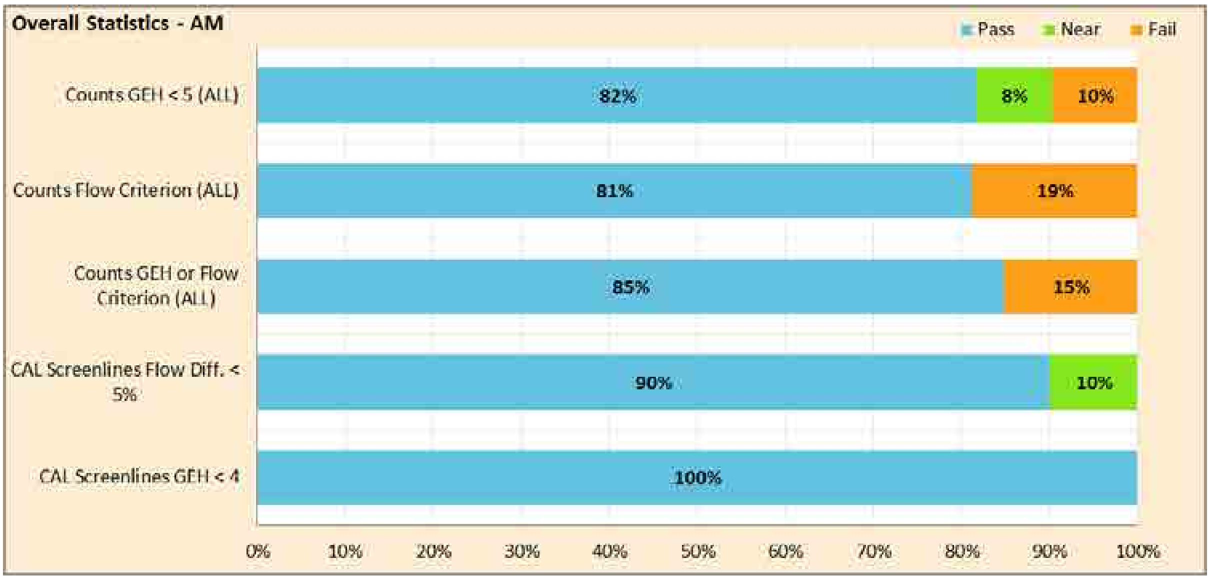
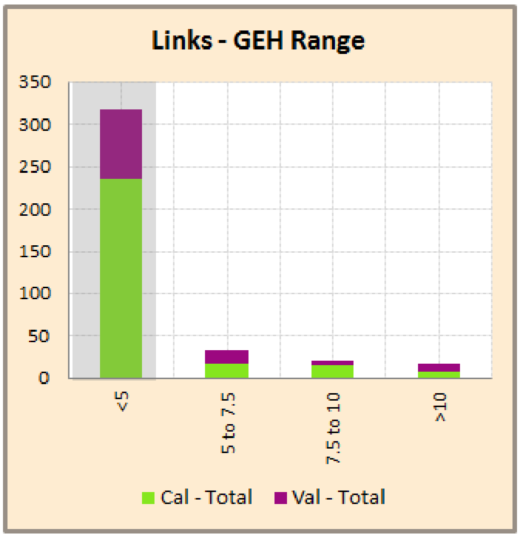


Figure 128 AM Model Links Meeting GEH Acceptability Criteria



	GEH < 5	GEH 5 – 7.5	GEH 7.5 - 10	GEH >10	TOTAL
CAL Links	85%	6%	5%	3%	85%
VAL Links	73%	13%	4%	9%	73%
TOTAL	**82%**	**8%**	**5%**	**5%**	

Figure 129 IP Model Summary Performance Statistics

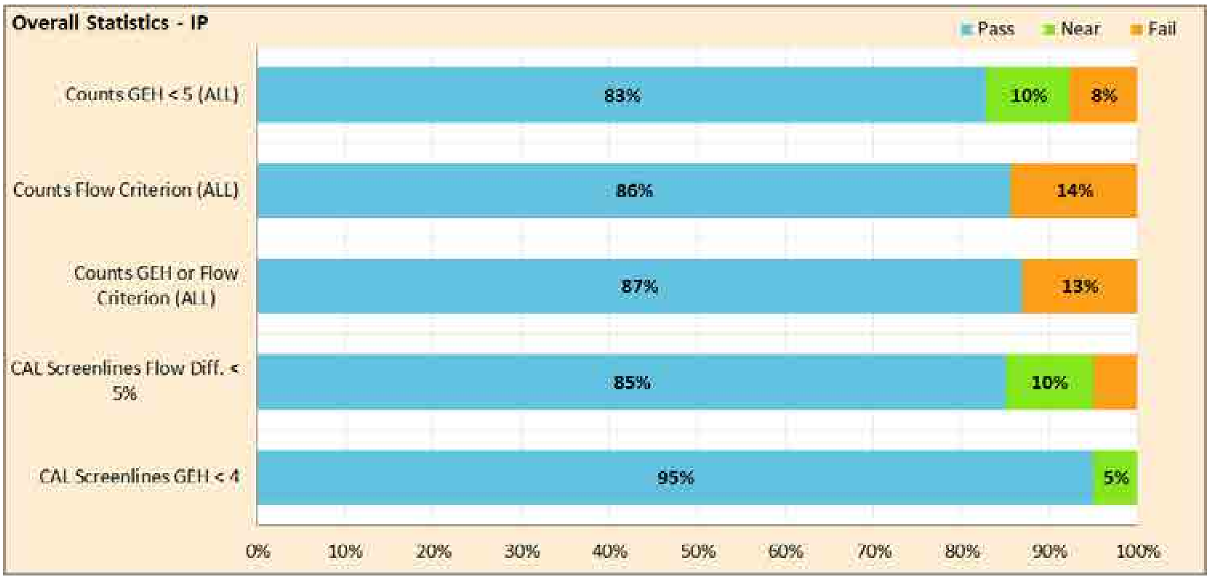
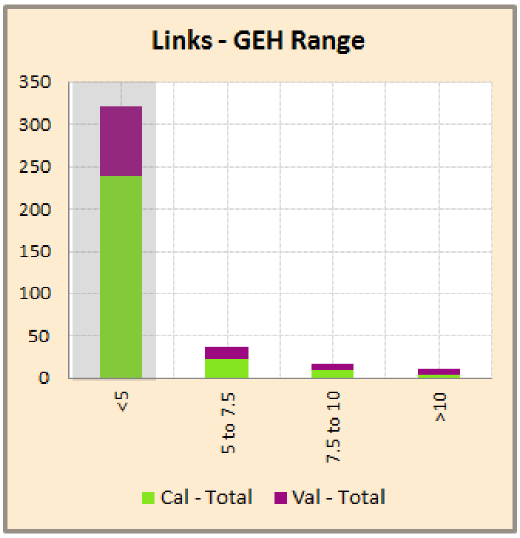


Figure 130 IP Model Links Meeting GEH Acceptability Criteria



	GEH < 5	GEH 5 – 7.5	GEH 7.5 - 10	GEH >10	TOTAL
CAL Links	86%	8%	4%	2%	86%
VAL Links	74%	13%	7%	6%	74%
TOTAL	**83%**	**10%**	**5%**	**3%**	**83%**

Figure 131 PM Model Summary Performance Statistics

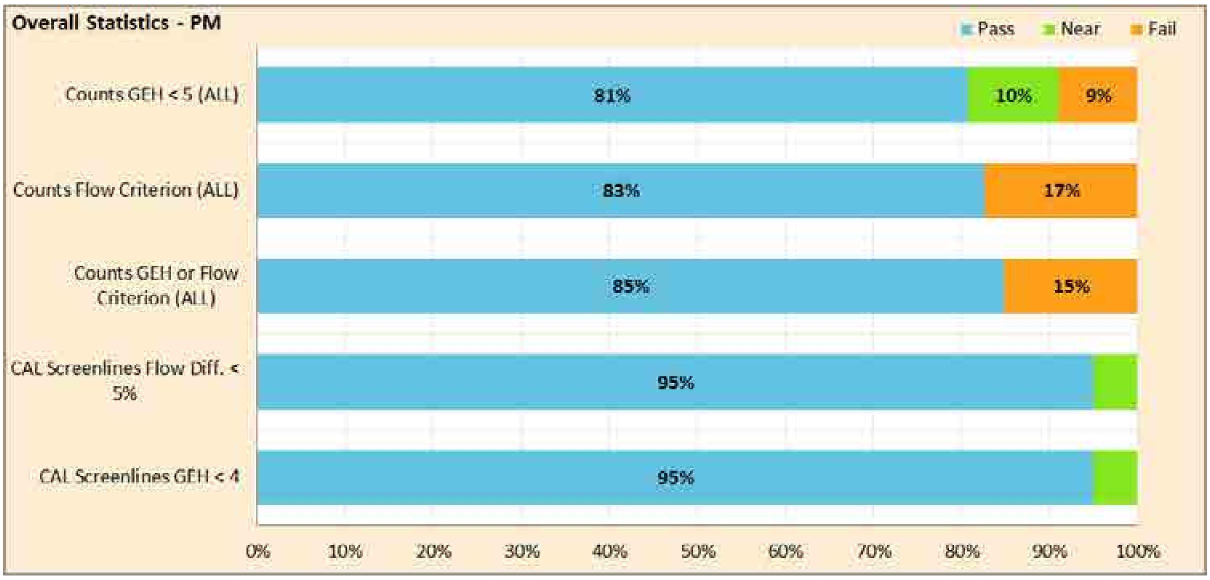
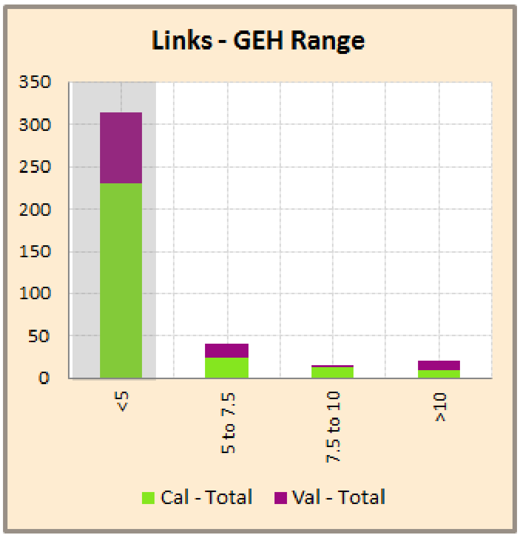


Figure 132 PM Model Links Meeting GEH Acceptability Criteria



	GEH < 5	GEH 5 – 7.5	GEH 7.5 - 10	GEH >10	TOTAL
CAL Links	83%	9%	5%	4%	83%
VAL Links	75%	14%	2%	9%	75%
TOTAL	**81%**	**10%**	**4%**	**5%**	**81%**

10. Variable Demand Model

10.1 Model Development

This chapter discusses the development, calibration and validation of the Variable Demand Model (VDM) for WMMTM16.

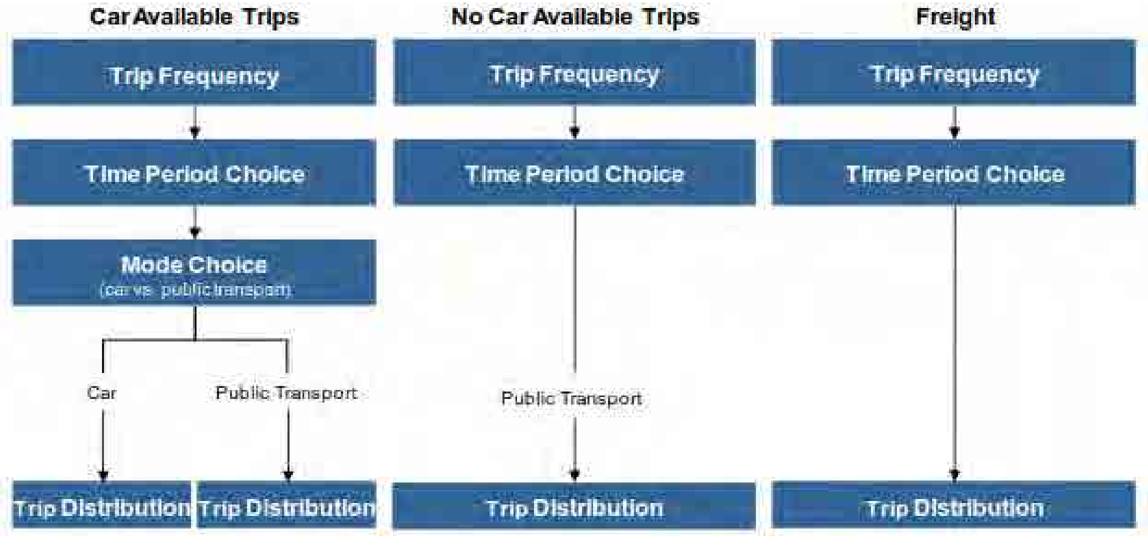
A key objective of the WMMTM16 project is to provide a multi-modal platform for transport scheme assessment. The VDM approach that has been adopted adheres to WebTAG Unit M2 guidance and models the key travel choices of:

- Route (trip frequency) – This choice process adjusts total demand from each production zone based on the changes in the cost of travel from that zone.
- Time period - This choice process adjusts, for each production zone, relative proportions of demand assigned to each time period, based upon the relative changes in cost of travel from that zone and time period.
- Mode choice (car vs. public transport) - This choice process adjusts, for each production zone and time period, relative proportions of demand assigned to each of the two modes, car and public transport, based upon the relative changes in travel cost for these zones, time periods and modes.
- Trip distribution (destination choice) - This choice process adjusts, for each production zone, mode and time period, relative proportions of demand assigned to each attraction zone, based upon the relative changes in cost of travel in that time period and by that mode between those two zones.

The choice models are applied to all person trips and to freight demand. The demand model choice structure, which is consistent with guidance provided in WebTAG Unit M2, is illustrated in Figure 133.

No-car-available and freight demand segments do not have the main mode choice process (car vs. public transport) available to them. Following WebTAG advice, the sensitivity of trip frequency for business trips (including freight) is zero.

Figure 133 Choice Model Structure



10.1.1 Software

The software required to run the VDM comprises:

- SATURN Version 11.3.12W – Highway Assignment Software;
- EMME Version 4.2 – PT Assignment Software; and
- EMME Version 4.2 – VDM software.

10.1.2 Pivoting

The WMMTM16 demand model is a pivot-point incremental model which estimates changes in trip patterns relative to a ‘reference’ matrix based upon observed data. The predicted relative changes reflect changes in travel costs and journey times. Changes in travel demand due to external factors (population, employment and personal income) are applied separately to establish the ‘reference’ matrices from base year matrices. In other words, the demand model seeks to forecast changes in demand in response to changes in cost, rather than attempting to estimate all demand based purely on costs of travel. This is considered to be practically preferable as this model form is generally more robust, and is thus recommended by WebTAG Unit M2.

In forecasting mode, the demand model pivots from the base year model, evaluating cost changes relative to the base year and adjusting the reference demand matrix to create do minimum scenarios. Do something scenarios then pivot from the appropriate year’s do minimum reference.

10.2 Structure of Demand

The demand model is a trip rather than tour-based model. A tour-based approach, when data are available, would provide more accurate forecasts in cases where policies involve parking restraint or other measures which introduce significant cost differences by time period. However, a tour-based approach would significantly increase the effort required both to develop and operate the model. Refer to Chapter 6 for details on demand matrix development.

10.2.1 Segmentation

Consistent with the base year demand matrices, the demand model has the following trip purposes:

- Commuting;
- Employers’ Business;
- Other;
- LGV; and
- HGV.

Within the demand model, business and other trips are considered to be either home-based (where one end of trip is permanent residence) or non-home-based (where neither end of trip is permanent residence). For home-based trips, from-home factors, reflecting the proportion of trips originating from home, are used to convert demand from origin-destination (OD) format to production-attraction (PA) format. Two modes of transport are modelled within the demand model: highway and public transport. Public transport trips are disaggregated by car ownership as follows:

- No car available trips (approximated as traveller belongs to a household owning no cars); and
- Car available trips (traveller belongs to a household owning one or more cars).

The model includes the following time periods, representing an average weekday:

- AM peak period – 07:45 – 09:15
- Inter-peak period – 09:15 – 16:30
- PM peak period – 16:30-18:00
- Off-peak – 18:00 – 07:45

The SATURN matrices are expressed in terms of hourly flows and so the peak period matrix is divided by 2/3 for output to the assignment process.

10.2.2 Generalised Cost Calculations

The WMMTM16 demand model is an incremental model that responds to changes in generalised cost. For the highway generalised cost calculations, the functions specified below are used, derived from WebTAG Unit M2. The data are expressed in minutes, pence and kilometres, except where otherwise stated:

$$Fuel\ Cost = F * D * i * \left(\frac{fa}{v} + fb + fcv + fdv^2\right)$$

$$Non\ Fuel\ Cost = D * \left(na + \left(\frac{nb}{V}\right)\right)\ for\ employers'business\ and\ freight\ trips$$

$$Highway\ Generalised\ Cost = Pure\ Time + \left(\frac{Fuel\ Cost + Non\ Fuel\ Cost + Charges}{Value\ of\ Time * Vehicle\ Occupancy}\right)$$

Where:

F = fuel cost, pence per litre;

D = assigned distance, kilometres;

V = average assigned speed for the matrix cell, kilometres per hour;

i = fuel efficiency improvement factor, which reduces fuel consumption over time;

$fabcd$ = fuel cost parameters;

nab = non-fuel cost parameters (assumed to be zero for non-work trips); and

charges = tolls and parking costs.

Public transport calculations used generalised costs (expressed in minutes) that are skimmed from the public transport model and used within the demand model.

$$Gen\ Cost = In\ Vehicle\ Time + Walk\ Time + Wait\ Time + Transfer\ Penalty + \left(\frac{Fare}{Value\ of\ Time}\right)$$

Within the highway and public transport generalised cost calculations the parameter values used vary by purpose and car availability. The parameter values adopted are discussed later in this chapter.

Within the demand model, the demand for home based trips is represented in production-attraction format. For these trips the costs for travel between productions and attractions are weighted by the proportions of trips observed travelling from and to home, thus resulting in generalised cost changes in PA format, separately for each time period. For non-home based trips, which are handled by the demand model in an origin-destination format, costs are taken directly from the origin destination cost skims.

The highway generalised cost matrices are derived from the demand model's SATURN highway supply model, which assigns five user classes; commuting, other, employers' business, LGV, and HGV. The public transport generalised cost matrices are derived from the embedded public transport supply model, using EMME software, which assigns a single demand user class. The cost skims from this single user class are used for all demand segments. Values of time, however, do vary, so overall generalised cost for public transport travel will vary by demand segment.

10.3 Demand Sensitivity of Longer Distance Demand Movements

The functions in the following three sections illustrate how incremental composite (logsum) costs are used throughout the demand model, ensuring that choices in the higher levels of the model hierarchy reflect the incremental composite cost of choices lower down the choice hierarchy.

The demand model, in common with any model representing the whole of the UK, albeit crudely outside the core area contains a wide range of trip lengths, from less than 1 kilometre to over 450 kilometres. The sensitivity of response to a ten-minute change would be expected in reality to be larger for a 30-minute journey than a six-hour journey, but in a pure logit model this ten-minute change would result in a similar demand response irrespective of trip length.

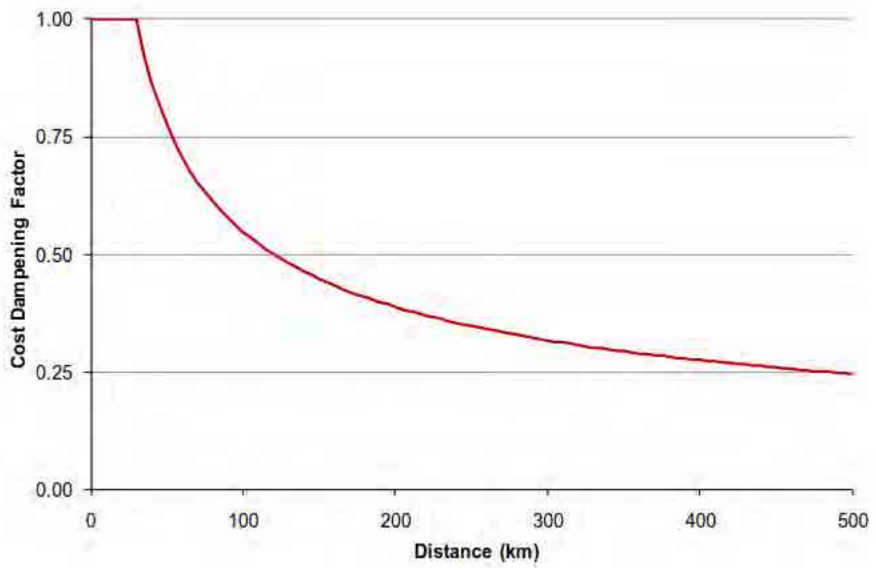
The following formula has therefore been developed to reflect the variation in response sensitivity to trip length:

$$Cost\ Dampening\ Factor = min(\frac{\sqrt{d1}}{\sqrt{distance}}, 1)$$

Where $d1$ is a calibrated parameter, set to 30km in the WMMTM16 demand model. this is consistent with advice in WebTAG Unit M2.

The function is plotted in Figure 134. Cumulative generalised cost changes that are used within the demand model are multiplied by the factor implied by this function. The distance used for each movement is the assigned distance on an uncongested base year highway network. This distance matrix remains constant and is used for all modelled years.

Figure 134 Cost Dampening Function



10.4 Trip Frequency

According to WebTAG Unit M2 (para 4.6.3), “*where the active modes of walk and cycle are not explicitly included then trip frequency may be thought of as, mainly, the transfer between the active modes and the mechanised modes”.* Where active modes are included then “*overall trip rates will be fairly stable and there will often be no need to model the response of trip frequency to changes in travel cost since the effect of trip frequency is likely to be small. It may therefore be proportional to omit this response, particularly since the frequency effect is markedly less important than the other choices and there is little evidence to justify the scale of frequency parameters and elasticities by purpose.”*

Following this guidance trip frequency responses are excluded from the model process.

10.5 Time Period Choice

The demand model simulates demand responses between the time periods. The model includes a mechanism for the reallocation of trips between these time periods on the basis of the respective cost changes for travel in different periods. There is no mechanism for reallocation of trips in time within a single modelled time period. i.e. the demand model does not have a micro time period choice mechanism.

$$\hat{D}_{t*i*} = \hat{D}_{**i*} \frac{\sum_{mj} D_{tmij} e^{\theta_t \Delta C_{t*i*}}}{\sum_{tmj} D_{tmij} e^{\theta_t \Delta C_{t*i*}}}$$

with:

$$\Delta C_{t*i*} = \log_e \left(\frac{\sum_{mj} D_{tmij} e^{\theta_m \Delta C_{tmi*}}}{\sum_{mj} D_{tmij}} \right)$$

The approach adopted aggregates trips by direction of travel and thus assumes that PA trips travelling from home have a similar sensitivity to trips returning to home in the same time period.

10.6 Mode Choice

Mode choice (car vs. public transport) is forecast as a function of cost change for all non-freight and car available demand, applied separately for each time period:

$$\hat{D}_{tmi*} = \hat{D}_{t*i*} \frac{\sum_{j} D_{tmij} e^{\theta_m \Delta C_{tmi*}}}{\sum_{mj} D_{tmij} e^{\theta_m \Delta C_{tmi*}}}$$

With:

$$\Delta C_{tmi*} = \log_e \left(\frac{\sum_{j} D_{tmij} e^{-\lambda_d C_{tmij}}}{\sum_{j} D_{tmij}} \right)$$

10.7 Trip Distribution

Trip distribution is forecast as a function of cost change for all demand segments:

$$\hat{D}_{tmij} = \hat{D}_{tmi*} \frac{D_{tmij} e^{-\lambda_d \Delta C_{tmij}}}{\sum_{j} D_{tmij} e^{-\lambda_d \Delta C_{tmij}}}$$

Where ΔC_{tmij} are cumulative generalised PA cost differences, with incremental cost differences being accumulated throughout each demand-supply iteration of the WMMTM16 demand model. These are cost changes, output by the supply model and for home based trips converted from OD to PA, for non-home based trips OD changes are retained.

Following guidance in WebTAG Unit M2, commuting trips are doubly-constrained within the demand model, ensuring that each zone produces and attracts a fixed total number of trip-ends[9]. All other trips are singly-constrained, with no constraint on the attractor zone. The double-constraint function is applied across modes, time periods and segments and is iterated until the two following criteria are achieved.

---

[9] There is therefore no trip frequency effect, implying no allowance for potential diversion between active and motorised modes for commuting.

$$\sum_{tmj} D_{tmij} = \sum_{tmj} \hat{D}_{tmij}$$

$$\sum_{tmi} D_{tmij} = \sum_{tmi} \hat{D}_{tmij}$$

The commuting double-constraint is applied by accumulating trips by mode to establish total trips by destination D’i*j*. Segment and mode specific proportions are calculated before the double-constraint process so that the doubly-constrained output total demand matrix (total demand across all segments and modes) can be disaggregated into demand by mode and segment, reflecting the distribution of these demand matrices before the double-constraint. These proportions are calculated using:

$$\%\hat{D}_{tmij} = \frac{\hat{D}_{tmij}}{\sum_{tm} \hat{D}_{tmij}}$$

The destination specific target totals are then calculated for use in the constraining process and the demand matrix is balanced to ensure that the double-constraint criteria (above) are enforced.

10.8 Calibration

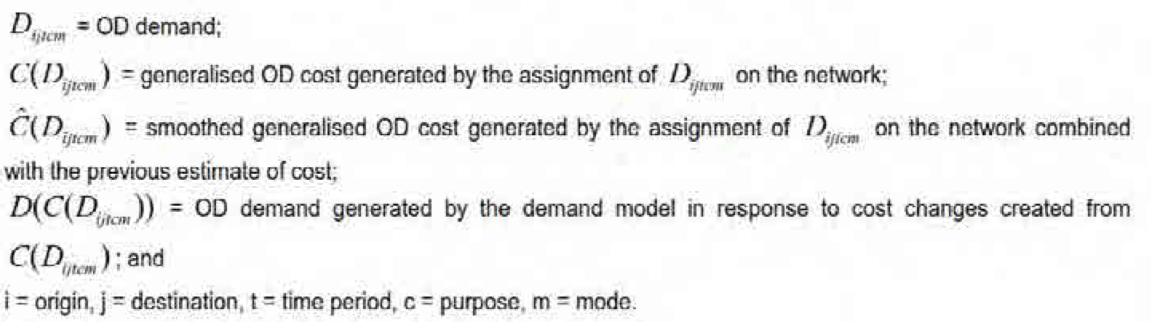
The highway and public transport supply (assignment) models and the demand model are run in sequence iteratively until the demand model is deemed to have converged. The costs from the supply models and functions are fed into the demand calculations, with the resulting demand used to recalculate the costs. This process continues until convergence.

10.8.1 %GAP Demand Supply Convergence

The measure of convergence of the demand and supply models is the demand-supply %GAP function as recommended by WebTAG Unit M2. This %GAP statistic is calculated using the following function:

$$G = \frac{\sum_{ijtc} C(D_{ijtc}).\left|D_{ijtc} - D(\hat{C}(D_{ijtc}))\right| * 100}{\sum_{ijtc} C(D_{ijtc}).D_{ijtc}}$$

Where:



D_{ijtcm} = OD demand;

$C(D_{ijtcm})$ = generalised OD cost generated by the assignment of D_{ijtcm} on the network;

$\hat{C}(D_{ijtcm})$ = smoothed generalised OD cost generated by the assignment of D_{ijtcm} on the network combined with the previous estimate of cost;

$D(C(D_{ijtcm}))$ = OD demand generated by the demand model in response to cost changes created from $C(D_{ijtcm})$; and

i = origin, j = destination, t = time period, c = purpose, m = mode.

All modes are included in this calculation. It is also performed separately for each mode (car, public transport, freight). Car trips do, however, dominate the calculation; they are also generally the slowest to converge within the demand model.

In calculating the %GAP, the demand model aggregates across time periods, aiming for a %GAP target of 0.1% overall demand segments and modes as specified in WebTAG guidance.

10.8.2 Demand Smoothing

Demand matrices are provided to the supply (assignment) models, which generate costs to feed into the demand model (unaltered). This in-turn generates a new set of demand matrices, from which a %GAP is calculated prior to the application of a smoothing process. The smoothing process adjusts the output demand matrices before they are assigned in the supply models in the next demand/supply iteration.

The demand smoothing uses the following function:

$$\hat{D}_X = \frac{2D_X}{X} + \frac{(X-2)\hat{D}_{X-1}}{X}$$

Where:

X = the current iteration of the demand model;

D_X = the demand matrix produced by the demand model in iteration X; and

$\hat{D}_X$ = the averaged demand matrix used as input to the supply model in iteration X.

Demand smoothing is only applied from the third iteration of the model onwards. The construction of the function is such that more recent iterations are given more weight in the calculation of an averaged demand matrix than earlier iterations; we have found in practice that this tends to result in faster convergence than a “straight” average of all previous iterations.

10.8.3 Generalised Cost Parameters

The functions used to calculate generalised cost were provided above. This section presents the parameters used in these functions.

10.8.3.1 Values of Time

A process has been introduced to modify value of time by trip length in accordance with WebTAG Unit M2, paragraph 3.3.10; a second form of cost, the cumulative effect of which yields plausible model sensitivity.

The non-work value of time is calculated as thus:

$$VoT = \max\left(VoT_c \left(\frac{D}{D_0} \right)^{\eta_s}, VoT_c \left(\frac{D_C}{D_0} \right)^{\eta_s} \right)$$

Where:

VoT = value of time used by the model;

VoT_c = central value of time given in table A1.3.2 in the WebTAG Data Book;

D = length of trip; and

D_0, D_C, η_s = parameters.

The elasticities (n_S) used are as defined in WebTAG Unit M2a and are shown in Table 103. In calculating these values, D has been taken as the assigned distance on an uncongested base year highway network. The distance skim used is static, ensuring that the value of time for any given segment for any given origin-destination pair remains the same for all WMMTM16 demand model tests.

The reason for the use of D_c is that the model contains a large number of intra-zonal trips with approximate, estimated distances, generally very short (<4km). It was felt that arbitrary increase in sensitivity of these trips was undesirable. A value of 4km for D_c was thus adopted. D_0 values were calibrated using the trip length distribution from the model to ensure that the average VoT weighted by distance matched the national averages used in the model.

Table 103 Value of Time Calculation Parameters

Purpose	Elasticity (n_s)	D_0 (km)
Commute	0.248	20
Business	0.387	29
Other	0.315	23

The central base year (2016) values of time, VOT_c, used as inputs to the function above were derived from the WebTAG Databook and are shown in Table 103, expressed as person values.

Table 104 2016 Person Values of Time (pence per minute, 2010 prices)

Purpose	Value of Time
Commuting	17.883
Business	26.708
Other	8.167
LGV	18.383
HGV	43.337

SOURCE: WebTAG Databook, March 2017

The HGV values of time used deviate from WebTAG guidance (Unit A1.3) to reflect operators’ rather than drivers’ value of time. This adjustment produces HGV values that are twice as high as those originally quoted. This is in accordance with WebTAG Section 3.1, paragraph 2.8.8 which states *“…the value of time given in TAG Unit A1.3 for HGVs relates to the driver’s time and does not take account of the influence of owners on the routeing of these vehicles. On these grounds, it may be considered to be more appropriate to use a value of time around twice the TAG Unit A1.3 values.”*

10.8.3.2 Vehicle Operating Costs

Vehicle operating costs (VOCs) have been implemented using WebTAG Unit M2 guidance, and are summarised in Table 104.

Table 105 Base Year (2016) Operating Cost Parameters, 2010 prices

Value	Car (Petrol)	Car (Diesel)	LGV (Petrol)	LGV (Diesel)	Car (Electric)	HGV (Diesel)
Work Fuel Cost, pence per litre	87.8549	87.8549	87.8549	87.8549	13.5387	87.8549
Non-Work Fuel Cost	105.4259	105.4259	105.4259	105.4259	14.2156	105.4259
Fuel VOC A-Factor	1.11932	0.49215	1.950833	1.396883	0.0000	2.353097

Fuel VOC B-Factor	0.044	0.06218	0.034528	0.033477	0.1260	0.465133
Fuel VOC C-Factor	-0.00008	-0.00059	0.000068	-0.00023	0	-.006792
Fuel VOC D-Factor	0.000002	0.000005	0.000004	0.000008	0	0.000054
Non- Fuel Cost A-Factor (work)	4.95368	4.95368	6.34744	6.34744	4.95368	
Non- Fuel Cost B-Factor (work)	135.946	135.946	41.45944	41.45944	135.946	
Non- Fuel Cost A-Factor (non-work)	10.50325	10.50325	6.34744	6.34744	10.50325	
Non- Fuel Cost B-Factor (non-work)	409.91133	409.91133	41.45944	41.45944	409.91133	
Fleet Proportion (Petrol / Diesel)	0.471	0.526			0.003	
Fuel Efficiency improvement factor	0.882	0.874	0.971	0.851	1.004	1

SOURCE: : WebTAG Databook, March 2017

The vehicle operating costs reported in Table 104 are perceived costs in 2016 prices and 2010 values. These values have been derived from the 2016 values specified in WebTAG using the forecast changes in fuel cost, fuel efficiency and fleet mix (diesel, petrol and electric).

10.8.3.3 Monetary Charges

The demand model generalised cost function includes a monetary cost matrix for highway demand segments. All monetary charges are converted to generalised minutes using value of time and occupancy, i.e. monetary costs are assumed to be shared by all vehicle occupants.

10.8.4 Choice Model Sensitivity Parameters

The demand model uses theta and lambda values in its choice functions, reflecting response sensitivity. The values used are given in the following paragraphs, along with discussions as to their origin. Following WebTAG guidance, lambda parameter values are specified for trip distribution; all other choice processes above distribution (frequency, mode, time period) use theta parameter values, which are scaling parameters. Theta parameters indicate the relative sensitivity of a choice process when compared with the next process down in the choice hierarchy. As the sensitivity of choice parameters should not increase when moving up the choice hierarchy, theta values will never be greater than unity.

10.8.4.1 Main Mode Choice

The main mode choice theta values are taken directly from WebTAG Unit M2 and shown in Table 106.

Table 106 Mode Choice Theta Values

Purpose	Theta
Commuting	0.68
Home Based Business	0.45
Home Based Other	0.53
Non Home Based Business	0.73
Non Home Based Other	0.81

10.8.4.2 Time Period Choice

Time period choice and main mode choice have identical sensitivity in the WMMTM16 demand model, and the time period choice parameters are equal to 1. WebTAG Unit M2 advises that the two choice mechanisms should have similar or identical sensitivity, indicating that there is no conclusive evidence as to whether individuals give preference to their choice of mode or their choice of time period of travel.

10.8.4.3 Trip Distribution

The lambda values for trip distribution used in the WMMTM16 demand model are shown in Table 107. The initial values were derived from WebTAG Unit M2 and adjusted during calibration. The WebTAG guidance notes that the minimum and maximum values are not targets, and are indicative. It does state that parameters should usually fall within ±25% of the median value. All parameters used in the WMMTM16 fall within this criterion.

Table 107 Car Trip Distribution Lambda Values

Purpose	WebTAG Min	Actual	WebTAG Max
Commuting	0.054	0.065	0.113
HB Business	0.038	0.067	0.106
HB Other	0.074	0.078	0.160
NHB Business	0.069	0.081	0.107
NHB Other	0.073	0.077	0.105

SOURCE: WebTAG Unit M2

Table 108 Public Transport Trip Distribution Lambda Values

Purpose	WebTAG Min	Actual	WebTAG Max
Commuting	0.023	0.041	0.043
HB Business	0.030	.0.043	0.044
HB Other	0.033	0.045	0.062
NHB Business	0.038	0.045	0.045
NHB Other	0.032	0.034	0.035

SOURCE: WebTAG Unit M2

10.8.5 Model Convergence

WebTAG Unit M2 advises that a %GAP of 0.1% should be achieved, and this is the gap that has been implemented as the requirement for convergence.

10.9 Validation

The WMMTM16 demand model is an incremental demand model that uses cost changes to estimate changes in demand from a base year or reference matrix. The validation of the demand model is a consideration of the realism tests and recommended acceptable values or ranges of values for model sensitivity, generally derived from WebTAG. A number of realism tests have been undertaken to demonstrate that the modelled demand responses are plausible, both in the direction and scale of change. Data from these tests are presented below.

Where elasticities are discussed, these are, except where otherwise specified, based on changes in vehicle kilometres with respect to changes in some element of cost, and are calculated via the arc-elasticity formula:

$$\text{elasticity} = \frac{\log_e\left(\frac{\text{km}_t}{\text{km}_b}\right)}{\log_e\left(\frac{v_t}{v_b}\right)}$$

Where:

km_t is the vehicle kilometres in the test case;

km_b is the vehicle kilometres in the base case;

V_b is the base value of the variable for which the elasticity is being calculated (fuel cost, rail fares, journey time, etc.); and

V_t is the test value of that variable.

An alternative formulation, used where specifically noted, for consistency with the data available, is that of the trip elasticity, which is given by:

$$\text{elasticity} = \frac{\log_e\left(\frac{t_t}{t_b}\right)}{\log_e\left(\frac{v_t}{v_b}\right)}$$

Where:

t_t is the total trips in the test case; and

t_b is the total trips in the base case.

10.9.1 Realism Testing

Elasticities have been calculated in two ways, in accordance with WebTAG guidance:

- At a matrix level, using demand matrices and OD distance skims, including only demand produced in the Warrington borough area. This ensures that a complete range of trip lengths is included in the calculation but that wholly external demand, which is modelled quite crudely and is of little interest, is excluded.
- At a network level, using link flows and link distances, including only links in the internal (simulation) area of the model.

10.9.1.1 Car Fuel Cost Elasticity

The main measure of the model highway sensitivity is the change in car vehicle kilometres with respect to a change in car fuel cost. Car fuel cost was increased by 10%, the resulting change in car vehicle kilometres was measured, and the elasticities were calculated.

WebTAG Unit M2 provides guidance on car fuel cost elasticities. They are expected to be in the range of -0.25 to -0.35, at a plausible level given the modelled area’s characteristics relative to the UK as a whole. The elasticity is expected to be weaker in the above range (closer to -0.25) where trip lengths are shorter than average, car driver mode shares are higher than average, and the proportion of business trips are higher than average, and the elasticity is expected to be stronger (closer to -0.35) where the opposite applies.

The model was run to convergence and converged after four iterations. Convergence statistics are shown in Table 110.

Table 109 Convergence Statistics for Fuel Cost Test

Sector	Car	PT
Commuting	0.10	0.02
HB Business	0.09	0.02
HB Other	0.10	0.01
NHB Business	0.10	0.04
NHB Other	0.10	0.02
Aggregate	0.08	

Table 110 shows the final car fuel cost vehicle kilometre elasticities for all trips originating in the model internal area, as derived from the test increase in car fuel cost by 10%.

Table 110 Car Fuel Cost Elasticities – Matrix Based (Vehicle Kilometres)

Purpose	AM Peak	Inter Peak	PM Peak	24 hr
Commuting	-0.18	-0.18	-0.17	-0.18
Business	-0.15	-0.15	-0.16	-0.15
Other	-0.37	-0.38	-0.33	-0.37
Overall	-0.25	-0.29	-0.25	-0.28

Table 111 Car Fuel Cost Elasticities – Network Based (Vehicle Kilometres)

Purpose	AM Peak	Inter Peak	PM Peak	24 hr
Commuting	-0.10	-0.14	-0.11	-0.11
Business	-0.05	-0.08	-0.04	-0.05
Other	-0.20	-0.22	-0.18	-0.20
Overall	-0.12	-0.15	-0.15	-0.14

The results show a low level of elasticity for non-discretionary commuting and business trips suggesting a small modal shift for these trips, while the discretionary trips exhibit a much higher response to cost changes. Overall the results fall within the bounds set out by WebTAG.

Considering the network based results the elasticities are significantly lower for business trips, although similar for non-business trips. It should be noted that the network based calculations have been carried out using trips on the whole of the simulation area network, which extends beyond the boundaries of Warrington and carries external to external traffic. The zoning in these areas is less well defined and thus the responses for such trips may not be so well represented, as a result the overall reported elasticities may be expected to be lower.

10.9.1.2 Public Transport Fare Elasticities

WebTAG Unit M2 states that public transport fare elasticity test is required in all cases where changes in public transport generalised costs, including changes in fares, are modelled. Accordingly, the elasticities of public transport trips to fare have been calculated, presented in Table 113, where fares were increased by 10% for this test. The model was run to convergence and converged after 3 iterations. The overall elasticity is within the suggested range of -0.20 to -0.90. The breakdown by purpose shows lower elasticities for non-discretionary trips and much higher rates for discretionary trips. The elasticity for business trips is high, but this is based on a very small number of business trips observed using public transport within the Warrington area.

Overall the values are at the lower end of the range. This is primarily driven by the fact that the fare element of the PT generalised cost represents a relatively small proportion of the total cost, thus a 10% increase in fare represents a very small increase in the modelled journey cost. This reflects the high use of season and concessionary fares in the model, particularly for commuting trips which reflects the high use of season and concessionary fares in the model.

The model was run to convergence and converged after three iterations. Convergence statistics are shown in Table 114.

Table 112 Convergence Statistics for Fares Elasticity Test

Sector	Car	PT
Commuting	0.08	0.02
HB Business	0.05	0.01
HB Other	0.07	0.01
NHB Business	0.08	0.03
NHB Other	0.07	0.02
Aggregate	0.06	

Table 113 Public Transport Fare Elasticities (Trips)

Purpose	AM Peak	Inter Peak	PM Peak	24 hr
Commuting	-0.22	-0.12	-0.17	-0.17
Business	-0.15	-0.13	-0.19	-0.15
Other	-0.63	-0.25	-0.44	-0.30
Overall	-0.37	-0.23	-0.18	-0.27

10.9.1.3 Car Journey Time Elasticity

WebTAG also requires calculation of elasticity of car demand (at the trip level) to journey times. Here the requirement is merely that the elasticities do not exceed -2 in magnitude, and that they are negative (as is logical). Journey times were increased by 10% for this test, and the demand and supply models were not iterated to convergence but run for a single iteration only, as advised in WebTAG M2.

The overall elasticities, shown in Table 114, range between -0.03 and -0.21, overall the elasticity is low and thus falls well within the suggested range. When measured on a network basis the values are higher as shown in Table 115, although still within the appropriate bounds. The differences between the two measures are as discussed above, that the network based measure will include some external to external trips

Table 114 Car Journey Time Elasticities - Matrix Based (Vehicle Kilometres)

Purpose	AM Peak	Inter Peak	PM Peak	24 hr
Commuting	-0.15	-0.03	-0.21	-0.09
Business	-0.12	-0.04	-0.06	-0.03
Other	-0.10	-0.07	-0.10	-0.06
Overall	-0.13	-0.06	-0.15	-0.07

Table 115 Car Journey Time Elasticities - Network Based (Vehicle Kilometres)

Purpose	AM Peak	Inter Peak	PM Peak	24 hr
Commuting	-0.34	-0.35	-0.40	-0.37
Business	-0.37	-0.38	-0.42	-0.39
Other	-0.51	-0.49	-0.50	-0.50
Overall	-0.41	-0.44	-0.45	-0.44

10.9.2 Summary of Realism Testing

The results of the realism testing show demand responses fall within the bounds suggested within WebTAG Unit M2, in general they fall toward the lower end of the range.

Primary responses to changes in costs are driven by trip redistribution with a lesser response in modal transfer. Existing trip making within Warrington is largely car based, with a relatively low observed market share for public transport.

The results suggest that the model responds in an appropriate way to changes in costs within the Borough area.

10.9.3 Model Robustness

The WMMTM16 demand model is a fully functioning variable demand model, designed to be compliant with WebTAG guidance. The sensitivity of the demand model is consistent with WebTAG guidance. The demand elasticities of the model to changes in car fuel cost, journey time and public transport fares are credible, varying by demand segment and time of day.

The car fuel cost sensitivity of the demand model is consistent with current research and guidance. Inter-peak model sensitivity is highest, reflecting lower levels of highway congestion which constrain the effects of the fuel cost change in the peak periods. The car journey time elasticity of the demand model is also consistent with WebTAG guidance, within the range of the values suggested for low to high modal competition.

Overall public transport fare sensitivity is within the range specified by WebTAG, with variation between demand purposes. Good demand-supply %GAP convergence is achieved, comparable with that required by WebTAG, and this demonstrates that the WMMTM16 demand model is converging to a level proportionate with the WebTAG guidance and appropriate for the scale of schemes to be tested in the model.

The demand model is currently suitable for estimating the highway demand response as a result of changes in highway travel costs (changes in value of time or fuel costs) and changes in journey time (e.g. from new infrastructure, changes in capacity, and changes in congestion related delays).

11. Conclusion

11.1 Background

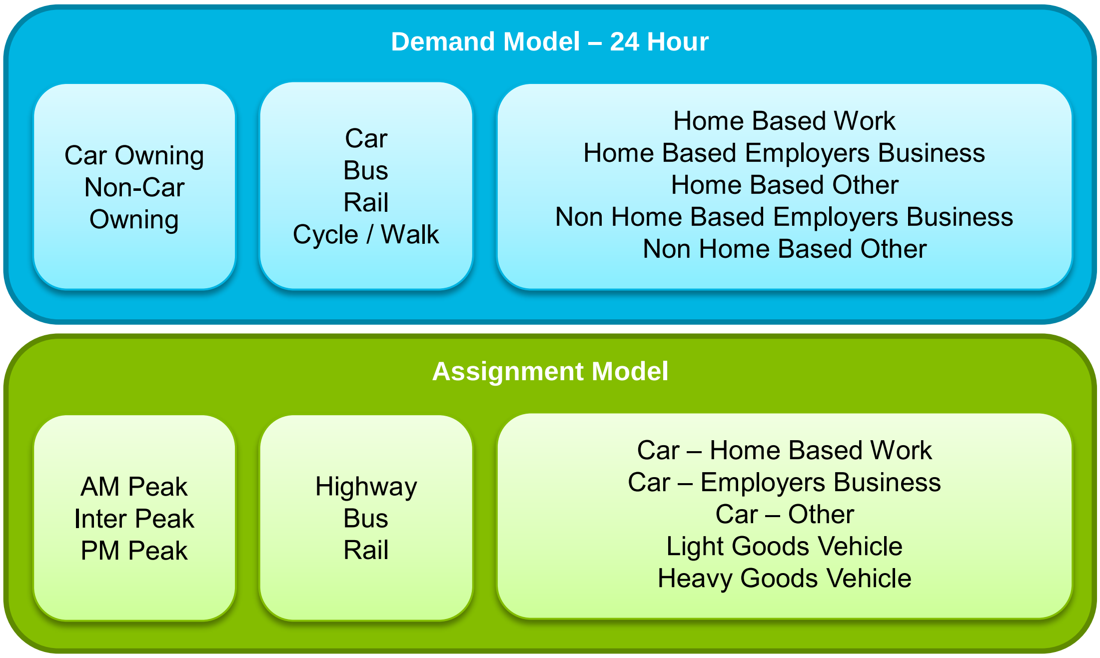
This LMVR documents the development of a new transport model for WBC, referred to as the Warrington Multi Modal Transport Model 2016 (WMMTM16). The model is designed to support the development of a spatial strategy for the Warrington Local Plan which is currently under review, and also to underpin the appraisal of a variety of transport proposals, notably a major western route, “Warrington Western Link”, which is currently in development.

11.2 Overview of Model

The WMMTM16 has been developed using SATURN modelling software, version 11.3.12U for highway assignment modelling aspects integrated with EMME 4.29 software for public transport and demand modelling aspects.

The WMMTM16 covers the whole of the Borough in detail with a buffer area of reduced detail and then an external area covering the rest of the country. The base year for the model is 2016 and it represents an average neutral “weekday” in June. The model includes AM, Inter-peak and PM peak periods for assignment purposes and a 24-hour demand model. The structure is illustrated in Figure 135.

Figure 135 Overview of Model Structure



11.3 Performance Summary

The ability of the model to reflect observed conditions has been tested in accordance with advice provided in WebTAG, the Department for Transport’s guidance on the conduct of transport studies.

For the highway assignment model, the key criteria are the ability to reproduce traffic flows on the network and journey times to pass through the network.

Traffic flows on the network have been checked at 389 individual sites across the whole Borough and also in terms of groups of sites known as screenlines and cordons.

The percentage of screenlines and cordons meets or exceeds the WebTAG criteria in all three time periods. The proportion of individual sites meeting the performance requirement is 85% in the AM, 87% in the inter peak and 85% in the PM peak against a desired WebTAG target of 85%.

Journey times have been assessed against 32 routes within the Borough and 6 on the surrounding motorway network. In total, 82% of the routes in the morning and evening peak and 84% in the inter peak meet the required criteria against a desired WebTAG target of 85%.

The public transport model was calibrated / validated against observed bus patronage levels and observed railway station patronage levels for bus routes and railway stations within Warrington. Although there is no strict guidance available for validating public transport models, the model meets the DMRB criteria set for highway models in terms of patronage levels measured in GEH and percentage flow.

Whilst no validation criteria exists for demand models the results of the realism tests presented in this report demonstrate a demand model that accurately reflects the transport demand characteristics of Warrington. The demand model has been checked and shown to meet the realism tests as set out in WebTAG.

11.4 Fitness for Purpose

This report has demonstrated that the WMMTM16 reflects existing travel patterns and transport network operating conditions very well across the Borough.

Modelled highway traffic flows meet or exceed WebTAG guidance criteria in all time periods and modelled journey times, although slightly below WebTAG requirements, show a high degree of correlation against observed across all time periods.

The public transport network reflects observed levels of patronage and delay and the demand model meets the realism tests as set out in WebTAG.

Taken in combination, these show that the model either meets, or is very close to meeting, WebTAG criteria in all the key areas: modelled flows/passengers; journey times and demand responsiveness. The limited areas in which the model fails to meet the required criteria are generally in locations where either the observed data is subject to high levels of variation (e.g. motorway journey times or specific one-off manual classified counts) or there are local specific conditions (e.g. route choice between parallel routes) which are not possible to reflect in the model.

We believe the model can be used with confidence to assess the impacts of planned land use changes in the Borough and to test potential infrastructure changes.

Appendix A

A.1 Expansion Factors for RSI Sites

Appendix B

B.1 Observed Count Data Tables

Appendix C

C.1 Bus Expansion Factors

Appendix D

D.1 Variable Signal Timings Example Output

Appendix E

E.1 WMMTM16 Coding Manual

Appendix F

F.1 Bus Service Routings – IP

F.2 Bus Service Routings – PM

F.3 PT Routing Checks

Appendix G

G.1 Telefonica Report – Mobile Phone Data

Appendix H

H.1 WSP Model Review and Checks

Appendix I

I.1 WMMTM16 Highway Calibration and Validation Dashboard – RUN053

I.2 WMMTM16 Highway Journey Time Dashboard – RUN053

I.3 Stress Test – 10% increase in Matrix Flow - AM and PM Delay Difference Plots

Appendix J

J.1 Trip Length Distributions – Mobile Phone Data vs. RSIs

J.2 Chapter 6 – Trip Length Distributions – NTS vs. Synthetic

J.3 Chapter 7 – Trip Length Distributions – Prior vs. Post ME Matrices

J.4 Chapter 7 – Origins & Destinations Regression Plots – Prior vs. Post ME matrices

J.5 Chapter 7 – Cell Regression Plots – Prior vs. Post ME matrices

Appendix K

K.1 Test of Network Response to Scheme Testing

aecom.com