TRANSPORT FOR LONDON

RIVER CROSSINGS: SILVERTOWN TUNNEL

SUPPORTING TECHNICAL DOCUMENTATION

BASE YEAR DEVELOPMENT AND VALIDATION REPORT

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October 2014

The purpose of this report is to set out the key features and performance of the 2012 base year traffic assignment model.

Topics examined include;

- Calibration and validation data;
- Network development;
- Trip matrix development;
- Network calibration and validation;
- Route choice.

This report is part of a wider suite of documents which outline our approach to traffic, environmental, optioneering and engineering disciplines, amongst others. We would like to know if you have any comments on our approach to this work. To give us your views, please respond to our consultation at www.tfl.gov.uk/silvertown-tunnel

Please note that consultation on the Silvertown Tunnel is running from October – December 2014.

River Crossing Modelling

Base Year Development and Validation Report

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1 Introduction

1.1 Context

In March 2011 Mott MacDonald was appointed by Transport for London (TfL) to carry out modelling work to support the case for new road crossings of the Thames in East London. This report documents the work undertaken to develop a base year highway assignment model representing an average weekday in November 2012.

1.2 Proposed Uses of the Model and Key Model Design Considerations

The model is required to estimate the changes in traffic flows and journey times which could result from the provision of possible new road and ferry crossings of the Thames in East London between Blackwall and Dartford. It is possible that tolls could be charged on river crossings. The model network needs to include all major links where traffic flows could change significantly as a result new river crossing capacity.

It is known that delays on the existing road network change by time of day. In order to estimate changes in traffic congestion at different times of day, separate models have been developed for the AM peak hour, average inter-peak hour, and PM peak hour separately.

Different vehicle types, incomes and trip purposes are associated with different values of time, and hence drivers may respond differently to the potential time savings from and tolls on new river crossings. The models therefore represent cars, light goods and heavy goods vehicles separately, and also cars in work time and out of work time.

It is important that the model is able to represent traffic flows and journey times on and approaching the existing Thames Crossings on which traffic levels could be affected by the possible new river crossings under consideration, and on the approaches to possible new crossings. The accuracy of the model becomes less important with increasing distance from possible new crossings.

1.3 Method

The starting point for prior matrix calibration was the East London Highway Assignment Model (ELHAM) Production Version 2, which was available for a 2009 base year. The matrices were first re-developed at a 2009 level to take into account a number of enhancements to the matrix-building process, as detailed in Section 6.2. The model was then updated with new count information and network changes to represent a November 2012 base year, as detailed in Sections 5.2 and 6.3.

The model was built, calibrated and validated with five user classes as described above and those results are included in this report. Income segmentation is then applied before forecasts are carried out. For cars in out of work time, 3 separate income segments are represented. A further assignment was therefore run with the income-segmented seven user classes to assess any impacts of the segmentation on the validation. This is reported in Chapter 12 of this report.

2 Model Standards

Guidance on appropriate validation criteria and acceptability guidelines are set out in WebTAG Unit 3.19, and is summarised in this section of the report. The test for the fitness for purpose of a model is defined in the Guidance as whether robust conclusions can be drawn from model outputs.

2.1 Trip Matrix Validation

A screenline should normally be made up of 5 or more links, and long screenlines which limit leakage around the ends are necessary for trip matrix validation. Screenlines containing high flow routes should be presented both including and excluding such routes. The differences between modelled flows and observed counts should be less than 5% when summed across a screenline. This should apply to all or nearly all screenlines, be segregated by vehicle type and be presented separately for roadside interview screenlines, other screenlines used as constraints in matrix estimation, independent validation screenlines and each time period.

2.2 Link Flow Validation

Absolute and percentage differences and the GEH statistic between observed counts and modelled flows are used to assess link flow validation.

The GEH statistic is expressed as follows:

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

Where: M = modelled flow;

C = observed count.

The absolute/percentage difference measure and the GEH measure are broadly consistent and link flows that meet either criteria should be considered satisfactory. Acceptability guidelines for link flows and turning movements are defined in **Table 2.1.** These should be presented separately for each time period and for cars and total vehicles. Calibration and validation for this model was based mainly on link traffic counts carried out over at least 5 days. Some turning movement data were also available, these were only carried out on a single day, but were converted to an average weekday level where possible using adjacent 5-day link counts.

Table 2.1: Link Flow Validation Criteria and Acceptability Guidelines (source: WebTAG unit 3.19)

Criteria	Description of Criteria	Acceptability Guideline
1	Individual flows within 100 veh/h of counts for flows less than 700 veh/h	> 85% of cases
	Individual flows within 15% of counts for flows from 700 to 2,700 veh/h	> 85% of cases

Criteria	Description of Criteria	Acceptability Guideline
	Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h	> 85% of cases
2	GEH < 5 for individual flows	> 85% of cases

WebTAG 3.19 notes that the acceptability guidelines should be applied to link flows but may be difficult to achieve for turning movements.

2.3 Journey Time Validation

The measure used for journey time validation is the percentage difference between modelled and observed journey times. Modelled times along routes should be within 15% of surveyed times, or 1 minute if higher. This should apply to 85% of routes. As the model represents a congested urban network the speeds that light and heavy vehicles drive at will be similar, therefore comparisons are presented for all vehicle types together, but are provided separately for each time period.

2.4 Convergence Criteria

The table below details the convergence criteria as set out in WebTAG unit 3.19.

Table 2.2: Summary of Convergence Measures and Base Model Acceptable Values

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

Source: WebTAG unit 3.19 Table 4

To ensure the model is a robust base for variable demand modelling and economic appraisal, the models have been set up with tighter convergence than those given above, requiring four consecutive loops with a %GAP of less than 0.05%.

3 Key Features of the Model

3.1 Introduction

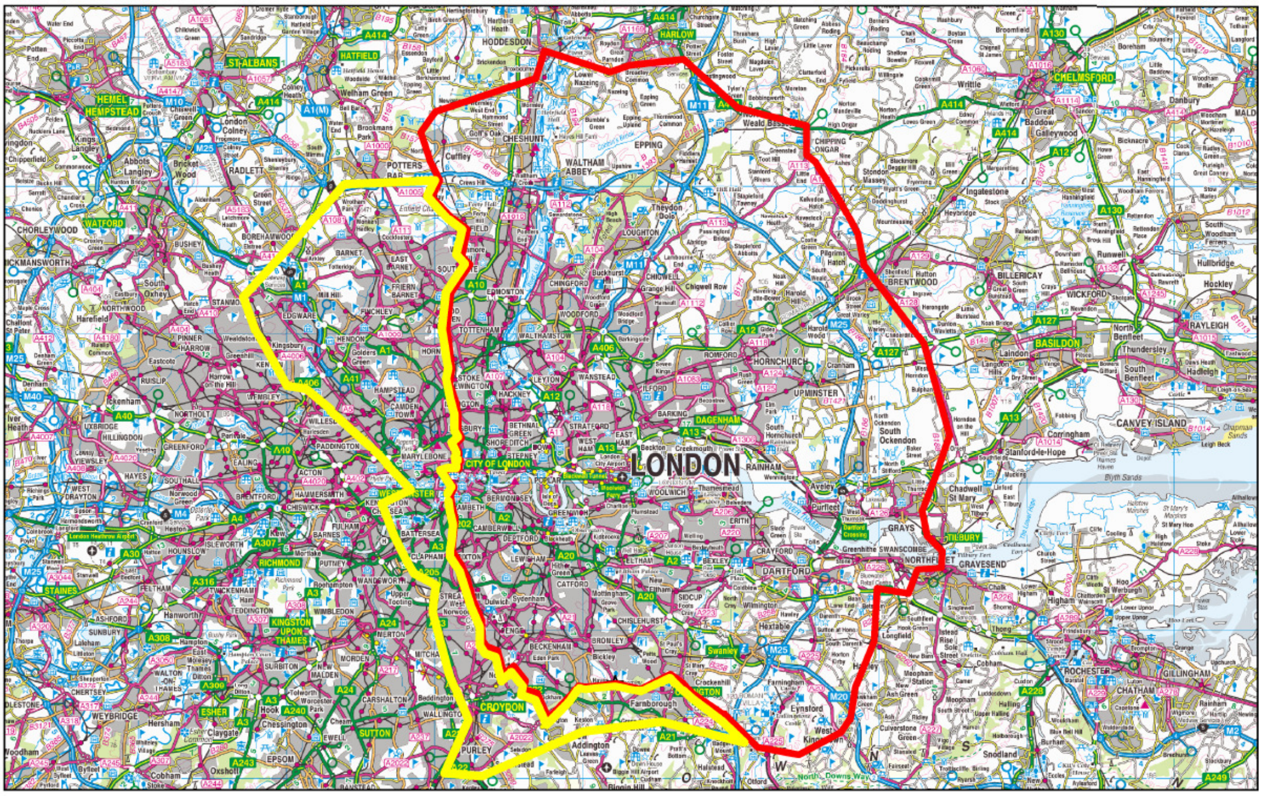
This section of the report summarises the features of the River Crossings Model and includes the following sections:

- 'Fully Modelled Area' and 'External Area';
- Zoning System;
- Network Structure;
- Centroid Connectors;
- Time Periods;
- User Classes;
- Assignment Methodology;
- Generalised Cost Formulations and Parameter Values; and
- Capacity Restraint Mechanisms: Junction Modelling and Speed/Flow Relationships

3.2 Fully Modelled Area and External Area

The model has a simulation area which extends to and includes the M25 on the eastern side, across to Southwark Bridge in the west, shown within the red line in **Figure 3.1** below. Within the yellow line the network is coded as buffer with speed/flow curves. The external area is coded as buffer with fixed speeds, taken initially from the LTS model. The simulation area is large enough to cover the major roads where traffic flows could be significantly affected by the proposed river crossings.

Figure 3.1: Network areas



Source: TfL

3.3 Zoning System

The model has 2448 zones covering the whole of the UK. The size of the zone decreases the closer to Greater London it is. Within Greater London the zone size reduces further in the simulation area such that this area has the smallest zones. **Figures 3.2** and **3.3** show the zone structure.

Figure 3.2: Detailed Zone System

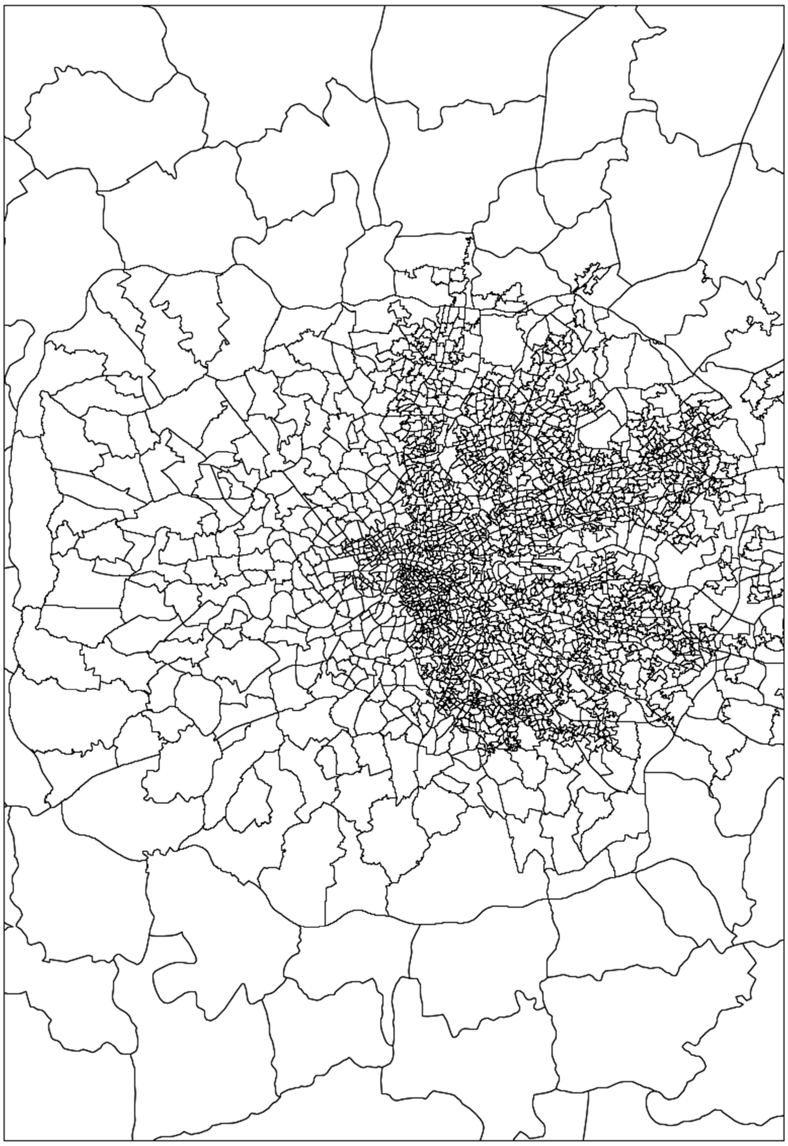
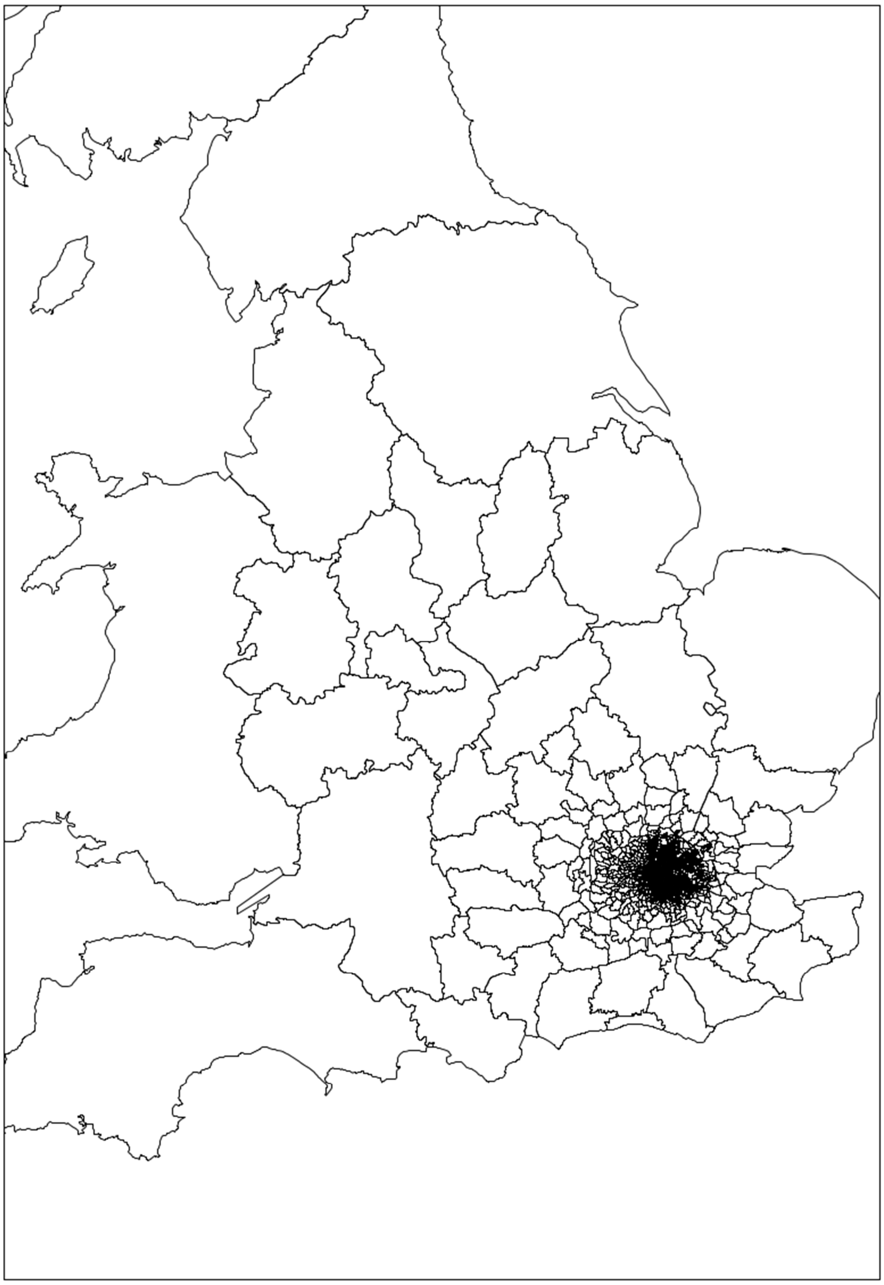


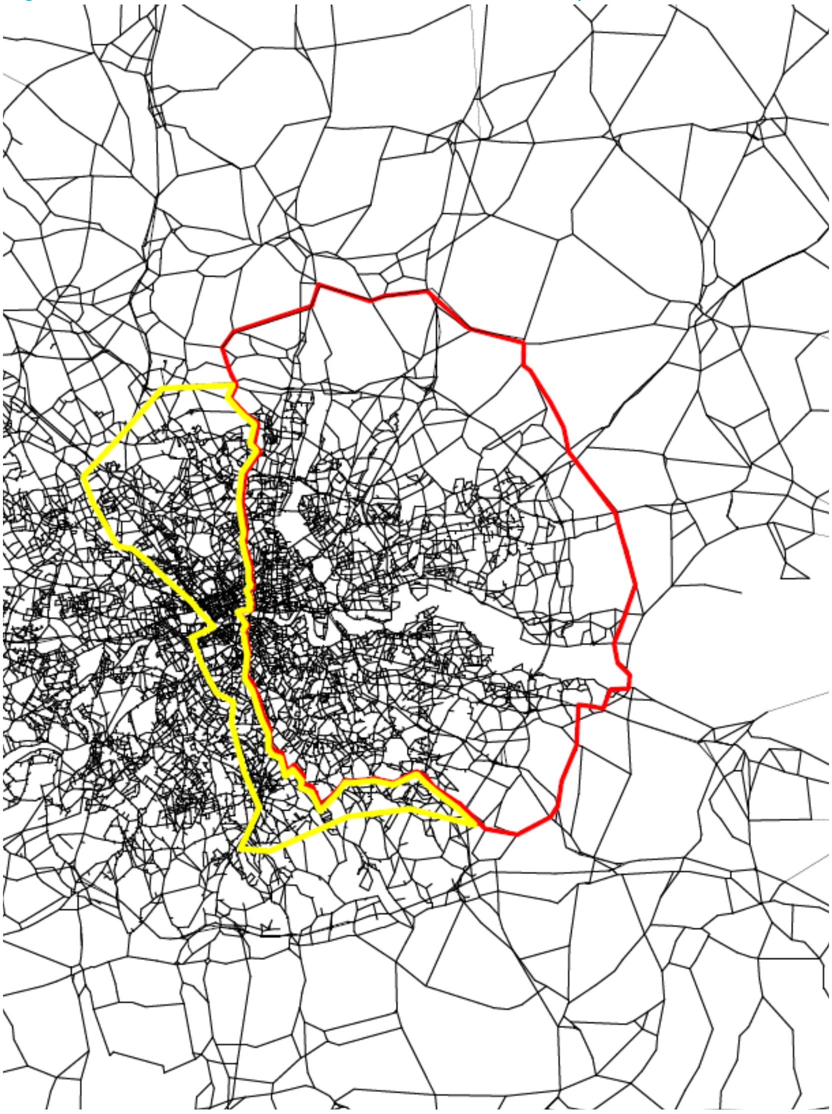
Figure 3.3: UK Zone System



3.4 Network Structure

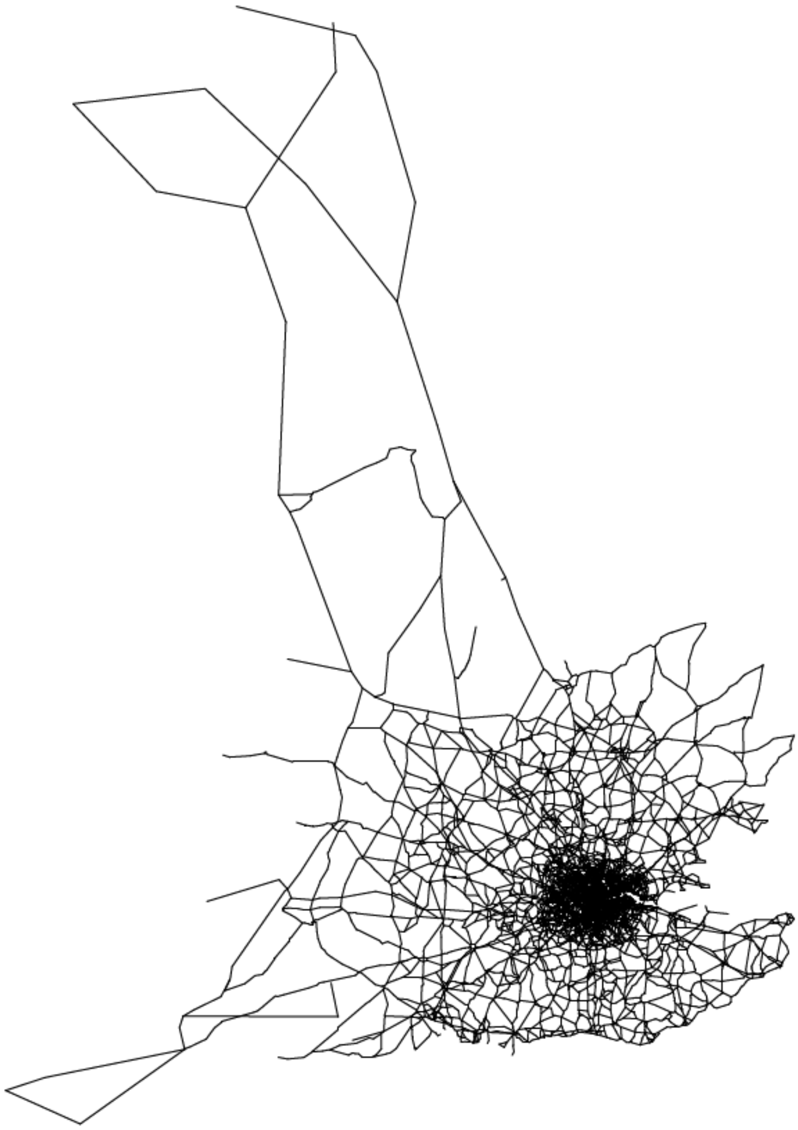
Similar to the zoning system, the network structure covers the whole of the UK. Within the M25 all motorways, A roads, B roads and other key local roads are included. Outside of the M25 all motorways and A roads are included and closer to London but still outside of the M25 B roads are included in the network structure. Within the simulation area the network includes all roads from the ITN mapping database and many C roads and unclassified roads. The network is shown in **Figure 3.4 and 3.5**.

Figure 3.4: Model Network in Simulation Area and Speed/Flow Curve Area



Source: TfL

Figure 3.5: Model Network (rest of UK)



Source: Insert source text here

3.5 Centroid Connectors

Zones have been connected to network links which represent an access/egress point approximately in the middle of the zone, or at the end of a link which represents the access/egress point from the network for the zone.

3.6 Time Periods

The model represents the AM peak hour (08:00-09:00), PM peak hour (17:00-18:00) and an average interpeak hour (between 10:00-16:00) for average weekday traffic conditions in a base year of November 2012.

3.7 User Classes

There are five user classes within the base year model:

- Car out of work time (represented with a PCU factor 1);
- Car in work time (represented with a PCU factor 1);
- Taxi (Hackney carriage) (represented with a PCU factor 1);
- Light Goods Vehicle (represented with a PCU factor 1); and
- Other Goods Vehicle (represented with a PCU factor 2).

In addition, buses are assigned as fixed flows on set routes by defining bus routes in terms of their constituent links and inputting the number of buses which service each route during the modelled hour.

When income segmentation is applied, as detailed in Chapter 12 of this report, car out of work is split into three separate user classes, making seven in total.

3.8 Assignment Methodology

Wardrop User equilibrium assignment method has been used for ELHAM with SATURN allowing the effects of blocking back and flow metering to be taken into account in the assignment.

3.9 Generalised Cost Formulations and Parameter Values

The ELHAM generalised costs are made up of time, distance and toll elements. These are combined using the following formula:

Generalised Cost = time + (vehicle operating cost/km x distance/value of time) + (toll/value of time) + (congestion charge/value of time)

Without income segmentation, the same average value of time is applied to vehicle operating costs, tolls and congestion charges for each user class.

With income segmentation, the value of time used for tolls and congestion charges differs for each of the three income segments. WebTAG paragraph 2.8.7 states that when introducing segmentation by income (that is, values of time which vary by income group), that variation in the value of time should usually only be allowed to affect the tolls and charges and not the vehicle operating costs; the same distance coefficient should be applied to all income groups in each car purpose[5]. In cases where there are no significant tolls and charges in the base year, this approach means that the assignment model can be calibrated without income segmentation, with merely a final check made that segmenting the matrices by income in the base year does not materially affect the validation.

By having different vehicle operating costs for each income segment therefore, shown in Table 3.6, the normalised generalised cost ends up as the same for each segment, as WebTAG specifies.

3.9.1 Values of Time

Values of Time (VoT) have been derived using WebTAG 3.5.6 August 2012, and vehicle occupancy and trip purpose data from the roadside interviews carried out to support the West, South, East and North London Highway Assignment Models. The 2009 and 2012 VoT are shown in **Tables 3.1** and **3.2**.

Table 3.1: 2009 Values of Time

	Value of Time (p/min) - per vehicle		
Vehicle Type	AM	IP	PM
car in-work	53.85	54.82	55.79
car out-of-work	13.35	14.26	14.48
taxi	53.85	54.82	55.79
lgv	21.47	21.10	22.44
ogv	35.78	35.78	35.78
Price base		2009	
Values		2009	

Table 3.2: 2012 Values of Time (5 user classes)

	Value of Time (p/min) - per vehicle		
Vehicle Type	AM	IP	PM
car in-work	54.58	55.56	56.54
car out-of-work	13.49	14.41	14.64
Taxi	54.58	55.56	56.54
Lgv	21.75	21.38	22.73
Ogv	36.26	36.26	36.26
Price base		2009	
Values		2012	

Car out-of- work values of time in each income segment are shown in **Table 3.3**.

Table 3.3: 2012 Values of Time (7 user classes)

	Value of Time (p/min) - per vehicle		
Vehicle Type	AM	IP	PM
Car out of work – low income	9.85	11.66	11.25
Car out of work – medium income	13.21	14.43	14.28
Car out of work – high income	17.15	17.40	18.13
car in-work	54.58	55.56	56.54
Taxi	54.58	55.56	56.54
Lgv	21.75	21.38	22.73
Ogv	36.26	36.26	36.26
Price base		2009	
Values		2012	

3.9.2 Vehicle operating costs

The vehicle operating costs (VOC) have been derived using WebTAG 3.5.6 August 2012, and average speed data from the West, South, East and North London Highway Assignment Models. The 2009 and 2012 values are shown in **Tables 3.4** and **3.5**. The 2012 values for seven user classes are shown in **Table 3.6**.

Table 3.4: 2009 Vehicle operating costs

	Vehicle operating costs (p/km) - per vehicle		
	AM	IP	PM
car in-work	14.19	13.70	14.43
car out-of-work	6.91	6.55	6.91
taxi	7.52	7.16	7.52
lgv	16.01	15.40	15.77
ogv	34.69	33.96	34.20
Price base		2009	
Values		2009	

Table 3.5: 2012 Vehicle operating costs

	Vehicle operating costs (p/km) - per vehicle		
	AM	IP	PM
car in-work	15.22	14.70	15.48
car out-of-work	8.51	8.06	8.51
taxi	8.06	7.67	8.06
lgv	17.55	16.88	17.28
ogv	39.25	38.43	38.70
Price base		2009	
Values		2012	

Table 3.6: 2012 Vehicle operating costs (7 user classes)

	Vehicle operating costs (p/km) - per vehicle		
Vehicle Type	AM	IP	PM
Car out of work – low income	6.21	6.52	6.54
Car out of work – medium income	8.34	8.07	8.42
Car out of work – high income	10.82	9.74	10.54
car business	15.22	14.70	15.48
Taxi	8.06	7.67	8.06
Lgv	17.55	16.88	17.28
Ogv	39.25	38.43	38.70
Price base		2009	
Values		2012	

3.9.3 Tolls and Congestion Charging

There are two sets of charges in the 2012 base year network, namely the Central London Congestion Charge and Dartford Crossing tolls.

In the 2009 network, the Western Extension to the Congestion Charging scheme was also in place. In January 2011, the Western Extension to the Congestion Charging scheme was removed. The tolls applied to the entry and exit points along the boundary of the Western Extension have therefore been removed from the 2012 network.

Between 2009 and 2012 the toll value for the remaining central Congestion Charging zone has been increased by 25% in nominal terms. Taking account of inflation, the real increase was 12.6% from the 2009 values to an equivalent 2012 value.

Dartford tolls have been determined using actual 2009 and 2012 tolls paid at Dartford and information about the 2009 payment type proportions contained in the Lower Thames Crossing Model Capability Report, Table 5.6. The 2009 and 2012 tolls as used in the model are shown in **Tables 3.7** and **3.8**.

Table 3.7: 2009 Dartford Crossing tolls

	2009 toll (2009 prices)
car in-work	£1.30
car out-of-work	£1.30
lgv	£1.88
ogv	£3.03

Table 3.8: 2012 Dartford Crossing tolls

	2012 toll (2009 prices)
car in-work	£1.56
car out-of-work	£1.56
lgv	£2.12
ogv	£3.66

3.10 Capacity Restraint Mechanisms

3.10.1 Junction Modelling

All junctions within the simulation area have been coded in detail with number of lanes, signal timings and saturation flows by turn and gap acceptance values included.

3.10.2 Speed/Flow Relationships

Within the simulation area capacity restraint has been primarily through the use of junction modelling. In addition, speed/flow curves were applied on motorways and grade-separated dual carriageways within this area. The speed/flow relationships were developed as described in section 5.2.5. On the Dartford Crossings, the speed/flow relationships were taken from the modelling carried out for the Department for Transport assessments of a possible new Lower Thames Crossing. The 'Speed/Flow Area' includes no junction modelling and includes speed/flow curves derived from LTS B6.0. These curves were used both inside and outside of the M25. In the ‘External Area’, fixed speeds are used. These have been sourced from the LTS B6.0 assignment output.

4 Calibration and Validation Data

4.1 Introduction

This chapter covers the traffic data available for calibration and validation. Traffic count data are available from both 2009 and 2012. Demand data are dealt with in chapter six. The model was built initially at a 2009 level, and then updated to 2012.

4.2 Traffic Counts at Roadside Interview Sites

Roadside Interview (RSI) Surveys were carried out in 2008/9 on the Thames Crossings and at the enclosures from the Continuous Roadside Interview Survey Programme (CRISP). Automatic Traffic Counts (ATCs) and Manual Classified Counts (MCCs) were undertaken at the same time at each RSI site.

4.3 Traffic Counts for Matrix Estimation

From 2009 traffic count data was available for a series of screenlines as well as the CRISP enclosures discussed above. The 12hr single day MCC's and two weeks' worth of ATC data were undertaken at each location. Some very minor roads crossing screenlines or enclosure boundaries were not counted, but are included in the model network. Traffic on these very minor roads would be included in the trip ends. Therefore 'gap' counts were included in relevant screenlines and enclosures to retain consistency between the matrix estimation and trip ends. No 'gap' count in the reported screenlines exceeds 200 pcus/hr.

Traffic growth between 2009 and 2012 was calculated by comparing traffic volumes recorded by long term continuous automatic traffic counters in November 2009 and November 2012. Comparisons were carried out by time period separately. The results are shown in **Table 4.1**.

Table 4.1: Traffic growth at key locations between 2009 and 2012

	2-way factor 2009 - 2012		
Location	**AM**	**IP**	**PM**
A200 Rotherhithe Tunnel	0.86	0.89	0.91
A208 Well Hall Road	0.97	0.93	0.97
A207 Blackheath Hill	1.04	1.00	0.94
A11 Mile End Rd	1.11	0.94	1.07
A1020 Royal Dock Rd North	0.91	0.93	1.05
A201 New Cross Road	1.10	1.07	1.04
A13 Alfreds Way	0.96	0.97	1.02
A13 E India Dock Rd	1.00	1.02	0.98
A124 Barking Rd	0.97	0.97	1.00
A2206 Southwark Pk	0.91	0.92	0.89
B207 Sandford St	1.12	1.04	1.13
B171 Goodmays Ln	1.03	1.00	0.99
A118 London Rd Havering	1.01	1.00	1.05

	2-way factor 2009 - 2012		
Location	**AM**	**IP**	**PM**
A2041 Knee Hill	1.02	0.97	0.99
A1261 Lower Lea Crossing	0.90	0.96	0.80
A206 Thames Rd	0.98	1.00	1.04
Total 2-way flow	**0.98**	**0.98**	**1.00**

The results indicate that overall there have been minimal changes in traffic flow between 2009 and 2012 and therefore a growth factor of 1.00 has been used to convert 2009 count data to 2012.

Additional manual classified count data was collected in November 2012. A set of seven additional screenlines were drawn-up north and south of the Thames between Bermondsey and Barking, and MCCs undertaken between 0600-2200 over five consecutive weekdays (Monday-Friday). As well as counts along the new screenlines a series of other manual classified link counts were undertaken at locations decided upon after consultation with TfL and the London Boroughs.

4.4 Traffic Counts for Validation

The 2012 counts across the River Thames screenline were held back for validation.

A number of one-day turning movement counts were also carried out at major junctions. It was planned that these would be factored to the average of the surveyed week in November 2012 using adjacent link counts (5-day MCCs as described above) at an aggregate level for the whole of each junction. Some counts had to be re-surveyed however due to camera malfunction or other problem and could therefore not be factored.

Turning movements at twelve junctions were able to be factored. Comparisons of modelled flows with these turning counts (listed below) were therefore carried out for the final version of the model (with all counts included in ME).

A13 East India Dock Road / A1206 Cotton Street

A13 / A102 movements at eastern side of junction

Silvertown Roundabout

Silvertown Way / Tidal Basin Road

A117 Woolwich Manor Way Ferndale Street

Ferry Approach/John Wilson Street/Church Street/Woolwich High Street

M25 J1A Site A

M25 J1A Site B

M25 J1B

M25 J3

M25 J30

A2203 Blackwall Lane / Milennium Way / Bugsby's Way Rbt

4.5 Journey time Surveys for Calibration and Validation

TrafficMaster (TfM) data have been used for the majority of journey time routes shown in Figure 10.1. November 2012 data were not available so data from November 2011 were used instead. As there was no overall growth in traffic between 2009 and 2012, the use of journey time data from 2011 is considered reasonable.

Moving Car Observer (MCO) surveys were also carried out on the route through Blackwall Tunnel in November 2012, and compared to TfM data for March 2011, November 2011 and March 2012 to assess the variability of the data. For most directions and time periods there was a close correlation between the MCO and TfM data for Nov 2011. However in the PM northbound, the November 2011 TfM data stood out as being markedly different from all other data sources. For this one route and time period therefore the MCO data have been used.

5 Network Development

5.1 Introduction

TfL provided the East London Highway Assignment Model (ELHAM) Production Version 2 highway network for a November 2009 base year. The development of this network is described below in sections 5.2-5.4.

ELHAM was originally developed in 2010 by consultants on behalf of TfL. The development of this network is covered in Section 5.2. A set of interim changes were made to the network by TfL in Spring 2011 (Production Version 1), covered in Section 5.3, but these were mostly superseded by TfL's 'Production Version 2', the development of which is covered in Section 5.4.

The 2009 network was used for the assignments during the development of the 2009 prior matrix, and subsequently updated to 2012. These changes are described below in section 5.6.

5.2 Initial Network Development

5.2.1 Network Building Process

This section describes the different contributions of data sources to the ELHAM network build process. ELHAM adopted network coding from NoLHAM, CLoHAM, SoLHAM, M25 Highway Assignment Model (M25HAM), and LTS and TGX models.

The 'Area of Detailed Modelling' covers ten London Boroughs: Tower Hamlets, Newham, Hackney, Redbridge, Barking & Dagenham, Havering, Bexley, Greenwich, Lewisham and Waltham Forest. Parts of Tower Hamlets, Lewisham, Newham and Hackney overlapped with other HAMs and the coding for these areas were taken from existing HAM coding. Waltham Forest is within the North London HAM area, but was included in ELHAM to better represent drivers' route choices and costs in the other nine boroughs. The Lea Valley, west of Waltham Forest, and the M25 define boundaries of limited access into the 'Area of Detailed Modelling' on the north-west, north and east edges of this area.

Within the 'Area of Detailed Modelling', the network was coded using the Code 'A' Node software (see **Section 5.2.3**). The coding for the rest of ELHAM was adopted from NoLHAM, CLoHAM, SoLHAM and M25HAM.

5.2.2 Network Data Sources

Within the 'Area of Detailed Modelling', LTS, TGX and ITN networks were used to build the ELHAM network. TGX was built based on LTS B5.4 and had a comparable level of network detail within this area. Differences between LTS and TGX occurred where either new links were included in LTS B6.0 or where extra refinement was undertaken to take account of local traffic impacts identified through the TGX study. The LTS networks required several improvements to include more network detail for ELHAM.

The ITN version used for the development of the ELHAM network was the August 2009 release representing the 2009 road network. In combination with a higher resolution of road network detail, this provided a reliable data source. In addition to the basic Road Link data provided with the ITN, the Road Routing Information dataset was also used to provide connectivity data at nodes and assisted in identifying where banned turns or route restrictions exist.

There was a large variation in network detail between LTS, TGX and the ITN. Across the model these three networks were rationalised to ensure that sufficient network was identified which gave a balance with LTS, representation of the 2009 road network connectivity (from ITN) and inclusion of any potential rat runs (identified within TGX). This included a full review to ensure that all motorway, A road, B road and main local roads (as specified in the ITN) were included in the network. This process identified the main routes that were included across the network. To ensure accurate link distances could be used in the simulation coding, this network was replicated using ITN definition.

This process involved the representation of ITN junctions and links that would make up the core network and ensured that the connectivity of links reflected that allowed within the ITN dataset. This took into consideration vehicle restrictions by time of day, width restriction, private vehicle access and turning restrictions. The result of the process was a link and node dataset that provided the basic structure of the network within the 'Area of Detailed Modelling'.

5.2.3 Junction Coding

Code'A'Node was a tool developed by TfL with the purpose of ensuring that coding could be delivered consistently across the HAM networks. The tool uses a basic set of assumptions relating to saturation flows and cruise speeds that provides coders with limited and consistent options in coding individual junctions. The data behind Code 'A' Node is derived from the work undertaken by the North and Central London HAM teams.

The process adopts conventions on saturation flows and GAP parameters at different junction types within a spreadsheet environment ensuring the coding is produced in a consistent manner. Code 'A' Node simply provided a user interface for the coding of these spreadsheets.

The saturation flows were later reviewed and amended slightly during the development of 'Production Version 2' by TfL, described in **Section 5.4**.

5.2.4 Cruise Speeds

The WeLHAM team undertook research into cruise speeds based on GPS data collected as part of the team's journey time survey programme. The technical note summarising these results is included as **Appendix A**. The links used in the cruise speed analysis were selected on the basis of an exercise to categorise each consistent section of the survey routes using six separate characteristics. Whenever a characteristic changed, this generated a timing point for the journey time analysis and a separate link in that route.

A database containing the link characteristics and cruise speeds was created from which the range of speeds on links with identical characteristics could be generated. It was not expected that cruise speeds would vary widely across the Greater London Area and thus these were adopted in ELHAM.

5.2.5 Speed/Flow Relationships on Motorways and Dual Carriageways

Speed/flow relationships have been used in addition to simulation coding on grade-separated routes within the ‘Area of Detailed Modelling’. This is to reflect the impact of vehicle interactions that may occur along each link. The speed/flow curves were adopted from the M25 North of Thames model. These were bespoke M25HAM curves and COBA speed/flow curves with the default percentage of OGVs (15%) implied in the capacities.

Speed/flow curves were used on the A12, A13, A2, M11 and M25.

5.2.6 Traffic Signal Coding

There are over 600 signalised junctions in the ELHAM boroughs. As part of the LTS Medium Term Enhancement (MTE) process, a major exercise was undertaken to calculate average timings for each peak hour for the major signalised junctions across London. The process was structured such that the output data would be suitable for direct use with SATURN and was provided in a SATURN RGS format.

The LTS MTE process covered the majority of junctions across East London; however, there were a number of instances where new timings were derived. This occurred most frequently at signalised gyratories, whereby the different network definitions between ELHAM and LTS required further detail that was not processed within the MTE programme.

Additional signal processing was undertaken for these sites involving engagement with TfL’s DTO team to obtain signal staging sheets, M16 data (where UTC controlled) and junction layout plans.

Detailed processing was undertaken for the signal timing data so that it provided a consistent basis for conversion of input data into a SATURN ready format. For each signal junction, a basic LINSIG model was constructed to aid in the conversion process, ensuring inter-green times were accurately represented.

For UTC controlled signals, M16 outputs were obtained which provided actual timings recorded on street for a period typically during weekdays within 2007 / 2008. This was processed to generate average observed timings for each time period.

For non-UTC controlled junctions, an estimation process was developed that adjusted the maximum stage green times to average green times. The adjustments were based on factors derived from a number of site observations undertaken during the MTE process.

5.2.7 Saturation Flows

In order to ensure consistency of coding across the 'Area of Detailed Modelling', a common approach to saturation flow rates has been used for each junction type. For signalised junctions, saturation flow rates were used that were derived from a number of surveys within London. Observations were undertaken across a range of junctions and turns and considered the impact of advance cycle lanes on the resulting saturation flow rates (although the impact of these was marginal).

For roundabouts, saturation flow rates were derived for typical roundabout approaches based on ARCADY relationships. This considers both mini and standard roundabouts differently generating different saturation flow rates as well as GAP values. For priority junctions, judgement has formed the basis of the saturation flow rates adopted.

For roundabouts, priority and signalised junctions, the saturation flows rates note above were implemented in the model through the use of the Code 'A' Node interface and the CLoHAM/NoLHAM spreadsheet coding tool. Saturation flows inherited from the M25 model were not adjusted.

The saturation flows of flared approaches were calculated based on the utilisation of the flare derived from green times.

These were reviewed during development of Production Version 2, described in **Sections 5.4.1.2** and **5.4.1.3**.

5.2.8 Gap Acceptance

The GAP acceptance parameter values for each junction type were tested during the calibration process using a range of GAP values to understand the sensitivity of the assignment. Following these tests and discussions from TfL, based on their experience from other HAM models, a set of GAP values was chosen.

These were reviewed during development of Production Version 2, described in **Section 5.4.1.5**.

5.2.9 Special Cases

The Woolwich Ferry operates between Woolwich and North Woolwich linking the North and South Circular Roads across the Thames. During November 2009, the Woolwich Ferry operated at a normal service consisting of four crossings per hour per direction. There is no charge for the service. Typically each sailing holds approximately 36 PCUs (this is based on typical loads provided by London River Services). This is equivalent to 144 PCUs per hour.

In order to restrict the crossing capacity to this, the approach nodes to the crossing were coded as signalised nodes enabling a capacity of 144 PCUs per hour. The cruise speeds were also adjusted accordingly to take account of the crossing time.

5.2.10 Imported Simulation Coding

Simulation coding was taken from a number of other models. The simulation coding elements of the model were used directly in ELHAM as they had all been developed along the same principles as described in the preceding sections. The exception to this was the coding of flares in SoLHAM, which was undertaken using relatively new features of SATURN (at that date) called FLAREX and FLAREF.

Correspondence lists were drawn up to tie together the imported simulation coding of NoLHAM, CLoHAM, SoLHAM and M25HAM with ELHAM.

Coding for the M25 area was taken from the M25HAM (provided December 2009). The M25HAM coding was subject to processing to make this more in line with the HAM coding guidelines. The M25HAM was coded using a combination of speed/flow curves and simulation coding at major junctions. In some locations this duplicated the representation of delays in the network. To resolve this issue, speed/flow curves were removed from links that did not represent grade-separated sections of motorway. Additional coding of junction detail was included for those areas that were coded originally with speed/flow curves.

Furthermore, the M25HAM was coded using spigots to provide loading points across the network. In some areas these did not represent the ELHAM zoning system and hence were removed.

5.2.11 Centroid Connectors

Within the ‘Area of Detailed Modelling’, centroid connectors were coded using the conventional loading across links rather than the use of spigots. This was preferred due to the additional link and node requirements of the spigot based system. Along calibration screenlines, centroid connectors were located away from count locations, either through the use of intermediate nodes or, in some instances, by spigot-style loading. In most instances, only a single connector was used for loading the network.

The external network has a coarser zone system and trip loading composition. This reflects the coarser network in the ‘External Area’. Each connector has a default length of 200m and a fixed speed of 20kph throughout the model.

5.3 TfL Spring 2011 update

Changes were made to the network during the Spring 2011 update, but the majority of these were subsequently superseded by changes made for ELHAM Production Version 2, with the following exception.

From comparison of journey times between modelled and observed data, it was found that in general the modelled journey times along the main corridors were faster than the observed ones. It was decided that in reality the full road capacity cannot be maintained due to the impact of road users’ misuse, heavy vehicles, etc and that a 10% reduction to capacity should be applied.

This 10% capacity reduction was applied to speed/flow curves for M25, M11 and some dual carriageways in the study area. The detailed changes are provided below:

- Along M25, M11 in the ELHAM simulation network, the link capacity for speed/flow curve was reduced from 2330 per lane to 2100 per lane;
- The Dartford Crossing link capacity was reduced from 7200 to 5900 pcu per hour to reflect the toll booth capacity. The free-flow speed between Dartford along the Dartford Tunnel and the QE2 Bridge were reduced from 113km to 80km/hr; and,
- Dual carriageway capacity reduction of 10%, mainly along A13, if it met the following criteria:
  - free-flow speed greater or equal to 104 kph, and,
  - the speed/flow curve's original capacity per lane was greater or equal to 2000 pcu per hour.

5.4 ELHAM Production Version 2

The 'Production Version 1' HAM networks had been created for TfL by separate consultant teams between 2008 and 2011, which contained some inconsistencies in approach. To reduce any such inconsistencies, all model development for the 'Production Version 2' models was undertaken in-house by TfL at a London-wide level (LoHAM) to ensure that all the HAMs are consistent in network structure and parameters.

The development of the Production Version 2 network is described in more detail in the following **Section 5.4.1**.

5.4.1 Network Data, Coding and Checking

The following areas were checked and changed as required:

5.4.1.1 Distance

Link lengths were reviewed for both the simulation and buffer areas. Distances were checked for consistency between different directions for the same link and crow-fly distance sense checks undertaken, with reference to MapInfo and Google Maps where appropriate. The distances were updated at a LoHAM database level and then incorporated into the HAMs.

5.4.1.2 Priority junction saturation flows

For development of 'Production Version 2', saturation flows were reviewed and the original values generally maintained as 'baseline' values. These values were however regarded as flexible and while a 'baseline' saturation flow was defined at the network coding stage, the values were frequently adjusted during calibration to reflect the detail of local circumstances, where a generic saturation flow might not be appropriate. Changed saturation flows were kept to predefined ranges, as described below.

Saturation flows coded for priority junctions take either standard (default) values or calibrated values, which were confined to an allowed range and specific to a junction environment. The standard saturation flows for priority junctions were derived from research work carried out for the development of Code-A-Node and ‘Production Version1’. **Table 5.1Error! Reference source not found.** shows the default saturation flows for priority junctions.

Table 5.1: Default Saturation Flows for Priority Junctions (pcu/hour)

Turn Link Type	Approach Lane Type	Left	Ahead	Right
Major Arm - No Marker	Full lane (No Flare)	1650	2000	1650
Major Arm X Major arm	Full lane (No Flare)		1250	1200
Minor Arm - Gives way	Full lane (No Flare)	1200	950	875
Major Arm - No Marker	Flare only	856	1038	856
Major Arm X Major arm	Flare only		649	623
Minor Arm - Gives way	Flare only	623	493	454
Major Arm - No Marker	Main+Flare	1681	2038	1681
Major Arm X Major arm	Main+Flare		1274	1223
Minor Arm - Gives way	Main+Flare	1223	968	892
Minor Arm - Merge	Full lane (No Flare)	1200		1200

Table 5.2 shows the minimum and maximum range of saturation flow values permitted for calibrated junctions, taking account of special local factors such as road and lane layout, sight lines, street-furniture and traffic volumes.

Table 5.2: Calibration Range Saturation Flows for Priority Junctions (pcu/hour)

Turn Link Type	Approach Lane Type	Left	Ahead	Right
Major Arm - No Marker	Full lane (No Flare)	1400 to 1900	1700 to 2300	1400 to 1900
Major Arm X Major arm	Full lane (No Flare)		1050 to 1450	1000 to 1400
Minor Arm - Gives way	Full lane (No Flare)	1000 to 1400	800 to 1100	750 to 1000
Major Arm - No Marker	Flare only	750 to 1000	900 to 1200	750 to 1000
Major Arm X Major arm	Flare only		550 to 750	550 to 700
Minor Arm - Gives way	Flare only	550 to 700	400 to 550	400 to 500
Major Arm - No Marker	Main+Flare	1450 to 1950	1750 to 2350	1450 to 1950
Major Arm X Major arm	Main+Flare		1100 to 1450	1050 to 1400
Minor Arm - Gives way	Main+Flare	1050 to 1400	800 to 1100	750 to 1050
Minor Arm - Merge	Full lane (No Flare)	1000 to 1400		1000 to 1400

All SATURN type 1 priority junctions conform to the saturation flows outlined above.

5.4.1.3 Roundabout saturation flows

Similarly, default saturation flows were specified for roundabouts taking account of many factors that affect the capacity of roundabouts including number of approach lanes, flares, roundabout diameter or inscribed circles, sightlines and lanes on the roundabout circulatory area. **Table 5.3** shows the default saturation flows derived as part of the development of the HAMs.

Table 5.3: Default Saturation Flows for Roundabouts (pcu/hour)

Roundabout Type	Approach Lane Type	One lane at give-way line	Two lanes at give-way line	Three lanes at give-way line	Four lanes at give-way line
Mini roundabout	Any lane	950			
Standard roundabout	One lane approach	1106	1655	2046	2421
Standard roundabout	Two lane approach		2212	2682	2942
Standard roundabout	Three lane approach			3318	3756

Table 5.4 shows the minimum and maximum range of values permitted for calibrated junction saturation flows on roundabouts.

Table 5.4: Calibration Range Saturation Flows for Roundabouts (pcu/hour)

Roundabout Type	Approach Lane Type	One lane at give-way line	Two lanes at give-way line	Three lanes at give-way line	Four lanes at give-way line
Mini roundabout	Any lane	800 to 1100			
Standard roundabout	One lane approach	950 to 1250	1400 to 1900	1750 to 2350	2050 to 2800
Standard roundabout	Two lane approach		1900 to 2550	2300 to 3100	2500 to 3400
Standard roundabout	Three lane approach			2800 to 3800	3200 to 4300

5.4.1.4 Roundabout Circulation Capacities

Circulatory traffic capacity is determined both by the number of lanes on the roundabout and the size of the roundabout. As part of the research described above, default and calibration circulatory saturation flows were developed. **Table 5.5** shows the default saturations and **Table 5.6** shows the permitted range of calibration values. GAP values which are used for gap acceptance modelling are considered in more detail below.

Table 5.5: Default Roundabout Circulation Capacities (pcu/hour)

Roundabout Type	Approach Lane Type	One lane at give-way line	Two lanes at give-way line	Three lanes at give-way line	Four lanes at give-way line	GAP in 10-1 Secs
Mini roundabout	Any lane	1984				25
Standard roundabout	One lane approach	2044	2657	3035	3249	15
Standard roundabout	Two lane approach		3021	3376	3487	15
Standard roundabout	Three lane approach			3627	3765	15

Table 5.6: Calibration Range Roundabout Circulation Capacities (pcu/hour)

Roundabout Type	Number of Approach Lanes	One lane at give-way line	Two lanes at give-way line	Three lanes at give-way line	Four lanes at give-way line
Mini roundabout	Any lane	1700 to 2300			
Standard roundabout	One lane approach	1750 to 2350	2250 to 3050	2600 to 3500	2750 to 3750
Standard roundabout	Two lane approach		2550 to 3450	2850 to 3900	2950 to 4000
Standard roundabout	Three lane approach			3100 to 4150	3200 to 4350

5.4.1.5 Junction GAP values

GAP defines the minimum gap in seconds accepted by a vehicle seeking to enter a junction. GAP applies to conflicting streams of traffic at SATURN junction types 1 (Priority), 2 (Non U-turn Roundabouts), 3 (Signals) and 5 (Roundabouts with U-turn allowed). The three types of SATURN GAP and their default values for the HAMs are shown in **Table 5.7**.

Table 5.7: Default GAP Values for the HAMs

Parameter	Relevance	Default Value (secs)
GAP	Priority Junctions Traffic Signals	2.0
GAPM	Merges (Priority Junctions)	1.0
GAPR	Roundabouts	1.5

The use of GAP in SATURN is in calculating transient 'minor approach' capacities in accordance with the following equation:

$$C = S_m(1 - V_m/S_m)^{GS\,m}$$

Where: C_m is the capacity of the minor arm
S_m is the saturation flow of the minor arm
V_m and S_m are the flow and saturation flow of the major arm
G is the GAP value

The transient capacity C ranges from a maximum value of S_m, equal to its saturation flow with zero opposing flows, down to zero at which major arm flow reaches saturation, with the power defined by $G.S_{Mi}$ giving shape to the transition between the two extremes.

5.4.1.6 Stacking Capacities

Stacking capacities are used in SATURN simulation modelling to represent blocking back realistically. By default, SATURN assumes that the number of lanes coded at the stop line is continuous along the approach link, with a stacking capacity in pcus calculated from the product of lanes and link length divided by the average length for a queued vehicle. Where this was not the case, and lane changes along the link reduced real stacking capacity, stacking capacities were coded explicitly.

Where FlareF and FlareX were coded at junctions, the default stacking capacity was usually appropriate. Given that there is no option to code flares at roundabouts, the appropriate stacking capacities were coded explicitly.

5.4.1.7 Cruise Speeds

Cruise speeds represent the speed for a vehicle in the absence of any traffic, taking into account such factors as road width, road geometry, on road parking, intensity of roadside development and volume of pedestrians on footpaths.

A comprehensive review of the cruise speeds inherited from the original ‘Production Version 1’ assessed their suitability for LoHAM and updates were made where appropriate. In particular, very low cruise speeds on some major roads were increased to exclude implicit junction delay costs, with greater attention subsequently paid to the associated junction modelling.

The coded speeds were generally considered appropriate for the majority of the network, although further significant changes were made for traffic calmed links and other very minor links. For these, a convention was adopted to code cruise speeds of 25kph which better reflected their position in the hierarchy of the overall road network.

5.4.1.8 Signal Timings

Signal timing data is very important in the development of an assignment model since signalised junctions generally have greatest impact on traffic flow, congestion, routeing and blocking back. Therefore:

- Signal timings at individual junctions were subject to review at calibration;
- Important junctions were checked individually and refined in line with available data; and
- Some refinements from SCOOT were approximated into SATURN compatible fixed time signals

5.4.1.9 Speed/flow relationships

The default assumption in SATURN simulation networks is that link speeds and costs are fixed with demand related cost changes arising from junction based delays. These are determined through turn based flow-delay curves as described above.

The consequence is that speed/flow curves are not usually defined for simulation links and this convention was followed for the HAMs.

There were two exceptions:

- Speed/flow curves were specified for high capacity/ grade separated dual carriageways and motorways in the simulation areas; and
- Traffic calmed roads in some parts of the network were coded with low capacity and speed/flow curves particularly where road humps and platforms were present.

In the case of the high capacity routes, the coding reflected the greater likelihood that delays were due to link rather than junction congestion. For traffic calmed links, the curves and reduced capacities were as a proxy for increased perceived costs where road humps were present.

5.4.1.10 Fixed Speeds

Two distinct types of fixed speed links are coded in the buffer network, covering:

- Buffer network links outside the M25; and
- Buffer network links inside and including the M25 (outside the ELHAM speed/flow curve area).

For links outside the M25, only partial demand was modelled so no reliance could be placed on speed/flow mechanisms in assignment. Instead, links were coded with fixed speeds derived directly from the loaded LTS models for the appropriate period.

For links inside the M25, a complete LoHAM fixed speed network was generated and maintained for each modelled period. This enabled fixed speed buffer networks to be constructed for areas away from the simulated area (and outside the speed/flow buffer area) for a particular HAM. Fixed link speeds for any particular 'core' area were consistent with simulated speeds from the relevant HAM. In practice these link speeds were derived by combining the cruise speed link times with the latest flow-weighted turn delay costs for all turns out of the link and converting the result to fixed link speeds.

The fixed speeds therefore reflected the best current estimates of traffic conditions from the most relevant HAM.

5.4.1.11 Generalised Costs: Knobs

For the Production Version 2 ELHAM, additional costs were defined to reflect extra perceived costs, dependent on user class and road type, over and above the direct costs described above. These additional costs were introduced through the Knobs columns in the generalised cost definitions for SATURN (88888 cards).

5.5 River Crossing network enhancements

5.5.1 Introduction

An audit of the network was carried out for the following parameters:

- Link lengths – the coded AB and BA link lengths were compared against each other and with crow-fly distances;
- Link stacking capacity – the coded link stacking capacities were compared against the coded link lengths;
- Cruise speeds and free-flow speeds – the coded cruise speeds in the simulation area and free flow speeds in the buffer area between AB and BA links were compared;
- GAP parameter values at priority junctions;
- Bus lane locations using available data from the TfL TECO bus lane database;
- Zone connectors - appropriateness of the number of coded zone connectors; and
- Signals - coded total green time compared to the coded cycle time.

Subsequently the capacity of existing river crossings was reviewed and amended to ensure consistency with the maximum observed traffic flows during peak periods, and to achieve consistency with the capacity of the Dartford Crossings used by AECOM for their modelling of possible Lower Thames Crossings. These changes and others made during calibration are described in the rest of this section of the report.

5.5.2 River Crossing capacities

The capacities of the River Crossings within the ELHAM simulation area (Southwark Bridge to Dartford Crossing) were reviewed during the development of the model. For Southwark, London and Tower Bridges the capacities are constrained by the signalled junctions at either end of the bridges. Rotherhithe has a width constraint (which cannot specifically be modelled), but is also constrained by the signalled junction at the northern end. Blackwall Tunnel is constrained northbound by the lane drop from three to two lanes south of the tunnel portal, and by the standard of the tunnel, particularly the height of the second lane, and southbound by the signalled junction with the A13 north of the tunnel.

Woolwich is constrained by the number of crossings per hour, the capacity of the ferry, and the number of OGVs on each ferry. Dartford is constrained in both directions by the toll booths, northbound the tunnel would be a capacity restraint due to safety restrictions even with free-flow tolling.

Maximum capacities in pcus per hour were calculated from 2012 counts using the highest recorded count in an hour where the crossings were known to operate at capacity. The Nov 2012 5-day MCCs were used, as these were classified counts it was possible to exclude motorcycles from the totals (as motorcycles are not modelled).

The capacities of each crossing are shown in **Table 5.8**.

Table 5.8: River Crossing Capacities

	AM pcus/hr	IP pcus/hr	PM pcus/hr
Tower Bridge NB	1688	1688	1688
Tower Bridge SB	1340	1432	1717
A101 Rotherhithe Tunnel NB	1210	1210	1210
A101 Rotherhithe Tunnel SB	1210	1210	1210
A102 Blackwall Tunnel NB	3236	3236	3236
A102 Blackwall Tunnel SB	3842	3839	3719
Woolwich Ferry NB	164	164	205
Woolwich Ferry SB	164	164	205
A282 Dartford Crossing NB	5500	4800	5400
A282 Dartford Crossing SB	5500	4800	5400

5.5.3 Knobs coding

For the River Crossings modelling the extra perceived costs coded through the Knobs facility in SATURN for ELHAM Production Version 2 (described above in section 5.4.1.11) were removed from all links within the model. Tests were run with and without these additional costs, and it was considered un-necessary to keep them as modelled journey times were within acceptable ranges, and there was no significant rat-running.

In the external 'fixed speed area' however, it was found necessary to halve the speeds on links which had previously had additional costs applied (mainly minor roads) to replicate the effect. This was because the fixed speeds in this area had been taken from an LTS assignment that would only have assigned a partial matrix in this area, therefore the assignment would not have achieved the correct point on the speed/flow curve.

5.6 2012 Network development

TfL provided lists of schemes on the network in the East London area that had been started since 2009, together with scheme construction start and end dates. The scheme descriptions and construction start/end dates were reviewed to produce a shorter list of schemes which would require network coding changes to be made. **Table 5.9** below details the final list of schemes which were included in the 2012 network.

Table 5.9: 2012 network changes

Scheme Title	Scheme Description
Greenwich Reach	Junction improvements to A200 Creek Road/B208 Norman Road due to new development
Queensbridge Road & Dalston Lane Junctions Works	A104 Dalston Lane/B108 Queensbridge Rd/A1207 Graham Rd Junction re-design
Evelyn Street safety scheme	New right turn reservoir at junction of A200 Evelyn Street/Grinstead Road, revised priorities at A200 Evelyn Street/A200 Lower Road/A200 Bestwood Street
Dalston Junction interchange	Revised lane allocation for two approaches at junction of A10 Kingsland Road/A104 Dalston Lane/A104 Balls Pond Road
A12 / Lochnagar Street / B125 Abbott Rd	A12 Blackwall Tunnel northern approach/B125 Abbott Road/Zetland Street/Lochnagar Street junction signalisation
A12 Gants Hill Town Centre Enhancement Scheme	Signalisation of A12 Eastern Avenue/A1400 Woodford Ave/A123Cranbrook Road “Gants Hill” roundabout
A20 Sidcup By Pass at Crittalls Corner	Signalisation of A20 eastbound off-slip entry to roundabout
A10 Great Cambridge Rd/Carterhatch Lane	Revised lane allocations and signal staging
A10 Great Cambridge Road /Church Street	Revised lane allocations and signal staging
A503 Seven Sisters Road & A1201 Rock Street	Bus only turning movements introduced
A3211 Upper Thames Street/ Arthur Street Junction Improvement	Revised lane allocations and banned turn introduced
Canning Town Highway Scheme	Replacement of signalled roundabout with new signal junction, removal of A13 eastern slips and creation of new A13 eastern access via existing local roads
M25 widening J27-J30	Widening from three lanes per direction to four lanes per direction

Source: TfL

Revised junction layouts and lane allocations were taken from Google Streetview images. New signal staging and timings were provided by TfL where available. For those locations where signal staging and timing was not available, staging and timings were taken from similarly designed signal junctions directly upstream.

6 Trip Matrix Development

6.1 Trip Matrix Building Process

Trip matrices were developed initially for 2009, and then updated to a 2012 level. The starting point was the ELHAM peak period trip matrices for five user classes (in-work time or Employers' Business cars (IWT), out-of-work time cars (OWT), Taxis, LGVs and OGVs). These are prior matrices, before any matrix estimation was applied.

6.2 2009 trip matrix development

6.2.1 Matrix Enhancements

A number of enhancements were made to the original ELHAM trip matrix-building process, the most significant of which are:

- For each enclosure, adjustments were made to the number of intra-enclosure trips so that they formed a plausible proportion of the total trip generation from each enclosure;
- 'Reliable' movements were defined as those with 95% confidence intervals of less than 30% of the cell value at sector level; and
- The peak period to peak hour factors were revised using the partial trip matrices for the peak period and peak hour at the sector system used to define reliable peak period movements.

6.2.2 Peak period trip matrices

TfL supplied Mott MacDonald with the ELHAM 2009 peak period synthetic car trip matrices for six purposes. The analysis of 'reliable' movements demonstrated that the smaller number of IWT trips could only be deemed reliable at a highly aggregated sector level. Also comparisons of the trip ends from the partial trip matrices with the trip ends derived from the LTS highway assignment model for each enclosure also showed inconsistencies at an IWT level. It was therefore decided that matrix development should be conducted at the all-purpose level, with the IWT/OWT split being introduced as late as possible in the process so that the necessarily approximate split factors could be modified easily. The first step was therefore to combine all IWT and OWT purposes.

Dartford Crossing trips have also been provided by TfL and added in at this stage to provide complete peak period matrices.

6.2.3 Zoning system

The next step involved the conversion of the zone system of the synthetic trip matrices from the 1471 zones used in ELHAM to 2446 zones. A zone correspondence was supplied by TfL. External-external trips contained in the prior trip matrices were set to zero at this stage, and were replaced later in the process.

6.2.4 Adjust trip ends

The starting point for the 2009 trip ends was the 2007 LTS highway assignment matrices. These were regarded as the most reliable estimate of car trip ends, on the grounds that the assignment trip matrices had been validated against the count and journey time data available at the time of their creation. These 2007 trip matrices were factored to 2009 and converted from the LTS zoning system. Estimates of trips to and from major developments which had come to fruition between 2007 and 2009, and which therefore had not been included in the LTS matrices, were then added in. For each enclosure, the trip ends derived from the LTS highway assignment matrices were compared with the trip ends from the partial trip matrices.

These comparisons were done for each enclosure in total and the expectation is that the LTS-based trips ends, being total trip ends, would exceed the partial matrix trip ends, by an amount that implied a plausible proportion of intra-enclosure trips. Where the implied proportion of trip ends was considered implausible, adjustments were made, at the enclosure level, to the LTS-based trip ends. These revised trip ends ensured that the number and proportion of intra-enclosure trips were plausible, given that the inter-enclosure trips were to be fixed from the partial trip matrices built from enclosure boundary roadside interview data.

The period prior trip matrices were furnessed to these new period trip ends.

6.2.5 Partial trip matrix sector constraints

The partial matrices were the output of a merging process where movements that were sampled more than once across different roadside interview cordons and screenlines across London were weighted averages. For each roadside interview record, an estimate was made of the time of the return trip to create synthetic transposed records. Taking account of the traffic count at the interview point, the interview sample rate, the additional variance associated with transposing trip records, and trips which could have been interviewed at more than one location, partial matrices for each time period and trip purpose were built.

The number of trips originating or with a destination within an enclosure or crossing a screenline after the merging process was then compared with the number of trips estimated from the roadside interviews at those same enclosure boundaries or screenlines, the reasons for any differences identified and corrections made where appropriate.

Details of the development of the partial trip matrices are contained in the following Technical Notes produced for TfL by AECOM, shown in **Appendix B**:

- “Specification of Partially Observed Highway Demand Matrices v5.5” dated November 2011; and
- “Treatment of Variability in Assembling Partial Observed Trip Matrices” dated August 2011.

Comparisons of the trips crossing enclosure boundaries before and after the merging process are shown in **Tables 6.1 – 6.4**, showing that the merging process has retained the observed volumes of enclosure boundary crossing trips.

Table 6.1: Comparison of Enclosure Boundary Crossing Trips AM Peak

Outbound	AM Peak Period	Cordon Matrix	Merged Matrix	Diff	% Diff
	Barking	7,562	7,542	-20	0%
	Barkingside	12,093	12,199	106	1%
	Bexley	5,183	5,085	-98	-2%
	Canary Wharf	3,281	3,248	-33	-1%
	Harold Hill	9,392	9,510	118	1%
	Hornchurch	7,245	7,455	210	3%
	Lewisham	7,341	7,953	613	8%
	Stepney	2,405	2,511	106	4%
	Stratford	7,542	7,543	1	0%
	Woolwich	9,023	8,910	-112	-1%
Inbound	Barking	7,721	7,750	29	0%
	Barkingside	12,093	11,834	-260	-2%
	Bexley	4,335	4,278	-57	-1%
	Canary Wharf	6,515	7,150	636	10%
	Harold Hill	7,520	7,431	-89	-1%
	Hornchurch	6,570	6,782	213	3%
	Lewisham	8,745	8,915	170	2%
	Stepney	4,038	4,053	15	0%
	Stratford	6,549	6,673	125	2%
	Woolwich	10,323	10,332	9	0%

Source: AECOM

Table 6.2: Comparison of Enclosure Boundary Crossing Trips Inter Peak

Outbound	Inter Peak Period	Cordon Matrix	Merged Matrix	Diff	% Diff
	Barking	16,101	16,242	140	1%
	Barkingside	20,224	20,089	-134	-1%
	Bexley	7,684	7,851	167	2%
	Canary Wharf	9,010	8,626	-385	-4%
	Harold Hill	14,850	15,049	199	1%
	Hornchurch	14,008	14,242	235	2%
	Lewisham	18,921	19,220	299	2%

Outbound	Inter Peak Period	Cordon Matrix	Merged Matrix	Diff	% Diff
	Stepney	8,615	8,597	-18	0%
	Stratford	15,825	15,923	98	1%
	Woolwich	19,335	19,295	-39	0%
Inbound	Barking	14,907	15,190	283	2%
	Barkingside	21,178	20,954	-225	-1%
	Bexley	8,630	8,774	144	2%
	Canary Wharf	5,569	5,724	155	3%
	Harold Hill	15,491	15,705	213	1%
	Hornchurch	13,877	14,216	339	2%
	Lewisham	16,333	17,020	687	4%
	Stepney	9,231	9,608	378	4%
	Stratford	12,952	13,205	253	2%
	Woolwich	17,527	17,671	145	1%

Source: AECOM

Table 6.3: Comparison of Enclosure Boundary Crossing Trips PM Peak

Outbound	PM Peak Period	Cordon Matrix	Merged Matrix	Diff	% Diff
	Barking	10,231	10,157	-74	-1%
	Barkingside	12,923	12,877	-46	0%
	Bexley	4,868	4,980	112	2%
	Canary Wharf	6,790	6,695	-95	-1%
	Harold Hill	8,228	8,357	129	2%
	Hornchurch	8,530	8,657	127	1%
	Lewisham	10,067	10,374	306	3%
	Stepney	5,182	5,145	-37	-1%
	Stratford	9,408	9,270	-138	-1%
	Woolwich	13,690	13,593	-96	-1%
Inbound	Barking	9,521	9,582	61	1%
	Barkingside	14,887	15,212	324	2%
	Bexley	5,871	5,937	67	1%
	Canary Wharf	3,622	3,479	-143	-4%
	Harold Hill	10,235	10,478	243	2%
	Hornchurch	8,297	8,448	151	2%
	Lewisham	8,798	9,298	500	6%
	Stepney	3,684	3,737	53	1%

Outbound	PM Peak Period	Cordon Matrix	Merged Matrix	Diff	% Diff
	Stratford	9,699	9,358	340	-4%
	Woolwich	11,287	11,184	-103	-1%

Source: AECOM

Table 6.4: Comparison of Enclosure Boundary Crossing Trips 12 Hours

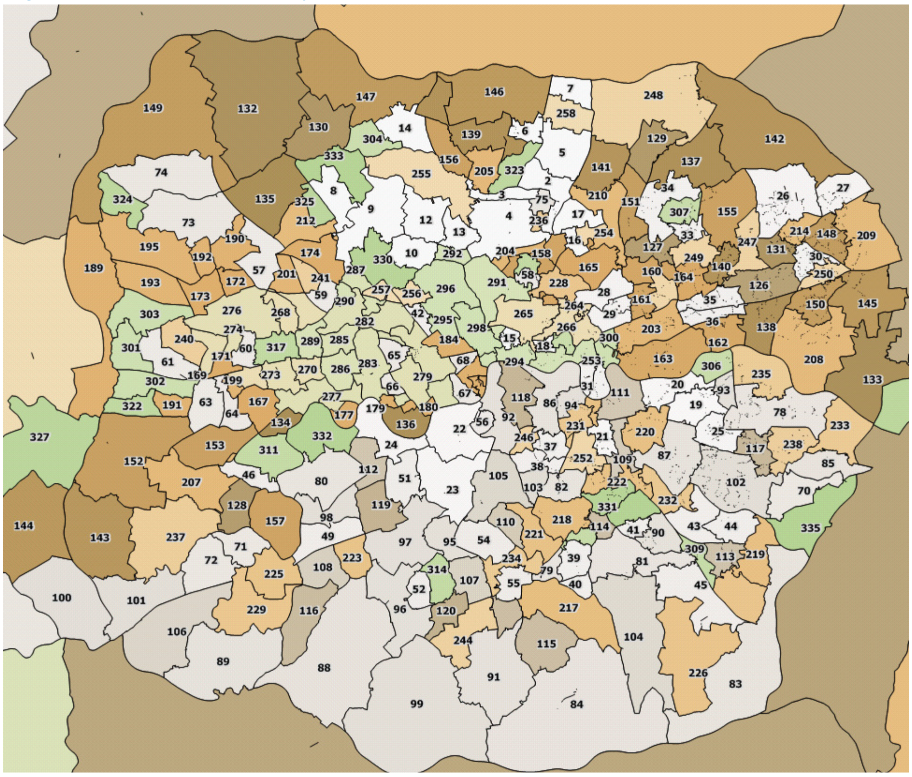
Outbound	12 Hours	Cordon Matrix	Merged Matrix	Diff	% Diff
	Barking	33,894	33,941	46	0%
	Barkingside	45,240	45,166	-74	0%
	Bexley	17,735	17,916	181	1%
	Canary Wharf	19,081	18,568	-513	-3%
	Harold Hill	32,470	32,916	446	1%
	Hornchurch	29,782	30,354	572	2%
	Lewisham	36,330	37,547	1,217	3%
	Stepney	16,201	16,253	52	0%
	Stratford	32,774	32,736	-38	0%
	Woolwich	42,047	41,799	-248	-1%
Inbound	Barking	32,149	32,522	373	1%
	Barkingside	48,159	47,999	-160	0%
	Bexley	18,835	18,990	154	1%
	Canary Wharf	15,706	16,354	647	4%
	Harold Hill	33,247	33,614	367	1%
	Hornchurch	28,744	29,447	703	2%
	Lewisham	33,875	35,233	1,358	4%
	Stepney	16,953	17,399	446	3%
	Stratford	29,199	29,237	37	0%
	Woolwich	39,136	39,187	51	0%

Source: AECOM

These London-wide zonal level partial matrices were aggregated into the most disaggregated sector to sector movements that were statistically robust, defined as a 95% confidence interval of between 20% and 30% of the cell value. The sector systems were specifically designed to retain the most spatial detail in the ELHAM modelled area. For all enclosures in each time period the 95% confidence interval range was within 30% of the total trips to or from each enclosure. This meant that trips to and from each enclosure could be defined as separate reliable movements without the need to merge them with neighbouring enclosure or screenline movements to increase their reliability. Outside the enclosures, sectors were aggregated as required with neighbouring sectors to increase reliability. The final sector-sector movements were defined as reliable movements.

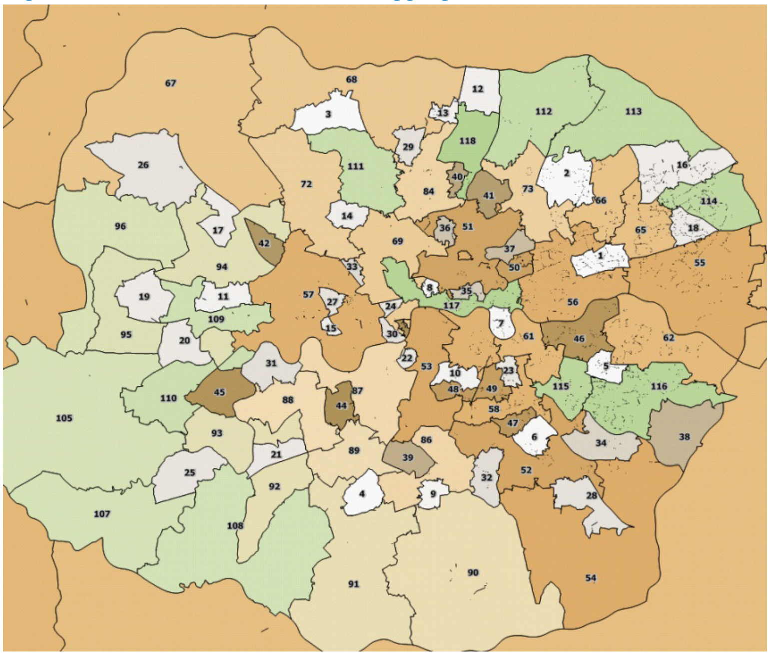
These statistically reliable sector level movements were used to constrain the synthetic trip matrices. For each time period a total of four sector levels were derived, corresponding to different levels of sector aggregation. The sector aggregations are shown in **Figures 6.1 – 6.4**.

Figure 6.1: Initial Sector System



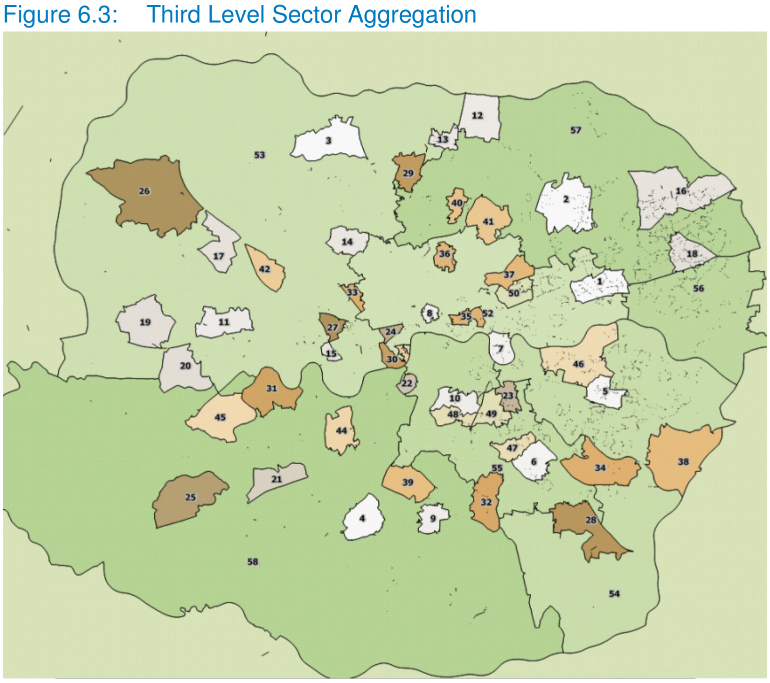
Source: Jacobs

Figure 6.2: Second Level Sector Aggregation



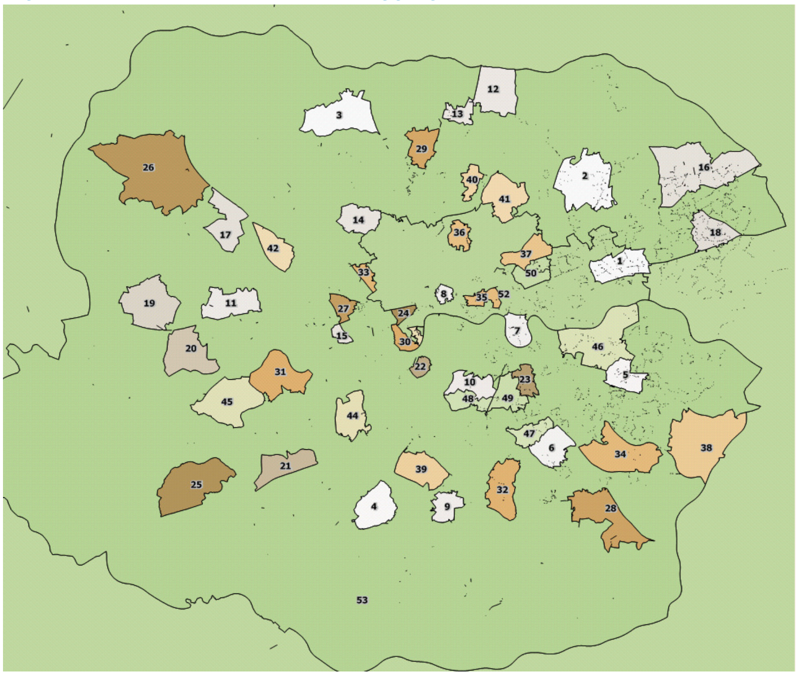
Source: Jacobs

Figure 6.3: Third Level Sector Aggregation



Source: Jacobs

Figure 6.4: Fourth Level Sector Aggregation



Source: Jacobs

A summary of the reliable movements and trips for each level is shown in **Table 6.5**.

Table 6.5: Number of Reliable Trips at Each Sector Level

Sector Level	Number of sectors	Number of reliable movements	Reliable trips	Number of reliable movements	Reliable trips	Number of reliable movements	Reliable trips
		AM	AM	IP	IP	PM	PM
Initial	335	84	63,561	418	445,556	120	103,619
2	120	263	362,587	389	533,360	294	409,237
3	58	62	124,162	112	198,185	83	155,232
4	53	11	19,533	14	13,230	9	20,390
Total (fully observed)		**420**	**569,843**	**933**	**1,190,332**	**506**	**688,478**

Source: Jacobs

In addition to controlling to reliable movements, the synthetic matrices also had to be controlled to the adjusted trip ends. This was done using a 3D furness procedure. The process is designed to satisfy both the trip end constraints, and the statistically reliable sector-sector movements. The process continues through an iterative process until convergence is reached.

For each complete process iteration the updated synthetic and partial matrix trips by reliable movement are compared. For this a GEH statistic for each reliable movement has been calculated. The GEH statistic is a common formula used in traffic model validation and has also been deemed appropriate to be used in this context in the form of :

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

Where: M = Estimate of reliable movement in the updated synthetic matrix;

C = Estimate of reliable movement in the partial matrix.

The 3D furness process as described above is repeated iteratively and once 85% of all reliable movements have reached a GEH<5 the process has been defined as converged and is stopped.

Since cross river trips play the most significant part in the project it was decided to extract the cross river trips from the partial trip matrices for each time period to replace the cross river trips contained in the updated synthetic trip matrix.

6.2.6 Split to two purposes

The combined car one purpose trip matrices described in Section 6.2.5 have then been split to In-Work Trips (IWT) and Out-of-Work Trips (OWT). Factors for this have been derived from a sector – sector analysis of reliable IWT trips.

Purpose split factors have been derived on the basis of the IWT reliable movement definitions and have been allocated to the sector to sector OD IWT pairs accordingly. IWT factors have been applied at zone level to the updated trip matrices after the reliable movement and trip end constraints have been applied. The OWT trip matrices have been derived by subtracting the IWT prior trip matrix from the combined car one purpose trip matrix. The derived percentage of IWT trips (weighted average) for each time period used are summarised in **Table 6.6**.

Table 6.6: % of IWT trips by time period

Time period	% of IWT trips
AM peak	14.7%
Interpeak	19.7%
PM peak	12.1%

Source: Jacobs

6.2.7 Peak hour factors

Peak hour factors have been estimated for each reliable trip movement at sector level. The minimum and maximum peak hour factors have been constrained to be the lower and upper limit of the 95% confidence interval range rather than the actual derived minimum and maximum values in order to remove very large or small outlier values. The calculated and revised peak hour ranges are shown in **Table 6.7**.

Table 6.7: Peak hour factors

Time period	Mean	Minimum	Maximum	Revised Minimum	Revised Maximum
AM peak	0.40	0.22	0.62	0.287	0.511
PM peak	0.35	0.23	0.58	0.259	0.439

Source: TfL, Mott MacDonald

Interpeak hour trip matrices have been derived by dividing the period trip matrices by 6 (the number of hours in the inter-peak period).

6.2.8 External to external trips

External to external trips, with both an origin and destination outside the M25, are taken from the assignment trip matrices from the Highways Agency M25 assignment model with a 2004 base year.

The external to external car trip matrices were split into IWT and OWT trip matrices. For this exercise the same IWT factor matrices have been applied to the car trip matrices as described in Section 6.2.6 and accordingly the OWT trip matrices have been derived by subtracting the IWT trip matrices from the total car trip matrices.

It has further been established that the M25 external to external assignment matrices include cross river trips that are also taken account of in the cross-river movements included in the partial trip matrices. In order to avoid double counting and to simplify the process the cross river external to external trips from the M25 assignment model have been set to zero.

6.2.9 Goods vehicle matrices

Trip matrices have been produced for goods vehicles from the London Transportation Study (LTS) model, B6.x series, and external-external trips from the M25 assignment model.

6.2.10 Taxi matrices

Taxi trip matrices have also been produced from the LTS model.

6.2.11 Prior trip matrix assignment

The trip matrices for the five user classes have been stacked and assigned to the model networks, and actual assigned flows compared to the counts at a total screenline level. The screenlines are shown in **Figure 9.1**.

6.2.12 Prior Matrix Adjustments

The initial screenline analysis of the prior trip matrix assignments revealed the requirement for further prior trip matrix adjustments. The following prior trip matrix modifications have been undertaken:

- Adjustment of the river screenline flows for taxis, and goods vehicles so that the level of traffic is in line with the observed for those three user classes prior to making changes to the cars;
- 2004 external-external trip matrices have been used and zero growth between 2004 and 2009 has been assumed. This was based on traffic counts at Dartford;
- Trips on a number of screenlines have been factored to have a better match with the total observed screenline trips. However, it should be noted that the factoring has not been applied to the reliable movements but only to all other trips; and
- Following all adjustments made to the prior trip matrices the cross river trips have been replaced again with the partial matrix cross river trips as a last step in order to avoid any effects of the screenline adjustments on cross river trips.

6.2.13 Sector system analysis

In order to review changes to the car prior trip matrix a sector system analysis has been carried out. A sector system with a total of 21 sectors, which is divided into boroughs within the east London area as well as North-West London, South-West London, Kent, Essex and the rest of the UK, has been developed. The sectored trip matrices are summarised in **Appendix C**.

6.2.14 Final 2009 Prior Trip Matrices

The final adjusted 2009 peak hour trip matrix totals are shown in **Table 6.8**.

Table 6.8: 2009 prior trip matrix totals

User class	AM Peak Hour (0800-0900)	Interpeak Hour	PM Peak Hour (1700-1800)
uc1 - cars out-of-work	4,437,850	3,104,629	4,354,772
uc2 - cars in-work	765,778	781,504	596,648
uc3 - taxi	26,544	35,608	40,700
uc4 - lgv	109,862	115,719	101,866
uc5 - ogv	89,483	103,482	57,551
TOTAL	**5,429,517**	**4,140,942**	**5,151,537**

Source: Mott MacDonald

A comparison of the 2009 prior assigned flows against the observed count data at a screenline level for the final matrices is shown in **Appendix D**. **Table 6.9** summarises the information where the comparison against observed counts has been carried out using both actual and demand modelled flows. The assumed pass criteria was that modelled flows should be within 7.5% of observed.

Table 6.9: Percentage of screenlines meeting validation criteria using 2009 prior matrix actual or demand modelled flows

	Actual modelled flows		Demand modelled flows	
Peak Period	Total vehs	Cars	Total vehs	Cars
AM Peak	48%	55%	43%	48%
Interpeak	64%	63%	63%	57%
PM Peak	63%	52%	64%	61%

6.3 2012 trip matrix development

Matrix growth from 2009 to 2012 consisted of three parts, namely background traffic growth and car trips generated by new housing and employment developments.

6.3.1 Background Traffic Growth

Background traffic growth was calculated by comparing traffic volumes recorded by long term continuous automatic traffic counters in November 2009 and November 2012. Comparisons were carried out by time period separately. The results are shown in **Table 6.10**.

Table 6.10: Traffic growth at key locations between 2009 and 2012

	2-way factor 2009 - 2012		
Location	AM	IP	PM
A200 Rotherhithe Tunnel	0.86	0.89	0.91
A208 Well Hall Road	0.97	0.93	0.97
A207 Blackheath Hill	1.04	1.00	0.94
A11 Mile End Rd	1.11	0.94	1.07
A1020 Royal Dock Rd North	0.91	0.93	1.05
A201 New Cross Road	1.10	1.07	1.04
A13 Alfreds Way	0.96	0.97	1.02
A13 E India Dock Rd	1.00	1.02	0.98
A124 Barking Rd	0.97	0.97	1.00
A2206 Southwark Pk	0.91	0.92	0.89
B207 Sandford St	1.12	1.04	1.13
B171 Goodmays Ln	1.03	1.00	0.99
A118 London Rd Havering	1.01	1.00	1.05
A2041 Knee Hill	1.02	0.97	0.99
A1261 Lower Lea Crossing	0.90	0.96	0.80
A206 Thames Rd	0.98	1.00	1.04
Total 2-way flow	**0.98**	**0.98**	**1.00**

The results indicate that overall there have been minimal changes in traffic flow between 2009 and 2012 and therefore a growth factor of 1.00 has been used.

6.3.2 New Housing Developments

TfL provided a list of housing developments in London by year from 2001 to 2011 and between 2011 and 2031 combined.

Housing numbers between November 2009 and November 2012 were calculated by combining half the 2009-2010 figures with the 2010-2011 figures. Houses only in the boroughs of Enfield, Haringey, Waltham Forest, Redbridge, Havering, Islington, Hackney, Newham, Barking and Dagenham City of London, Tower Hamlets, Southwark, Lewisham, Greenwich, Bexley and Bromley were considered.

Table 6.11 lists the final set of housing areas and numbers of dwellings included within the trip generation process.

Table 6.11: Housing Developments

Housing Site	Total number of dwellings
Lower Lea Valley (inc Stratford)	1668
Upper Lea Valley	1036
Isle of Dogs	2821
Royal Docks & Beckton Waterfront	229
City Fringe	690
Lewisham/Catford/New Cross	610
London Riverside	916
Greenwich Peninsula	370
Thamesmead & Abbey Wood	104
Charlton Riverside	226
London Bridge/Bankside	360
Bexley Riverside	41
Arsenal/ Holloway	173
Elephant & Castle	132
Deptford Creek/Greenwich Riverside	203
Woolwich	93
Ilford	175
King's Cross	36
Canada Water/Surrey Quays	164
Farringdon/Smithfield	19
Dalston	71
Euston	14
Kidbrooke	16

The housing numbers were then multiplied by car trip rates to produce new housing car trips generated between 2009 and 2012. The trip rates used are as detailed below and have been taken from the TRAVL database. The TRAVL trip rates were given for a three hour morning period, a six hour interpeak period and a three hour evening period and separately by Inner and Outer London. These trip rates were therefore divided by three, six and three respectively to give the hourly trip rates in **Tables 6.12** and **6.13**.

Table 6.12: Inner London Housing Car Trip Rates (per dwelling)

Time Period	Direction	Trip Rate per dwelling
AM Peak Hour (0800-0900)	Arrival	0.065
	Departure	0.134
Interpeak Hour	Arrival	0.069
	Departure	0.079
PM Peak Hour (1700-1800)	Arrival	0.123

Time Period	Direction	Trip Rate per dwelling
	Departure	0.090

Table 6.13: Outer London Housing Car Trip Rates (per dwelling)

Time Period	Direction	Trip Rate per dwelling
AM Peak Hour (0800-0900)	Arrival	0.146
	Departure	0.336
Interpeak Hour	Arrival	0.194
	Departure	0.200
PM Peak Hour (1700-1800)	Arrival	0.348
	Departure	0.219

6.3.3 New Employment Development

TfL provided output from the London employment sites database listing all developments and re-developments in London. For each site, the database provided site reference, location, allocation to LTS zone, planning status, timescales and development type and size details. Completion timescales were given in five yearly intervals of 2011, 2016, 2021, 2026 and 2031.

Details for sites which were completed by 2011 in the boroughs of Enfield, Haringey, Waltham Forest, Redbridge, Havering, Islington, Hackney, Newham, Barking and Dagenham City of London, Tower Hamlets, Southwark, Lewisham, Greenwich, Bexley and Bromley were considered.

Table 6.14 lists the final set of employment (re)developments included within the trip generation process.

Table 6.14: Employment Development Sites

Site Name	Borough	Development Type(s) affected	Total Additional Development Size (sqm)
Site Bounded By Cheapside, Bread Street, Watling Street	City of London	A1, A2. A3, A4, A5, B1, SG	29,666
106 – 126 Bishopsgate/ Camomile Street	City of London	A1, A2, A3, A4, B1	53,799
Cannon Street Railway & Underground Station & 78 Cannon Street	City of London	A3, B1, SG	23,501
New Court, 1-10 St Swithuns Lane	City of London	B1	10,283
Riverbank House, 2 Swan Lane	City of London	B1	24,383
Maritime Industrial Estate, Horizon Way	Greenwich	A1, B1, B2	10,875
Phase 1, 21 – 55 Wellington Street / Love Lane	Greenwich	A1, A4, B1, SG	14,779
Thomas Tallis School	Greenwich	D1	5,726
Former World Of Leather Site, 400 Westhorne Avenue	Greenwich	A1, B8, D1	5,916

Site Name	Borough	Development Type(s) affected	Total Additional Development Size (sqm)
Land At Woodberry Grove	Hackney	D1	12,560
53, 61 and 85, Central Street &, Seward Street, 20-24, EC1V 8AD	Islington	B1	6,825
156-176 St John Street	Islington	B1	8,586
13-15 Eagle Court	Islington	B1, D1	1,728
43-57 Gee Street	Islington	B1	2,485
Conewood Children's Centre	Islington	B1	1,973
Giffin Street Regeneration Area	Lewisham	A2, B1, D1	5,419
Deptford Green School (Lower School Site)	Lewisham	D1	7,960
Prendergast Hilly Fields College	Lewisham	D1	8455
Land Bounded By A12 Waterworks river, to west, railway to east	Newham	D2	36,615
Depot Dlr, Armada Way	Newham	B1	1,579
University Square Docklands Campus	Newham	D1	8,181
Royal Victoria Employment Hub	Newham	A1, A3, B1, D1	5,219
Aquatic Centre, Bounded By Waterworks River & New Carpenters Road	Newham	B1, D2	28,000
New Caledonian Market, Bermondsey Square	Southwark	A1, A3, B1, C1, D1	4,418 (+64 bedrooms)
Geoffrey Chaucer & Joseph Lancaster Schools	Southwark	D1	6,717
Part Ex Printing Works, Amelia Street/Robert Dashwood Way	Southwark	B1	1,152
Units A-D Abbey Wharf Industrial Estate	Barking and Dagenham	B1, B2, B8	400
Town Square, Phase 2, Clockhouse Ave	Barking and Dagenham	A1, B1	5,555
Dagenham Business Centre	Barking and Dagenham	B1, B2	3,650
Land Adjacent To River Thames/ Norman Road	Bexley	B2	15,148
Former Nufarm Uk Ltd Site	Bexley	B1, B2, B8	23,225
Formerly Pinnacle Storage	Bexley	B1, B2, B8	0 (*change of use)
Unit 7 & 8, Morson Road	Enfield	B1, B2, B8	5,610
20 Jute Lane	Enfield	B8	1,700
4 Morson Road	Enfield	B8	3,511
965 (Formerly Part Of Esab) Hertford Road	Enfield	B8	14,354
3 Solar Way	Enfield	B1, B2, B8	3,539

Source: LESD 2012

Employment development site floorspace areas or numbers of bedrooms were multiplied by car trip rates to produce new employment development car trips generated between 2009 and 2012. As with the housing trips, the trip rates were taken from the TRAVL database for a three hour morning period, a six hour interpeak period and a three hour evening period and divided by three, six and three respectively to give hourly trip rates. **Tables 6.15** and **6.16** provide the employment development trip rates used.

Table 6.15: Inner London Employment Development Car Trip Rates (per 100sqm/bedroom)

Development Type	AM Peak Hour (0800-0900)		Interpeak Hour		PM Peak Hour (1700-1800)	
	Arrival	Departure	Arrival	Departure	Arrival	Departure
Food (20%)/non food (80%) (A1)	1.388	0.708	1.907	1.619	2.639	3.141
Financial and Professional Services (A2)	0.811	0.077	0.413	0.329	0.153	0.779
Restaurant & Café (A3)	0.789	0.750	1.296	0.999	2.491	2.284
Drinking Establishments (A4)	0.000	0.000	1.345	1.151	1.448	0.915
Hot Food Takeaway (A5)	4.225	4.033	2.444	2.328	2.630	2.330
Business (B1)	0.811	0.077	0.413	0.329	0.153	0.779
General Industry (B2)	0.455	0.160	0.426	0.395	0.120	0.436
Storage or Distribution (B8)	0.146	0.142	0.187	0.199	0.181	0.193
Hotels (C1) per bedroom	0.069	0.069	0.066	0.066	0.123	0.123
Non-Residential Institutions (D1)	4.778	2.039	3.622	3.880	2.816	3.983
Cinema (D2)	0.044	0.000	0.757	0.453	1.108	0.709
(SG)	1.448	0.662	2.983	2.495	2.415	2.138

Table 6.16: Outer London Employment Development Car Trip Rates (per 100sqm/bedroom)

Development Type	AM Peak Hour (0800-0900)		Interpeak Hour		PM Peak Hour (1700-1800)	
	Arrival	Departure	Arrival	Departure	Arrival	Departure
Food (20%)/non food (80%) (A1)	4.691	2.812	6.671	6.238	4.061	5.717
Financial and Professional Services (A2)	1.051	0.136	0.323	0.256	0.296	1.018
Restaurant & Café (A3)	0.449	0.224	3.901	2.096	3.498	1.137
Drinking Establishments (A4)	0.000	0.000	3.696	3.629	3.925	1.801
Hot Food Takeaway (A5)	12.148	10.305	30.965	30.290	45.600	44.289
Business (B1)	1.051	0.136	0.323	0.256	0.296	1.018
General Industry (B2)	0.401	0.065	0.108	0.099	0.077	0.474
Storage or Distribution (B8)	0.462	0.106	0.213	0.258	0.105	0.354
Hotels (C1) per bedroom	0.121	0.187	0.116	0.130	0.210	0.161
Non-Residential Institutions (D1)	1.663	1.000	1.816	1.865	1.233	1.651

Development Type	AM Peak Hour (0800-0900)		Interpeak Hour		PM Peak Hour (1700-1800)	
Cinema (D2)	0.000	0.000	6.937	4.530	7.166	6.523
(SG)	0.760	0.322	1.075	0.885	1.377	1.580

It was assumed that the developments within the City of London would generate no additional car trips and this was verified as a sensible approach by checking the planning applications for some of the sites which showed minimal, if any, new car parking spaces provided by the development. Similarly, for other Inner London developments, planning application information was reviewed to check if any additional car parking was to be provided and trip numbers generated by the development adjusted accordingly.

Finally, a correspondence between LTS zones and ELHAM zones was created to provide employment development trips by ELHAM zone.

6.3.4 Overall Trip Matrix Growth

The new car trips generated by the housing and employment developments were split between business and other car trips using the proportions of those two purposes in the 2009 prior trip matrices by time period. **Table 6.17** below details the proportions used.

Table 6.17: 2009 Prior Matrix Car Trip Purpose Proportions

Time Period	Other % of trips	Business % of trips
AM Peak Hour	85.3	14.7
Interpeak Hour	79.9	21.1
PM Peak Hour	87.9	12.1

The trips were then added to the 2009 prior trip matrices by user class to give the 2012 prior trip matrix totals. **Tables 6.18 – 6.20** provide the 2009 prior matrix trip totals, new car trips generated and final 2012 prior trip matrix totals by time period and user class. The car trips generated by the new developments have added between 0.07% and 0.08% to the overall trip matrix total.

Table 6.18: 2009 Prior Trip Matrix Totals

User Class	AM Peak Hour (0800-0900)	Interpeak Hour	PM Peak Hour (1700-1800)
uc1 - cars out-of-work	4,437,850	3,104,629	4,354,772
uc2 - cars in-work	765,778	781,504	596,648
uc3 – taxi	26,544	35,608	40,700
uc4 – lgv	109,862	115,719	101,866
uc5 – ogv	89,483	103,482	57,551
TOTAL	**5,429,516**	**4,140,942**	**5,151,537**

Table 6.19: New Development Trips

User Class	AM Peak Hour (0800-0900)	Interpeak Hour	PM Peak Hour (1700-1800)
uc1 - cars out-of-work	3,180	2,228	3,267
uc2 - cars in-work	549	498	759
TOTAL	3,728	2,726	4,025

Table 6.20: 2012 Prior Trip Matrix Totals

User Class	AM Peak Hour (0800-0900)	Interpeak Hour	PM Peak Hour (1700-1800)
uc1 - cars out-of-work	4,441,029	3,106,857	4,358,038
uc2 - cars in-work	766,326	782,002	597,407
uc3 – taxi	26,544	35,608	40,700
uc4 – lgv	109,862	115,719	101,866
uc5 – ogv	89,483	103,482	57,551
TOTAL	5,433,244	4,143,668	5,155,563

These 2012 prior trip matrices were then multiplied by 1.03 to give the final 2012 prior trip matrices. This factor was based on work carried out by TfL which identified that the peak hour to peak period factors were likely to be under-estimated, based on an initial comparison of observed and modelled journey times. The sectored matrices are summarised in **Appendix C**.

A comparison of the prior matrix assigned flows against the observed count data at a screenline level for the final 2012 prior matrices is shown in **Appendix D**. **Table 6.21** summarises the information where the comparison against observed counts has been carried out using both actual and demand modelled flows. The assumed pass criteria was that modelled flows should be within 7.5% of observed. Screenline totals include the 'gap' counts where relevant, as described in **Section 4.3**.

This shows that total modelled flows validate for around 45% of screenlines in the AM Peak, around 64% in the Interpeak and 61% in the PM Peak. Consequently it was felt that matrix estimation is required to improve the model to ensure it is appropriate for use.

Table 6.21: Percentage of screenlines meeting validation criteria using 2012 prior matrix actual or demand modelled flows

	Actual modelled flows		Demand modelled flows	
Peak Period	Total vehs	Cars	Total vehs	Cars
AM Peak	45%	46%	45%	43%
Interpeak	64%	63%	66%	61%
PM Peak	61%	57%	50%	54%

7 Network Calibration and Validation

7.1 Introduction

Calibration is the adjustment and refinement of the model network and can be carried out both before and after assignment. As described in Section 5 of this report, a series of checks were carried out on the network covering link lengths, stacking capacity at junctions, cruise speeds, GAP parameters, bus lanes, zone connectors, and signal timings. Key network link lengths and junction layouts were checked against mapping.

Further adjustments to the network coding were made as part of the process of calibrating the model, as described in **Section 7.2**.

Validation is the comparison of the model network post-assignment with real life observations, as described in **Section 7.3**.

7.2 Network Calibration

Using initial assignments, the location of zone connectors were reviewed where excessive delays were being experienced by traffic entering or exiting a zone to ensure trips could enter and exit the zone. Zone connectors were relocated where necessary.

An initial comparison of modelled against observed journey times was also used to identify any junctions where insufficient or excess delay was being generated by the model, and where cruise speeds through an area were inaccurate. At these locations, adjustments were made to link speeds, signal timings or lane allocations as required, to more closely match observed conditions.

7.3 Network Validation

WebTAG unit 3.19 para 6.3.1 states that “there is little data available against which to validate the network that has not already been used in coding the network”. The validation of the network has therefore been undertaken in conjunction with the matrix validation and reported in **Chapter 10** with the comparison of observed and final modelled journey times.

8 Route Choice Calibration and Validation

8.1 Introduction

WebTAG 7.1.4 states that at various stages in the model development process, modelled routes should be examined and their plausibility checked. For the River Crossings model this was initially carried out using the prior matrix assignments, described in **Section 8.2** below. If at this stage routes are found to be implausible, a process of route choice calibration may be required, this is covered in **Section 8.3**. The post-ME assignments were then used for route choice validation, as described in **Section 8.4**.

8.2 Route Choice Plausibility

Appendix E contains tree plots for five different OD pairs using the AM Peak prior matrix assignments. This allows us to check whether the model is initially assigning traffic to appropriate routes or whether network coding errors are present impacting on route choice. The OD pairs shown are:

- Avery Hill to Wanstead
- Greenwich to Dartford
- Knockholt to Chadwell Heath
- Upmister to Avery Hill
- South Darenth to Deptford

The routes chosen are a mixture of routes between OD pairs on either side of the river (which should use routes including Blackwall Tunnel or Dartford Crossing) and the same side of the river Thames. Route choices for both cars and OGVs are included.

The plots show that both cars and OGVs are using the main roads for the majority of the routes, switching to more local roads at the start and end of the journeys. The plots show that for the route from Knockholt to Chadwell Heath OGVs use the A1306 and A1125 for part of the journey whereas the cars use the A13 and A1240. For the Upminster to Avery Hill, OGVs leave the M25 to use more local roads earlier than the cars. The other routes have minor route choice differences between cars and OGVs at either the very beginning or end of the routes.

8.3 Route Choice Calibration

Because route choices looked plausible in the prior assignments, as described above, there was no requirement for any significant route choice calibration such as different link speeds or speed/flow curves for OGVs.

8.4 Route Choice Validation

Appendix F contains tree plots for the same five OD pairs but using the final AM Peak assignments with route choices for both cars and OGVS again included.

Again the plots show that both cars and OGVs are using the main roads for the majority of the routes, switching to more local roads at the start and end of the journeys. The plots show that for the route from Knockholt to Chadwell Heath, OGVs continue to use the A1306 and A1125 for part of the journey whereas the cars have switched to using the A13 and A1125. For the Upminster to Avery Hill, OGVs now remain on the M25 as long as the cars. Only the South Darenth to Deptford route now shows any other differences in route choice between cars and OGVs and this is limited to the start of the journey.

These route choice changes show that the full post matrix estimation assignment has more appropriate car and OGV routings than those seen in the prior matrix assignments.

9 Trip Matrix Calibration and Validation

9.1 Introduction

This chapter describes:

- Trip matrix estimation, including checks of significance of differences between prior and estimated trip matrices; and
- Trip matrix validation, including checks of screenline flow against WebTAG guidelines.

9.2 Trip Matrix Estimation Process

The screenline comparisons from the prior matrix assignments, referred to in **Section 6.3.4** and shown in **Appendix D**, did not meet acceptability guidelines. Consequently it was felt that matrix estimation was required to improve the matrices.

Matrix estimation (ME) was carried out using the final networks and the final prior trip matrices described in **Chapters 7** and **6** respectively. Matrix estimation has been undertaken by vehicle type separately, namely cars, taxis, LGV and OGV. Counts at all screenlines and enclosures have been included in the matrix estimation, including the new 2012 counts, except for the River Thames screenline which was held back for validation. Screenlines cover both the simulation and speed/flow curve area, and additional counts in the external area are also included in ME.

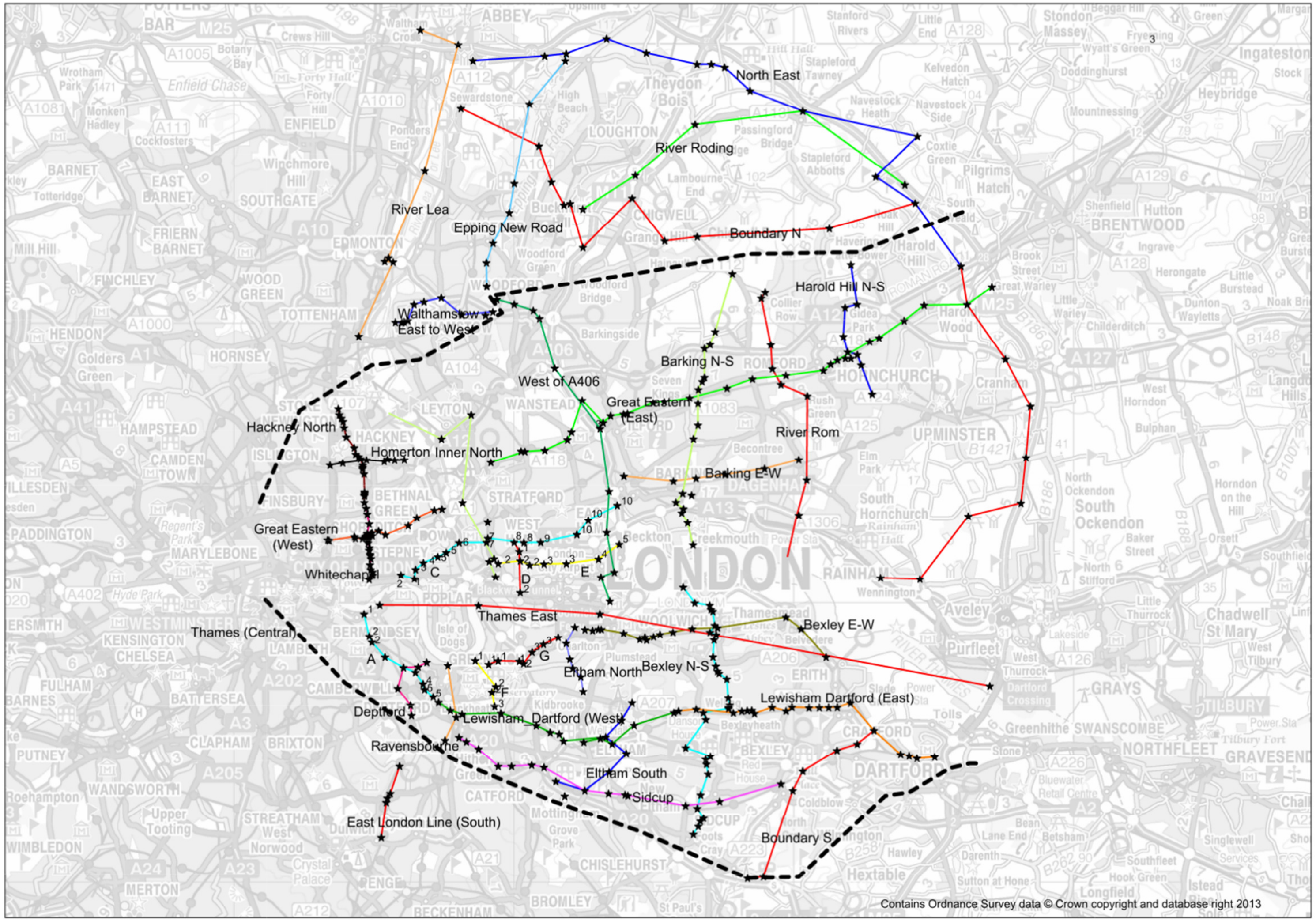
Results from this matrix estimation process are reported in **Section 9.3**, for the screenlines and enclosures within the dotted lines in **Figure 9.1**, defined as the area of interest for the River Crossings modelling. A second matrix estimation process was also carried out using all the counts, including the River Thames screenline, these results are reported in **Section 9.4**.

Each screenline has been subdivided into a series of mini-screenlines in line with guidance in WebTAG unit 3.19 chapter 8, as shown for the ELHAM simulation area in **Figure 9.1**, and these were used for the initial matrix estimation runs. However although these resulted in a good match to screenline and enclosure flows in total, the modelled flows on individual links within each mini-screenline were in some cases significantly different from the observed flow.

A second round of matrix estimation was therefore carried out with the main roads in each screenline defined as individual links. This produced a much better representation of main road flows, but resulted in the total modelled screenline flows not being close enough to observed flows in some cases.

A better fit between observed and modelled flows was therefore achieved by taking an average of the output matrices from both ME runs and assigning this averaged matrix to the network. In the interpeak and PM peak it was also found that a better fit between observed and modelled flows was achieved by applying a post-ME factor of 1.03 to the total matrix before re-assigning, consistent with the factor of 1.03 applied before matrix estimation described in **Section 6.3.4**.

Figure 9.1: Screenline Location and Mini Screenline Definition within the ELHAM simulation area



9.3 Matrix Estimation (without River Thames screenline in ME)

9.3.1 Calibration screenlines

A comparison of the post matrix estimation assigned flows against the count data at a screenline level for the final matrices is shown in **Section 10.3.1**. The table below summarises the information for the calibration screenlines and enclosures for both pre and post matrix estimation. The acceptability guideline is that modelled flows should meet the criterion of being within 5% of the count on all or nearly all screenlines.

Table 9.1: Percentage of screenlines and enclosures meeting WebTAG flow criterion

Peak Period	Total vehs		Cars	
	Pre ME	Post ME	Pre ME	Post ME
AM Peak	33%	56%	41%	63%
Interpeak	49%	91%	47%	84%
PM Peak	47%	75%	45%	66%

9.3.2 Validation screenline

Table 9.2 shows the percentage difference between count and modelled flow for the River Thames screenline for each time period and direction. The pass criterion is that modelled flows for the whole screenline should be within 5% of observed. The criterion is met only in the interpeak.

Table 9.2: River Thames Screenline validation

Time Period	Northbound		Southbound	
	Total vehs	Cars	Total vehs	Cars
AM Peak	No (7%)	No (8%)	No (-7%)	No (-8%)
Interpeak	Yes (-4%)	Yes (-2%)	Yes (-3%)	Yes (-4%)
PM Peak	No (-7%)	Yes (-5%)	No (10%)	No (14%)

9.3.3 Trip Matrix Estimation Outcomes

The differences between Prior and Post estimation matrices by user class are shown in **Table 9.3**.

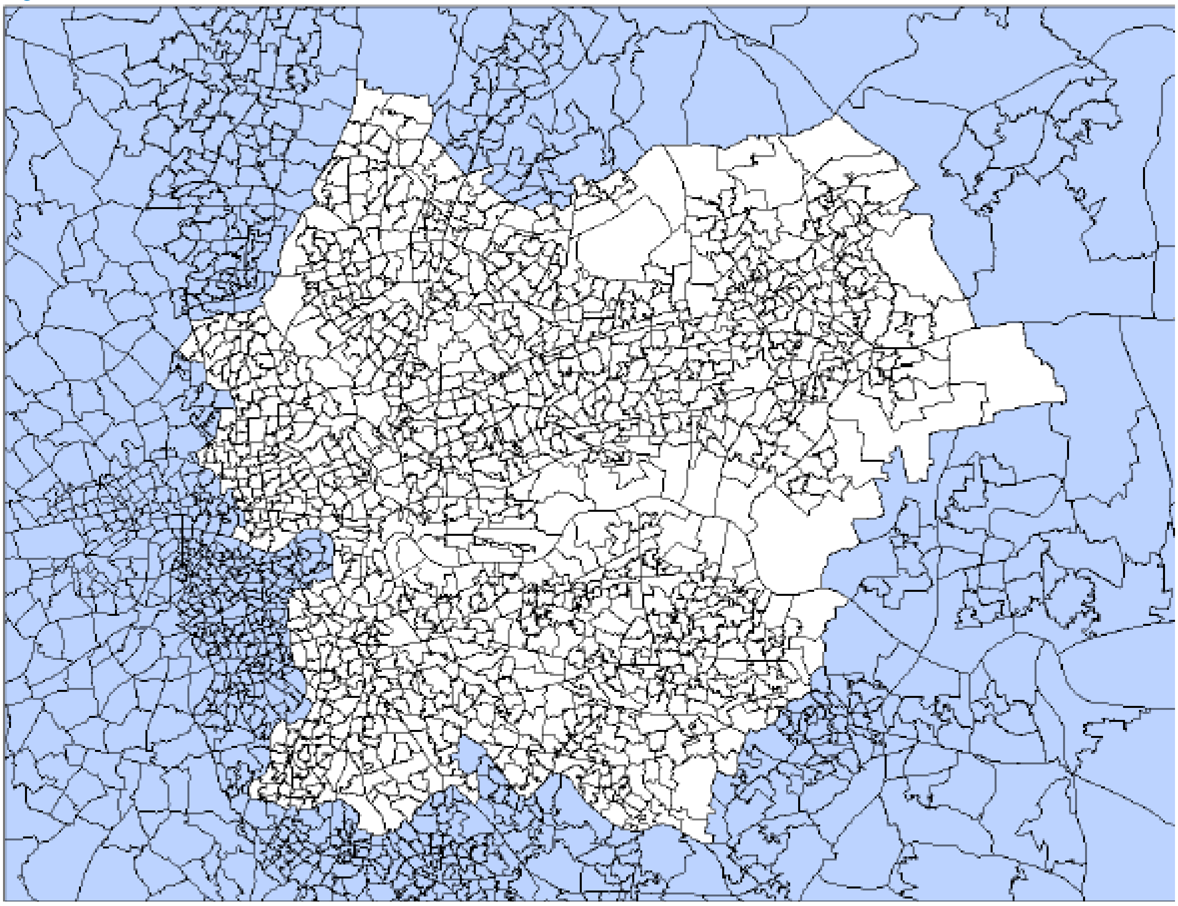
Table 9.3: Prior and Post Matrix Estimation matrix totals

	1	2	3	4	5	Total
	Car out of work time	Car in work time	Taxis	LGV	HGV	All vehicles
AM						

	1	2	3	4	5	Total
Prior	4,574,260	789,316	27,340	113,158	92,168	5,596,241
Post	4,604,344	794,418	25,805	118,761	91,300	5,634,628
% Diff.	1%	1%	-6%	5%	-1%	1%
IP						
Prior	3,200,063	805,462	36,676	119,191	106,586	4,267,978
Post	3,317,122	836,529	37,176	126,740	104,614	4,422,180
% Diff.	4%	4%	1%	6%	-2%	4%
PM						
Prior	4,488,779	615,329	41,921	104,922	59,278	5,310,230
Post	4,673,204	641,212	40,968	111,537	54,599	5,521,521
% Diff.	4%	4%	-2%	6%	-8%	4%

In order to assess the impact of matrix estimation in detail, and following guidance set out in Section 8.3 of TAG Unit 3.19, a number of tests have been carried out to assess the significance of matrix estimation changes. Tables showing the regression statistics for zonal changes at cell level disaggregated by time period and user class are shown in **Appendix G.1**. This analysis has been done for all cells including those where the value is zero, where the zones outside the white area shown in **Figure 9.2** are considered as a single zone and where trips that have both an origin and destination outside this area have been removed. The tables show that changes brought about by matrix estimation to all user classes and in all time periods are significant.

Figure 9.2: Area of interest for matrix estimation tests



Appendix H.1 contains scatter diagrams of the trip destinations at zonal level. The scatter diagrams are annotated with the regression statistics and show that when assessed against the criteria set out in Table 5 of Section 8.13 of TAG Unit 3.19, the changes brought about by matrix estimation are not significant.

Appendix I.1 contains the comparison of trip length distributions between the prior and post matrix estimated matrices, including tables showing means and standard deviations for prior and post matrix estimated matrices. Both the means and standard deviations are generally within 5% and are therefore not significant.

Appendix J.1 contains scatter diagrams of matrix cell values at the 21-sector level and summary tables of sector to sector level matrix differences. Most sector-sector movements change by less than 5%.

Appendix K.1 contains scatter diagrams of the trip destinations at sector level .The changes at sector level are less significant than the changes at cell level.

9.4 Matrix estimation with all counts included in ME

9.4.1 Calibration screenlines

To further improve the model, the River Thames screenline was included in the matrix estimation procedure. A comparison of the post matrix estimation assigned flows against the count data at a screenline level for the final matrices is included in **Chapter 10**. **Table 9.4** summarises the information for the calibration screenlines for both pre and post matrix estimation. The acceptability guideline is that modelled flows should meet the criterion of being within 5% of the count on all or or nearly all screenlines.

Table 9.4: Percentage of calibration screenlines and enclosures meeting WebTAG flow criterion

Peak Period	Total vehs		Cars	
	Pre ME	Post ME	Pre ME	Post ME
AM Peak	33%	62%	41%	61%
Interpeak	49%	89%	47%	80%
PM Peak	47%	74%	45%	67%

Table 9.5 shows the percentage difference between count and modelled flow for the River Thames screenline (not included in the percentages shown in **Table 9.4**) for each time period and direction. The pass criterion is that modelled flows for the whole screenline should be within 5% of observed. The criterion is met only in the interpeak.

Table 9.5: River Thames Screenline calibration

Time Period	Northbound		Southbound	
	Total vehs	Cars	Total vehs	Cars
AM Peak	No (6%)	No (9%)	Yes (-1%)	Yes (-1%)
Interpeak	Yes (0%)	Yes (2%)	Yes (2%)	Yes (3%)
PM Peak	Yes (2%)	Yes (0%)	No (13%)	No (15%)

9.4.2 Trip Matrix Estimation Outcomes

The differences between Prior and Post estimation matrices by user class are shown in **Table 9.6**.

Table 9.6: Prior and Post Matrix Estimation matrix totals

	1	2	3	4	5	Total
	Car out of work time	Car in work time	Taxis	LGV	HGV	All vehicles
AM						
Prior	4,574,260	789,316	27,340	113,158	92,168	5,596,241
Post	4,604,306	794,439	25,520	118,703	91,220	5,634,189
% Diff.	1%	1%	-7%	5%	-1%	1%
IP						
Prior	3,200,063	805,462	36,676	119,191	106,586	4,267,978
Post	3,317,029	836,540	37,160	126,788	104,505	4,422,022
% Diff.	4%	4%	1%	6%	-2%	4%
PM						
Prior	4,488,779	615,329	41,921	104,922	59,278	5,310,230
Post	4,673,400	641,295	41,082	111,550	54,667	5,521,994
% Diff.	4%	4%	-2%	6%	-8%	4%

Tables showing the regression statistics for zonal changes at cell level disaggregated by time period and user class are shown in **Appendix G.2**. This analysis has been done for all cells including those where the value is zero, where the area outside of ELHAM is considered as a single zone and where trips that have both an origin and destination outside of ELHAM have been removed. The tables show that changes brought about by matrix estimation to all user classes and in all time periods are significant.

Appendix H.2 contains scatter diagrams of the trip destinations at zonal level. The scatter diagrams are annotated with the regression statistics and show that when assessed against the criteria set out in Table 5 of Section 8.13 of TAG Unit 3.19, the changes brought about by matrix estimation are not to be significant.

Appendix I.2 contains the comparison of trip length distributions between the prior and post matrix estimated matrices, including tables showing means and standard deviations for prior and post matrix estimated matrices. Both the means and standard deviations are generally within 5% and are therefore not significant.

Appendix J.2 contains scatter diagrams of matrix cell values at the 21-sector level and summary tables of sector to sector level matrix differences. Most sector-sector movements change by less than 5%.

Appendix K.2 contains scatter diagrams of the trip destinations at sector level .The changes at sector level are less significant than the changes at cell level.

10 Assignment Calibration and Validation

10.1 Introduction

This chapter presents results from the model validation process, under the following headings:

- Further network calibration;
- Link flow validation; and
- Journey time validation.

The link flow and journey time validation are shown for both sets of matrix estimation results:

a) Without the River Thames screenline in ME; and
b) With all counts included in ME.

Comparisons of modelled flows with observed turning counts were carried out for the final version of the model (with all counts included in ME) only.

10.2 Further Network Calibration

Following initial runs of matrix estimation, further refinement of the network was undertaken as issues were identified. Typically this was where capacities were lower than counts or where journey time profiles indicated differences relating to junction delays where these had not been picked up using assignments with the prior matrices. Further network adjustments were made, such as adjusting signal timingsor lane allocations where initial assumptions were incorrect.

10.3 Link Flow Validation

10.3.1 Matrix Estimation (without River Thames screenline in ME)

Tables 10.1 – 10.3 compare the modelled flows against the observed count data for the River Thames validation screenline.

In the AM Peak all individual northbound links meet either or both of the validation flow or GEH criteria (detailed in **Table 2.1**, **Section 2.2**) but the overall screenline flow is about 7% too high. Three of the river crossings in the southbound direction do not meet either of the validation criteria and the total screenline modelled flow is also too low.

In the interpeak, two of the northbound river crossings and one southbound do not meet either of the validation criteria but overall screenline flows do in both directions.

In the PM Peak three of the individual northbound links do not meet the either of the validation criteria and the overall screenline flow is too low. Two of the river crossings in the southbound direction do not meet either of the validation criteria and the total screenline modelled flow is too high.

Table 10.1: Observed and modelled flows across the Thames screenline AM Peak (by direction)

Northbound	Observed (vehs)	Modelled (vehs)	% diff	abs diff	GEH	meet flow or GEH criteria
Southwark Bridge	270	325	21%	55	3.2	✓
London Bridge	712	803	13%	91	3.3	✓
Tower Bridge	841	970	15%	129	4.3	✓
A101 Rotherhithe Tunnel	862	796	-8%	-66	2.3	✓
A102 Blackwall Tunnel	2893	3060	6%	167	3.1	✓
Woolwich Ferry	126	129	2%	3	0.3	✓
A282 Dartford Crossing	4376	4678	7%	302	4.5	✓
TOTAL	**10078**	**10761**	**7%**	**683**	**6.7**	**x**

Southbound	Observed (vehs)	Modelled (vehs)	% diff	abs diff	GEH	meet flow or GEH criteria
Southwark Bridge	244	376	54%	132	7.5	x
London Bridge	718	712	-1%	-6	0.2	✓
Tower Bridge	819	707	-14%	-112	4.1	✓
A101 Rotherhithe Tunnel	858	669	-22%	-189	6.8	x
A102 Blackwall Tunnel	2620	2138	-18%	-482	9.9	x
Woolwich Ferry	136	120	-12%	-16	1.4	✓
A282 Dartford Crossing	4573	4596	1%	23	0.3	✓
TOTAL	**9967**	**9319**	**-7%**	**-648**	**6.6**	x

Table 10.2: Observed and modelled flows across the Thames screenline Inter Peak (by direction)

Northbound	Observed (vehs)	Modelled (vehs)	% diff	abs diff	GEH	meet flow or GEH criteria
Southwark Bridge	248	167	-33%	-81	5.7	x
London Bridge	715	666	-7%	-49	1.9	✓
Tower Bridge	798	673	-16%	-125	4.6	✓
A101 Rotherhithe Tunnel	762	599	-21%	-163	6.3	x
A102 Blackwall Tunnel	2582	2812	9%	230	4.4	✓
Woolwich Ferry	120	128	7%	8	0.7	✓
A282 Dartford Crossing	3924	3916	0%	-8	0.1	✓
TOTAL	**9149**	**8960**	**-2%**	**-189**	**2.0**	✓

Southbound	Observed (vehs)	Modelled (vehs)	% diff	abs diff	GEH	meet flow or GEH criteria
Southwark Bridge	252	333	32%	81	4.7	✓
London Bridge	712	720	1%	7	0.3	✓
Tower Bridge	785	612	-22%	-172	6.5	x
A101 Rotherhithe Tunnel	578	471	-18%	-107	4.7	✓
A102 Blackwall Tunnel	2684	2809	5%	124	2.4	✓
Woolwich Ferry	135	92	-32%	-43	4.1	✓
A282 Dartford Crossing	3797	3914	3%	117	1.9	✓
TOTAL	**8943**	**8950**	**0%**	**7**	**0.1**	✓

Table 10.3: Observed and modelled flows across the Thames screenline PM Peak (by direction)

Northbound	Observed (vehs)	Modelled (vehs)	% diff	abs diff	GEH	meet flow or GEH criteria
Southwark Bridge	223	112	-50%	-111	8.6	x
London Bridge	779	669	-14%	-110	4.1	✓
Tower Bridge	844	647	-23%	-196	7.2	x
A101 Rotherhithe Tunnel	1002	717	-28%	-285	9.7	x
A102 Blackwall Tunnel	2827	2905	3%	77	1.4	✓
Woolwich Ferry	160	110	-31%	-50	4.3	✓
A282 Dartford Crossing	4755	4779	1%	24	0.4	✓
TOTAL	**10590**	**9939**	**-6%**	**-650**	**6.4**	x

Southbound	Observed (vehs)	Modelled (vehs)	% diff	abs diff	GEH	meet flow or GEH criteria
Southwark Bridge	258	204	-21%	-54	**3.5**	✓
London Bridge	751	784	4%	33	**1.2**	✓
Tower Bridge	878	967	10%	89	**2.9**	✓
A101 Rotherhithe Tunnel	882	1210	37%	328	**10.1**	x
A102 Blackwall Tunnel	3424	3609	5%	185	**3.1**	✓
Woolwich Ferry	191	198	4%	8	**0.5**	✓
A282 Dartford Crossing	4879	5511	13%	631	**8.8**	x
TOTAL	**11264**	**12483**	**11%**	**1220**	**11.2**	x

Table 10.4 below details how many sites on each screenline and enclosure by direction and time period meet the validation criteria given in **Chapter 2**. The same information is provided for the additional locations decided upon after consultation with TfL and the London Boroughs. Motorway counts are included in a single screenline only, namely GreatEastern (east), so results for this screenline with and without motorway counts are included in the table below. These comparisons exclude ‘gap’ counts, because these links were not actually counted.

Table 10.4: Validation Summary (Total vehs)

			AM		IP		PM	
Screenline	Direction	No of sites	Within % / abs	With GEH < 5	Within % / abs	With GEH < 5	Within % / abs	With GEH < 5
Barking E-W	NB	6	50%	83%	83%	83%	67%	67%
Barking E-W	SB	6	100%	100%	100%	100%	33%	50%
Barking N-S	WB	12	75%	58%	75%	75%	67%	58%
Barking N-S	EB	12	83%	75%	92%	100%	75%	75%
Bexley E-W	NB	9	100%	89%	78%	67%	78%	89%
Bexley E-W	SB	10	70%	70%	60%	70%	60%	30%
Bexley N-S	WB	15	73%	67%	87%	73%	80%	80%
Bexley N-S	EB	15	73%	67%	87%	73%	60%	67%
Deptford	WB	5	60%	40%	100%	100%	40%	40%
Deptford	EB	5	60%	60%	80%	80%	20%	20%
Eltham North	WB	6	100%	67%	67%	67%	67%	83%
Eltham North	EB	6	67%	83%	100%	83%	50%	50%
Eltham South	WB	7	29%	57%	71%	71%	43%	57%
Eltham South	EB	7	57%	71%	100%	100%	43%	43%
GreatEastern (east)	NB	25	64%	52%	76%	64%	56%	52%
GreatEastern (east)	SB	25	64%	64%	80%	68%	72%	64%
GreatEastern (east) except Mways	NB	24	63%	50%	75%	63%	54%	50%
GreatEastern (east) except Mways	SB	24	63%	63%	79%	67%	71%	67%
GreatEastern (west)	NB	14	79%	64%	93%	86%	64%	64%
GreatEastern (west)	SB	15	73%	53%	87%	67%	73%	60%
Hackney North	WB	11	64%	55%	73%	55%	100%	82%
Hackney North	EB	10	90%	80%	100%	80%	70%	60%
HaroldHillN-S	WB	7	43%	43%	71%	57%	57%	57%
HaroldHillN-S	EB	7	57%	43%	71%	71%	43%	43%
Homerton	NB	6	67%	50%	50%	83%	50%	50%
Homerton	SB	6	50%	33%	33%	33%	50%	50%
Inner North	WB	6	83%	83%	83%	83%	67%	67%

Screenline	Direction	No of sites	AM Within % / abs	AM With GEH < 5	IP Within % / abs	IP With GEH < 5	PM Within % / abs	PM With GEH < 5
Inner North	EB	6	67%	83%	83%	83%	50%	50%
LewishamDartford (east)	NB	14	57%	64%	86%	93%	93%	93%
LewishamDartford (east)	SB	14	64%	57%	86%	79%	71%	71%
LewishamDartford (west)	NB	11	73%	73%	64%	82%	55%	55%
LewishamDartford (west)	SB	11	91%	82%	82%	91%	91%	91%
Ravensbourne	WB	4	75%	75%	75%	75%	100%	100%
Ravensbourne	EB	4	100%	100%	100%	100%	100%	75%
River Screenline	NB	7	86%	100%	71%	71%	57%	57%
River Screenline	SB	7	57%	57%	71%	86%	71%	71%
RiverRom	WB	10	60%	60%	100%	90%	100%	90%
RiverRom	EB	9	56%	78%	89%	89%	78%	89%
Screenline A	EB	9	67%	56%	100%	100%	33%	44%
Screenline A	WB	9	67%	56%	44%	44%	78%	78%
Screenline C	NB	15	87%	73%	87%	87%	80%	67%
Screenline C	SB	15	87%	80%	100%	93%	60%	60%
Screenline D	EB	2	100%	100%	100%	100%	100%	50%
Screenline D	WB	2	100%	100%	100%	100%	100%	100%
Screenline E	NB	7	100%	57%	86%	71%	71%	71%
Screenline E	SB	7	86%	71%	86%	71%	71%	57%
Screenline F	EB	4	100%	100%	100%	100%	75%	75%
Screenline F	WB	4	75%	75%	100%	100%	100%	100%
Screenline G	NB	7	71%	57%	100%	86%	100%	86%
Screenline G	SB	7	100%	71%	100%	86%	100%	86%
Sidcup	NB	11	64%	64%	64%	73%	64%	73%
Sidcup	SB	11	55%	45%	45%	55%	55%	55%
West of A406	WB	11	73%	73%	73%	73%	36%	55%
West of A406	EB	11	55%	55%	82%	82%	45%	36%
Whitechapel	WB	9	78%	78%	89%	89%	89%	89%
Whitechapel	EB	8	100%	75%	75%	75%	63%	63%
Boundary S	NB	7	71%	57%	57%	57%	71%	71%
Boundary S	SB	7	86%	86%	86%	86%	57%	57%
Total Screenline count sites (by direction)		**513**	**72%**	**67%**	**81%**	**78%**	**67%**	**65%**
Enclosures								
Barking	In	28	82%	64%	86%	79%	68%	36%

Screenline	Direction	No of sites	AM Within % / abs	AM With GEH < 5	IP Within % / abs	IP With GEH < 5	PM Within % / abs	PM With GEH < 5
Barking	Out	29	76%	55%	79%	62%	62%	55%
Barkingside	In	27	59%	37%	81%	63%	56%	56%
Barkingside	Out	27	70%	56%	89%	63%	81%	59%
Bexley	In	11	55%	64%	82%	73%	64%	55%
Bexley	Out	11	64%	55%	91%	73%	55%	55%
Canary Wharf	In	6	67%	50%	67%	50%	33%	33%
Canary Wharf	Out	6	33%	33%	50%	33%	33%	33%
Harold Hill	In	16	63%	50%	88%	69%	50%	44%
Harold Hill	Out	16	69%	56%	81%	69%	75%	69%
Hornchurch	In	14	64%	64%	79%	79%	64%	64%
Hornchurch	Out	14	79%	79%	86%	79%	64%	64%
Lewisham	In	41	85%	56%	93%	73%	68%	56%
Lewisham	Out	40	80%	68%	85%	63%	75%	55%
Stepney	In	34	85%	59%	88%	47%	79%	47%
Stepney	Out	35	94%	63%	91%	71%	80%	54%
Stratford	In	19	63%	53%	74%	63%	74%	53%
Stratford	Out	19	79%	68%	68%	53%	79%	63%
Swanley	In	13	77%	62%	92%	69%	85%	54%
Swanley	Out	13	92%	69%	100%	69%	85%	69%
Woolwich	In	23	96%	74%	87%	78%	78%	61%
Woolwich	Out	24	71%	50%	96%	75%	88%	75%
Total Enclosure count sites (by direction)		**466**	**77%**	**59%**	**85%**	**67%**	**71%**	**56%**
Total Borough Counts (by direction)		**104**	**81%**	**82%**	**88%**	**84%**	**74%**	**72%**

Of the counts located on the screenlines, some 65% to 81% meet the required criteria of flow difference or GEH, with the interpeak having the highest percentages. The statistics for the counts on the enclosure boundaries range from 56% through to 85% with the interpeak again having the highest percentages. The borough counts have the highest percentages with the interpeak flow differences meeting the acceptability guideline of 85% or more achieving either or both of the criteria. The interpeak GEH statistics are just outside the required 85% at 84%, as are the flow differences and GEHs in the AM peak at 81% and 82%.

As a consequence of the River Crossing screenline flow results, it was decided to include the River Thames screenline in the matrix estimation process to ensure that these flows were accurately represented by the model.

10.3.2 Matrix estimation with all counts included in ME

Tables 10.5 – 10.7 compare the modelled flows with the River Thames included in matrix estimation against the count data for the River Thames crossings in the key area of interest. The tables show that traffic using Blackwall Tunnel is well represented in both directions and all three time periods.

In the AM Peak the southbound crossings now meet the WebTAG criteria both individually and as a total screenline and the total modelled northbound flow is not as high as previously. In the interpeak all links in both directions as well as total screenline flow now meet either or both of the criteria. In the PM Peak, only one northbound link does not meet the required criteria but the GEH is only just outside the criterion at 5.1. In the southbound direction four of the crossings and the total screenline flow do not meet either the flow or GEH criteria.

Table 10.5: Observed and modelled flows across the Thames screenline AM Peak (by direction)

Northbound	Observed (vehs)	Modelled (vehs)	% diff	abs diff	GEH	meet flow or GEH criteria
Southwark Bridge	270	298	10%	28	1.7	✓
London Bridge	712	679	-5%	-33	1.3	✓
Tower Bridge	841	1033	23%	192	6.3	x
A101 Rotherhithe Tunnel	862	986	14%	124	4.1	✓
A102 Blackwall Tunnel	2893	3018	4%	125	2.3	✓
Woolwich Ferry	126	127	1%	1	0.1	✓
A282 Dartford Crossing	4376	4533	4%	157	2.4	✓
TOTAL	**10078**	**10674**	**6%**	**596**	**5.9**	**x**

Southbound	Observed (vehs)	Modelled (vehs)	% diff	abs diff	GEH	meet flow or GEH criteria
Southwark Bridge	244	304	25%	60	3.6	✓
London Bridge	718	672	-6%	-46	1.7	✓
Tower Bridge	819	828	1%	9	0.3	✓
A101 Rotherhithe Tunnel	858	790	-8%	-68	2.4	✓
A102 Blackwall Tunnel	2620	2558	-2%	-62	1.2	✓
Woolwich Ferry	136	123	-10%	-13	1.1	✓
A282 Dartford Crossing	4573	4548	-1%	-25	0.4	✓
TOTAL	**9967**	**9824**	**-1%**	**-143**	**1.4**	**✓**

Table 10.6: Observed and modelled flows across the Thames screenline Inter Peak (by direction)

Northbound	Observed (vehs)	Modelled (vehs)	% diff	abs diff	GEH	meet flow or GEH criteria
Southwark Bridge	248	194	-22%	-54	3.6	✓
London Bridge	715	690	-3%	-25	0.9	✓
Tower Bridge	798	800	0%	2	0.1	✓
A101 Rotherhithe Tunnel	762	758	-1%	-4	0.1	✓
A102 Blackwall Tunnel	2582	2623	2%	41	0.8	✓
Woolwich Ferry	120	117	-3%	-3	0.3	✓
A282 Dartford Crossing	3924	3925	0%	1	0.0	✓
TOTAL	**9149**	**9106**	**0%**	**-43**	**0.5**	**✓**

Southbound	Observed (vehs)	Modelled (vehs)	% diff	abs diff	GEH	meet flow or GEH criteria
Southwark Bridge	252	276	10%	24	1.5	✓
London Bridge	712	701	-2%	-11	0.4	✓
Tower Bridge	785	781	-1%	-4	0.1	✓
A101 Rotherhithe Tunnel	578	570	-1%	-8	0.3	✓
A102 Blackwall Tunnel	2684	2772	3%	88	1.7	✓
Woolwich Ferry	135	107	-21%	-28	2.5	✓
A282 Dartford Crossing	3797	3914	3%	117	1.9	✓
TOTAL	**8943**	**9121**	**2%**	**178**	**1.9**	**✓**

Table 10.7: Observed and modelled flows across the Thames screenline PM Peak (by direction)

Northbound	Observed (vehs)	Modelled (vehs)	% diff	abs diff	GEH	meet flow or GEH criteria
Southwark Bridge	223	153	-31%	-70	5.1	x
London Bridge	779	740	-5%	-39	1.4	✓
Tower Bridge	844	743	-12%	-101	3.6	✓
A101 Rotherhithe Tunnel	1002	1059	6%	57	1.8	✓
A102 Blackwall Tunnel	2827	2820	0%	-7	0.1	✓
Woolwich Ferry	160	122	-24%	-38	3.2	✓
A282 Dartford Crossing	4755	4781	1%	26	0.4	✓
TOTAL	**10590**	**10419**	**-2%**	**-171**	**1.7**	**✓**

Southbound	Observed (vehs)	Modelled (vehs)	% diff	abs diff	GEH	meet flow or GEH criteria
Southwark Bridge	258	246	-5%	-12	0.8	✓
London Bridge	751	918	22%	167	5.8	x
Tower Bridge	878	1084	23%	206	6.6	x
A101 Rotherhithe Tunnel	882	1210	37%	328	10.1	x
A102 Blackwall Tunnel	3424	3595	5%	171	2.9	✓
Woolwich Ferry	191	192	1%	1	0.1	✓
A282 Dartford Crossing	4879	5493	13%	614	8.5	x
TOTAL	**11264**	**12738**	13%	1474	13.5	x

Table 10.8 below details how many sites on each screenline and enclosure by direction and time period meet the WebTAG flow and GEH criteria detailed in Chapter 2. The same information is provided for the additional locations decided upon after consultation with TfL and the London Boroughs. Motorway counts are included in a single screenline only, namely GreatEastern (east), so results for this screenline with and without motorway counts are included in the table below.

Table 10.8: Validation Summary (Total vehs)

			AM		IP		PM	
Screenline	Direction	No of sites	Within % / abs	With GEH < 5	Within % / abs	With GEH < 5	Within % / abs	With GEH < 5
Barking E-W	NB	6	50%	83%	83%	83%	67%	67%
Barking E-W	SB	6	100%	100%	100%	100%	50%	67%
Barking N-S	WB	12	75%	50%	75%	75%	67%	58%
Barking N-S	EB	12	92%	75%	92%	100%	75%	75%
Bexley E-W	NB	9	100%	89%	78%	67%	78%	78%
Bexley E-W	SB	10	80%	80%	60%	70%	60%	30%
Bexley N-S	WB	15	73%	67%	87%	73%	80%	80%
Bexley N-S	EB	15	73%	60%	87%	73%	60%	67%
Deptford	WB	5	60%	60%	100%	100%	60%	40%
Deptford	EB	5	60%	60%	80%	80%	20%	20%
Eltham North	WB	6	100%	83%	67%	67%	83%	83%
Eltham North	EB	6	50%	83%	100%	83%	50%	50%
Eltham South	WB	7	43%	57%	71%	71%	43%	43%
Eltham South	EB	7	57%	71%	100%	100%	43%	43%
GreatEastern (east)	NB	25	60%	56%	76%	64%	56%	52%
GreatEastern (east)	SB	25	64%	68%	80%	68%	72%	64%
GreatEastern (east) except Mways	NB	24	58%	54%	75%	63%	54%	50%
GreatEastern (east) except	SB	24	63%	67%	79%	67%	71%	67%

			AM		IP		PM	
Screenline	Direction	No of sites	Within % / abs	With GEH < 5	Within % / abs	With GEH < 5	Within % / abs	With GEH < 5
Mways								
GreatEastern (west)	NB	14	79%	64%	93%	86%	64%	64%
GreatEastern (west)	SB	15	73%	53%	87%	67%	73%	60%
Hackney North	WB	11	82%	55%	73%	45%	100%	82%
Hackney North	EB	10	90%	70%	100%	80%	70%	60%
HaroldHillN-S	WB	7	43%	43%	71%	71%	57%	57%
HaroldHillN-S	EB	7	43%	43%	71%	71%	57%	43%
Homerton	NB	6	67%	50%	67%	67%	50%	67%
Homerton	SB	6	50%	33%	50%	33%	67%	67%
Inner North	WB	6	83%	67%	83%	83%	67%	67%
Inner North	EB	6	83%	83%	83%	83%	50%	50%
LewishamDartford (east)	NB	14	50%	64%	93%	93%	86%	93%
LewishamDartford (east)	SB	14	64%	57%	79%	71%	71%	71%
LewishamDartford (west)	NB	11	73%	64%	64%	91%	55%	55%
LewishamDartford (west)	SB	11	91%	82%	73%	91%	91%	91%
Ravensbourne	WB	4	75%	75%	75%	75%	100%	100%
Ravensbourne	EB	4	100%	100%	100%	100%	100%	75%
River Screenline	NB	7	86%	86%	100%	100%	100%	86%
River Screenline	SB	7	100%	100%	100%	100%	43%	43%
RiverRom	WB	10	60%	60%	100%	90%	100%	90%
RiverRom	EB	9	67%	78%	89%	89%	89%	89%
Screenline A	EB	9	67%	67%	100%	100%	22%	33%
Screenline A	WB	9	67%	56%	56%	44%	78%	78%
Screenline C	NB	15	87%	73%	87%	80%	80%	60%
Screenline C	SB	15	87%	87%	100%	100%	60%	60%
Screenline D	EB	2	100%	100%	100%	100%	100%	50%
Screenline D	WB	2	100%	100%	100%	100%	100%	100%
Screenline E	NB	7	100%	57%	86%	86%	71%	71%
Screenline E	SB	7	86%	71%	86%	71%	71%	57%
Screenline F	EB	4	100%	100%	100%	100%	75%	75%
Screenline F	WB	4	75%	75%	100%	100%	100%	100%
Screenline G	NB	7	71%	57%	100%	86%	100%	86%
Screenline G	SB	7	100%	86%	100%	86%	100%	86%
Sidcup	NB	11	64%	64%	64%	73%	73%	64%
Sidcup	SB	11	36%	36%	45%	45%	55%	45%
West of A406	WB	11	64%	64%	73%	73%	36%	45%
West of A406	EB	11	55%	55%	82%	82%	45%	36%

Screenline	Direction	No of sites	AM Within % / abs	AM With GEH < 5	IP Within % / abs	IP With GEH < 5	PM Within % / abs	PM With GEH < 5
Whitechapel	WB	9	78%	78%	89%	78%	78%	78%
Whitechapel	EB	8	100%	75%	75%	75%	63%	75%
Boundary S	NB	7	71%	71%	57%	57%	71%	71%
Boundary Sl	SB	7	86%	86%	86%	86%	57%	57%
Total Screenline count sites (by direction)		**513**	**73%**	**67%**	**82%**	**78%**	**68%**	**65%**
Enclosures								
Barking	In	28	82%	64%	89%	82%	71%	36%
Barking	Out	29	76%	55%	83%	62%	72%	55%
Barkingside	In	27	59%	41%	81%	63%	56%	56%
Barkingside	Out	27	67%	52%	89%	63%	81%	56%
Bexley	In	11	55%	64%	82%	73%	64%	55%
Bexley	Out	11	64%	55%	91%	73%	55%	55%
Canary Wharf	In	6	67%	50%	67%	67%	17%	33%
Canary Wharf	Out	6	33%	33%	50%	33%	50%	33%
Harold Hill	In	16	56%	50%	88%	69%	56%	38%
Harold Hill	Out	16	63%	56%	81%	75%	75%	69%
Hornchurch	In	14	64%	64%	79%	79%	64%	64%
Hornchurch	Out	14	79%	71%	86%	79%	64%	64%
Lewisham	In	41	83%	59%	93%	73%	66%	56%
Lewisham	Out	40	78%	68%	83%	63%	75%	58%
Stepney	In	34	85%	62%	88%	44%	79%	44%
Stepney	Out	35	94%	60%	91%	63%	80%	54%
Stratford	In	19	63%	53%	74%	63%	74%	53%
Stratford	Out	19	84%	68%	74%	58%	79%	63%
Swanley	In	13	77%	62%	92%	69%	85%	54%
Swanley	Out	13	92%	69%	100%	69%	85%	69%
Woolwich	In	23	96%	74%	91%	78%	78%	61%
Woolwich	Out	24	67%	50%	96%	75%	83%	75%
Total Enclosure count sites (by direction)		**466**	**76%**	**59%**	**86%**	**67%**	**72%**	**55%**
Total Borough Counts (by direction)		**104**	**82%**	**83%**	**88%**	**85%**	**77%**	**73%**

Of the counts located on the screenlines, some 65% to 82% meet the required criteria of flow difference or GEH, with the interpeak having the highest percentages. The statistics for the counts on the enclosure boundaries range from 55% through to 86% with the interpeak again having the highest percentages. The borough counts have the highest percentages with the interpeak flow differences meeting the acceptability guideline of 85% or more achieving either or both of the criteria. The AM peak flow difference and GEH percentages are just outside the acceptability guideline of 85%, at 82% and 83%.

10.4 Turning Count Validation

Comparisons of observed and modelled turning movements are shown in **Table 10.9** for the twelve junctions where it was possible to factor the counts to an average of the surveyed week in November 2012. The modelled flows are taken from the final version of the model (with all counts included in ME).

Table 10.9: Turning Count Comparison

		% meeting GEH criterion			% meeting flow criteria		
	Number of counted turns	AM	IP	PM	AM	IP	PM
A13 East India Dock Road / A1206 Cotton Street	6	33%	17%	50%	67%	50%	67%
A13 / A102 Movements at eastern side of junction	12	36%	58%	36%	67%	92%	75%
Silvertown Roundabout	6	67%	56%	50%	94%	100%	100%
Silvertown Way / Tidal Basin Road	6	50%	67%	33%	100%	100%	100%
A117 Woolwich Manor Way Ferndale Street	16	81%	81%	69%	100%	94%	88%
Ferry Approach/John Wilson Street/Church Street/Woolwich High Street	16	73%	60%	47%	94%	100%	94%
M25 J1A Site A	12	58%	58%	45%	83%	83%	73%
M25 J1A Site B	12	50%	44%	44%	75%	81%	81%
M25 J1B	12	8%	8%	17%	83%	75%	67%
M25 J3	36	78%	72%	58%	94%	92%	81%
M25 J30	16	44%	25%	25%	69%	75%	69%
A2203 Blackwall Lane / Milennium Way / Bugsby's Way Rbt	17	35%	59%	41%	82%	100%	88%
A13 East India Dock Road / A1206 Cotton Street	6	33%	17%	50%	67%	50%	67%
Total	**167**	**56%**	**55%**	**45%**	**85%**	**88%**	**81%**

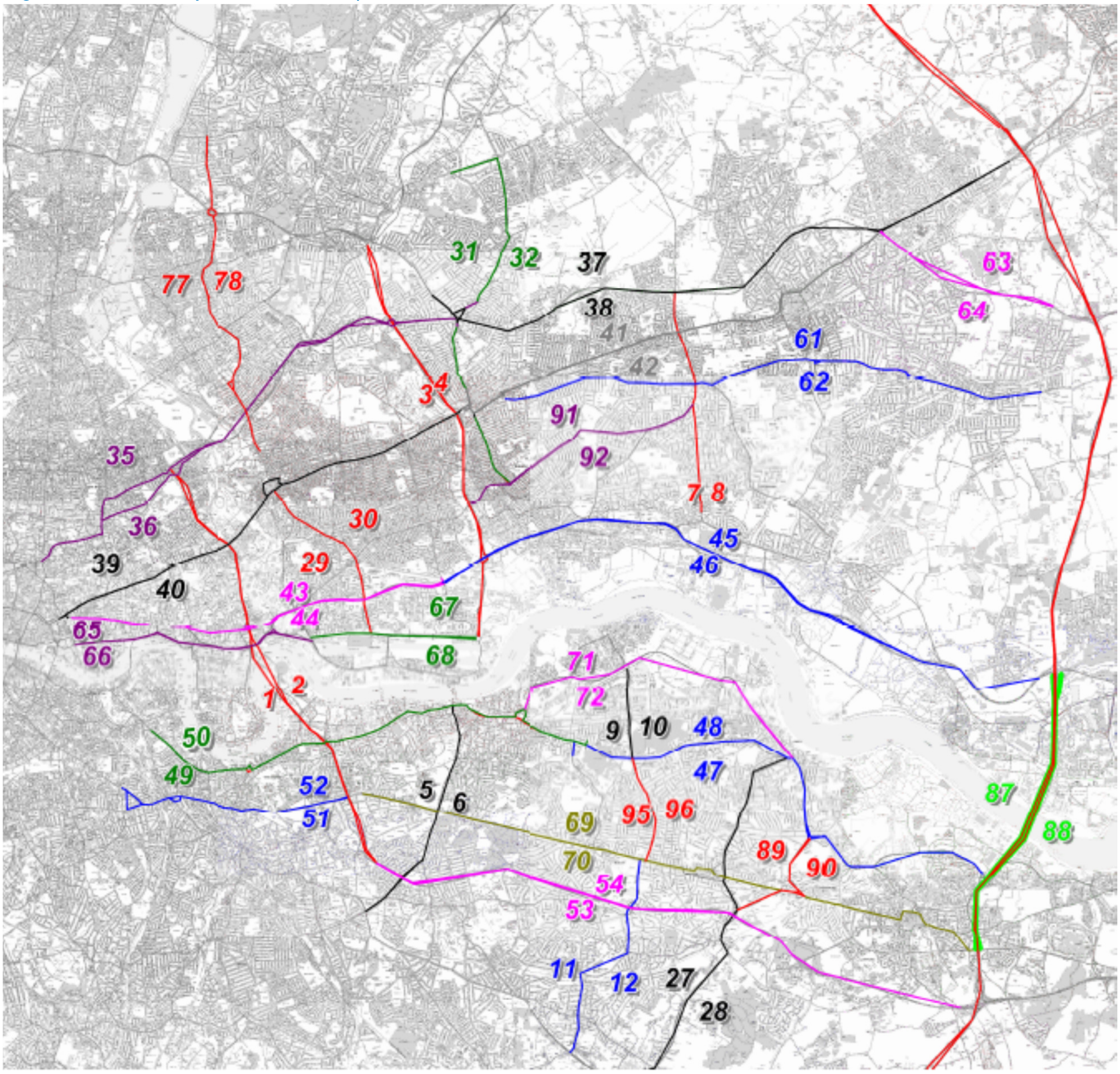
The table above shows that the modelled turning flows meet the required flow criteria in the AM and interpeak and are just outside the acceptability guideline of 85%, at 81% in the PM peak. WebTAG unit 3.19 section 3.2 recognises that achievement of the criteria is more difficult for turning movement flows.

10.5 Journey Time Validation

10.5.1 Matrix Estimation with River Thames screenline as validation

Modelled and observed journey times have been compared for the 62 one way journey time routes illustrated in **Figure 10.1.** The journey time acceptability guidelines in WebTAG specify that modelled times along routes should be within the criteria of 15% or 1 minute of the observed times (whichever the greater) for more than 85% of the routes. The model has been assessed against these criteria for the 62 one-way routes.

Figure 10.1: Journey Time Route Map



Of the 62 routes, 65% meet the required validation criteria in the AM Peak, 86% in the Interpeak and 66% in the PM peak. The following **Figures 10.2-10.4** summarise the journey time differences for each route and direction in each time period.

Journey time/distance graphs comparing observed and modelled journey times for the most significant routes (route 1 and 2 (Blackwall North bound and southbound) and routes 87 and 88 (Dartford crossing northbound and southbound)) are shown in **Appendix L.1.** Route 87 in the Interpeak does not meet the validation criteria with modelled journey times too slow and Route 1 in the PM does not meet the validation criteria with modelled journey times too fast.

Figure 10.2: Summary Journey Time Differences for AM peak model

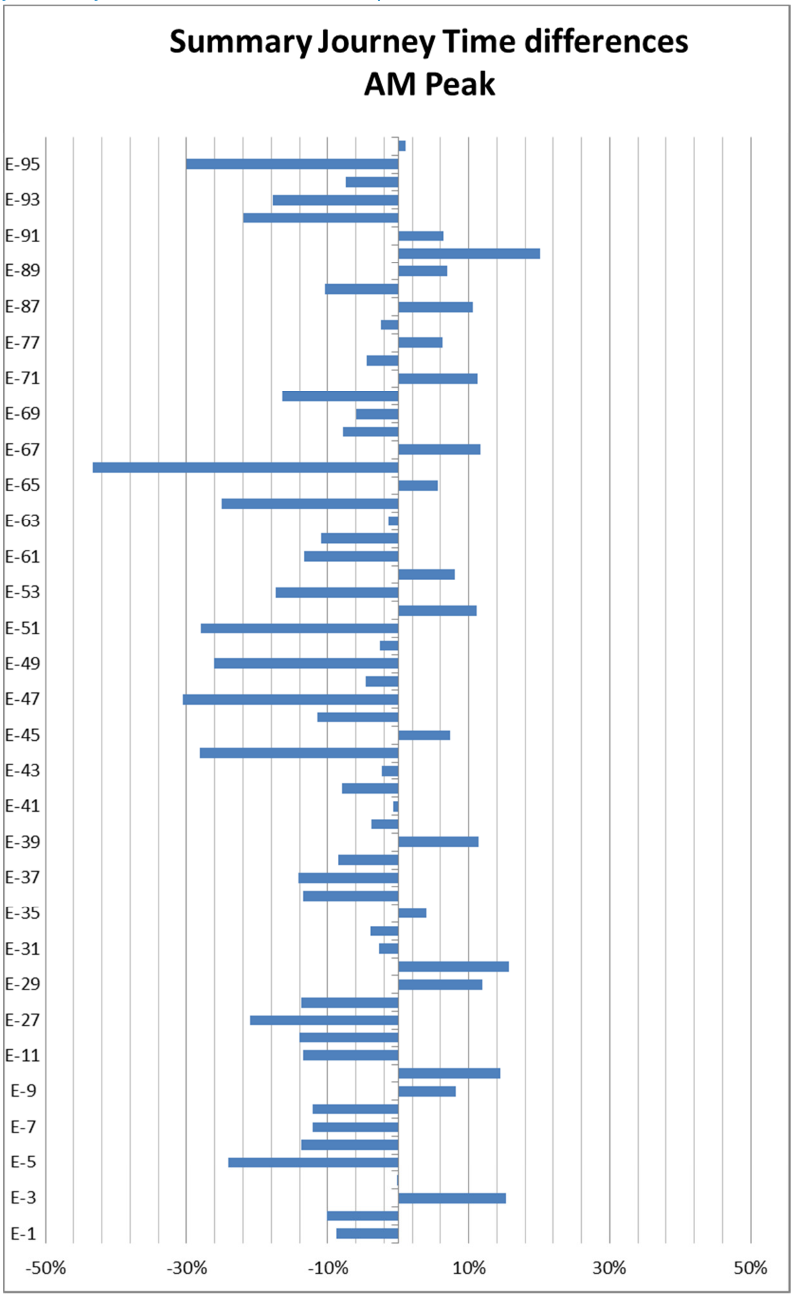


Figure 10.3: Summary Journey Time Differences for Interpeak model

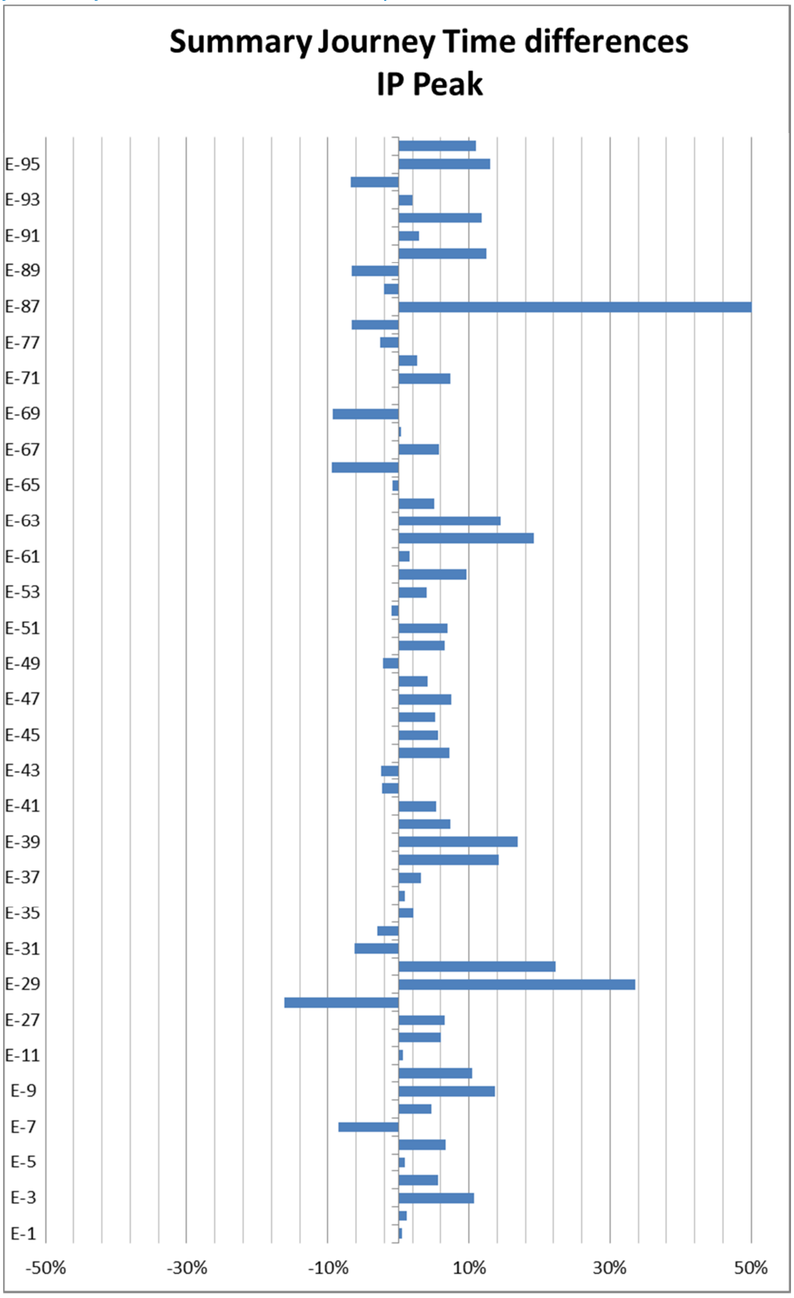
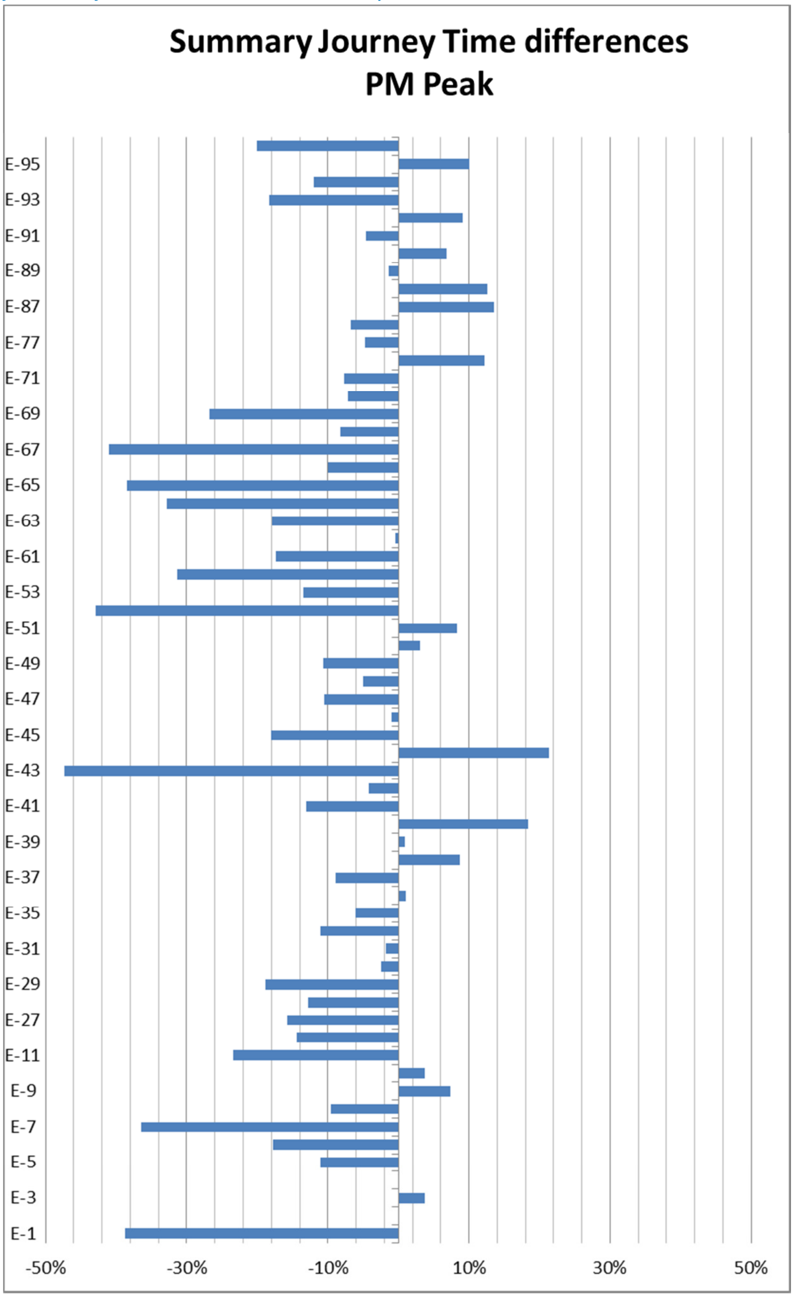


Figure 10.4: Summary Journey Time Differences for PM peak model



10.5.2 Matrix estimation with all counts

With the River Thames screenline counts included in matrix estimation, 76% of the journey time routes meet the required validation criteria in the AM Peak, 90% in the Interpeak and 68% in the PM peak. The following **Figures 10.5-10.7** summarise the journey time differences for each route and direction in each time period.

Journey time graphs comparing observed and modelled journey times for the most significant routes (route 1 and 2 (Blackwall northbound and southbound) and routes 87 and 88 (Dartford crossing northbound and southbound)) are shown in **Appendix L.2.** Both routes meet the required validation criteria in both directions and all time periods.

Figure 10.5: Summary Journey Time Differences for AM peak model

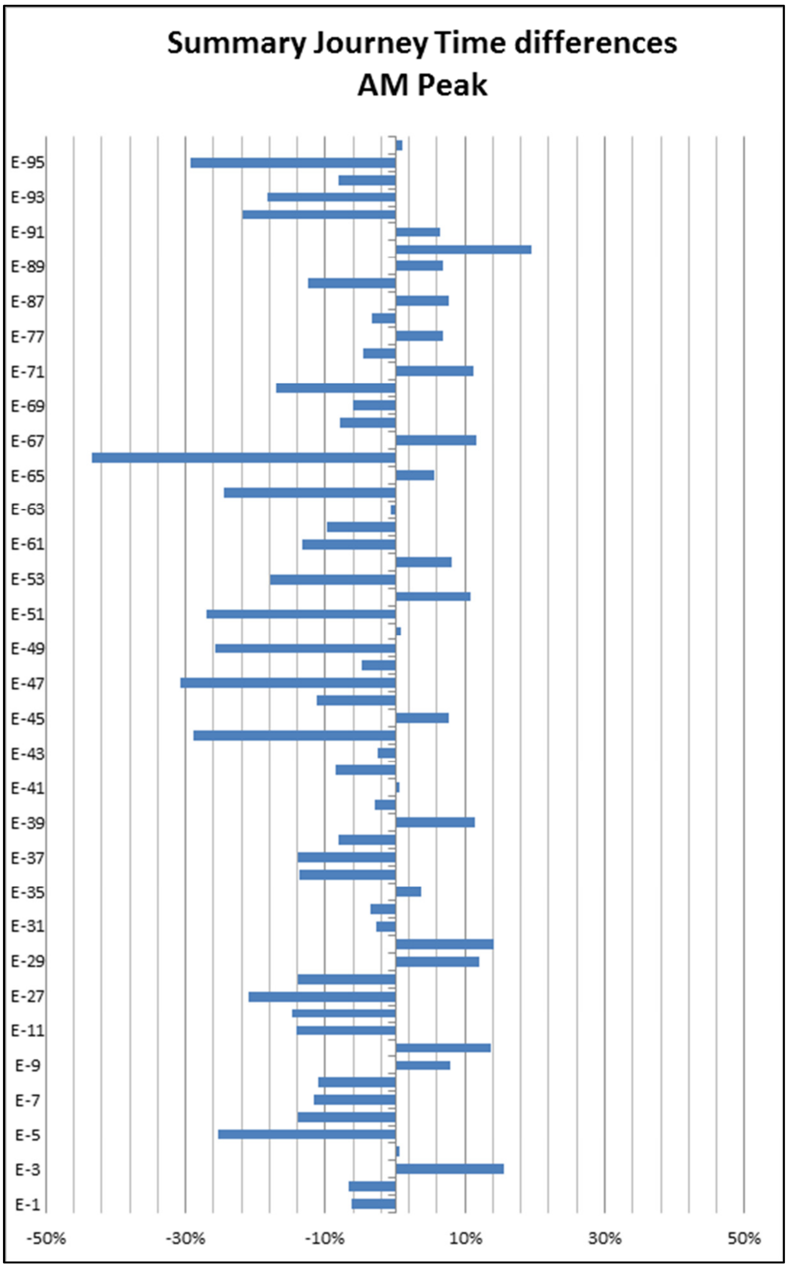


Figure 10.6: Summary Journey Time Differences for Interpeak model

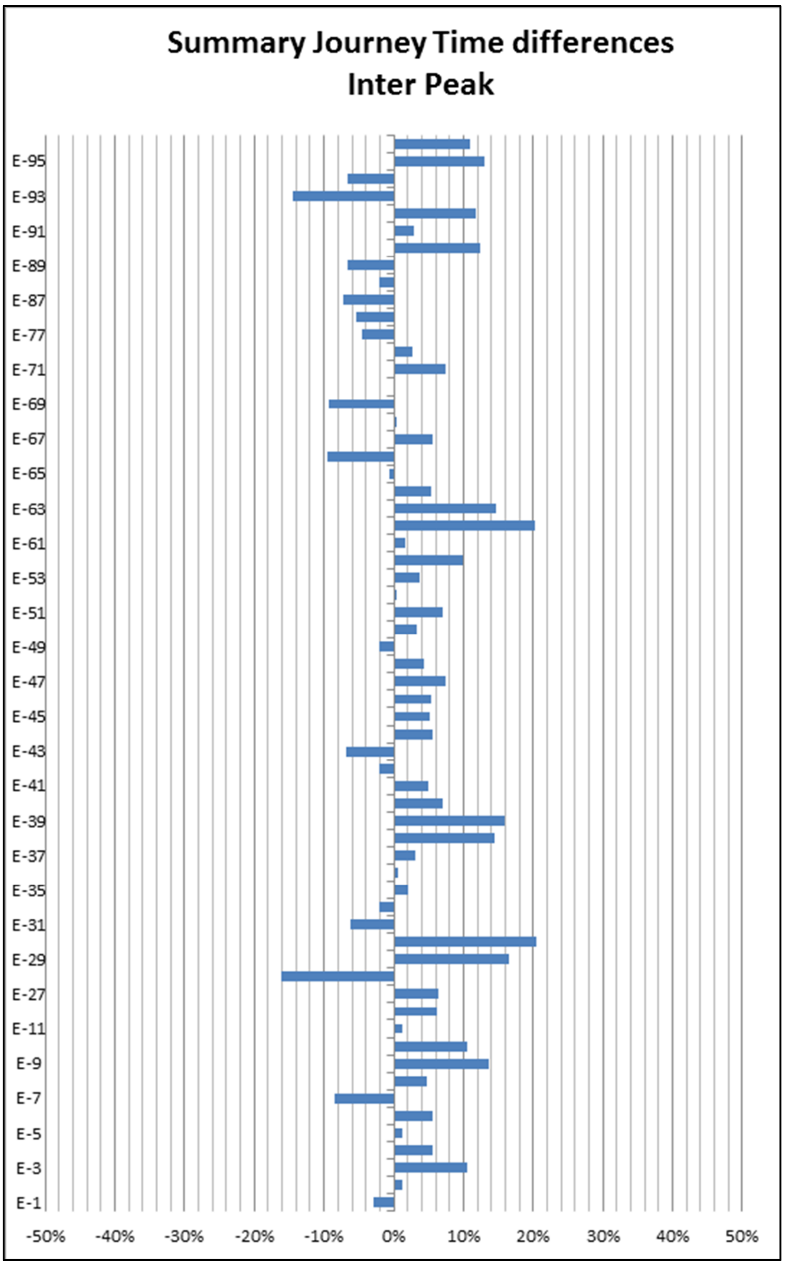
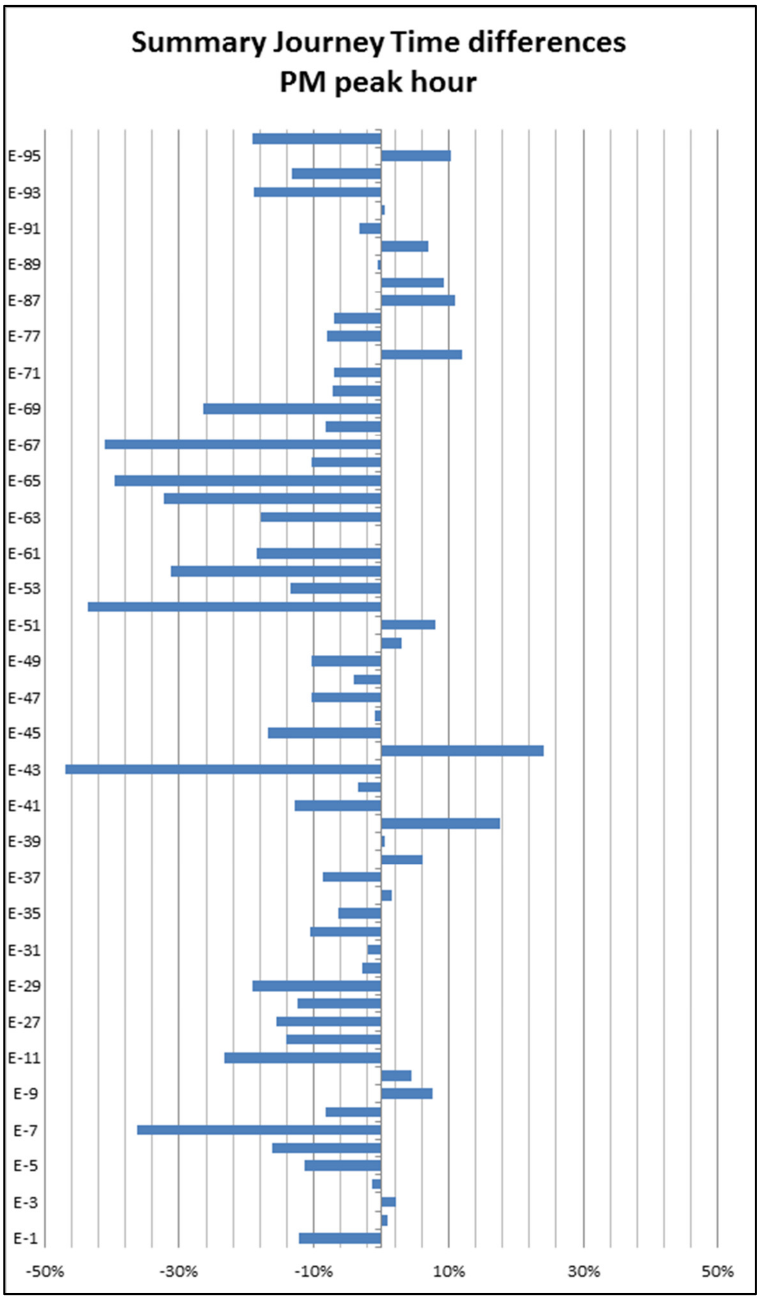


Figure 10.7: Summary Journey Time Differences for PM peak model



11 Income Segmentation

11.1 Income Segmentation Process

Following calibration and validation of the model, the final car out-of-work (OWT) matrices from the matrix estimation process with all counts included were segmented by income based on the proportions derived using an income segmentation process described in Mott MacDonald and Halcrow Technical Note 002, 23 April 2012 which is included as **Appendix M**.

The key process inputs are based on the following:

- The income segmentation proportions by purpose and trip length category (based on LATS Household interview data base);
- A matrix of crow-fly zone-to-zone trip lengths, calculated using the grid reference of each zone centroid;
- The base year LTS 6.2 car driver matrices by trip purpose; and
- The matrix of ELHAM base year car driver OWT trips, requiring disaggregation.

The OWT trips have been disaggregated into three different income bands defined as follows, in 2009 prices and 2012 values:

Group1: < £20,000

Group 2: £20,000 - £50,000

Group 3: > £50,000

The final proportions applied to the ELHAM matrices are summarised in **Table 11.1**.

Table 11.1: Income Group Proportions in ELHAM base year matrices

Income group	Excluding Central London and external			Total matrices		
	AM	IP	PM	AM	IP	PM
Group 1	24.8%	29.9%	26.8%	23.7%	28.2%	25.2%
Group 2	48.8%	45.5%	47.8%	48.8%	46.1%	48.0%
Group 3	26.4%	24.5%	25.4%	27.4%	25.7%	26.8%

11.2 Effect on Validation

River Crossing flows from a 7-user class assignment are shown in **Tables 11.2-11.4**, compared to those for the 5-user class assignment, and show that the flows are all within 2.5%. The income segmentation has therefore not had a significant effect on the validation.

Table 11.2: Modelled flows across the Thames screenline AM Peak (by direction)

Northbound	5 user classes (vehs)	7 user classes (vehs)	abs diff	Difference %
Southwark Bridge	298	298	0	0.0
London Bridge	679	690	11	1.6
Tower Bridge	1033	1044	11	1.1
A101 Rotherhithe Tunnel	986	994	8	0.8
A102 Blackwall Tunnel	3018	3021	3	0.0
Woolwich Ferry	127	127	0	0.0
A282 Dartford Crossing	4533	4530	-3	0.0
TOTAL	**10674**	**10705**	**29**	**0.3**

Southbound	5 user classes (vehs)	7 user classes (vehs)	abs diff	Difference %
Southwark Bridge	304	304	0	0.0
London Bridge	672	671	-1	0.0
Tower Bridge	828	836	8	1.0
A101 Rotherhithe Tunnel	790	792	2	0.3
A102 Blackwall Tunnel	2558	2569	11	0.4
Woolwich Ferry	123	122	-1	0.8
A282 Dartford Crossing	4548	4552	4	0.1
TOTAL	**9824**	**9847**	**23**	**0.2**

Table 11.3: Modelled flows across the Thames screenline Interpeak (by direction)

Northbound	5 user classes (vehs)	7 user classes (vehs)	abs diff	Difference %
Southwark Bridge	194	192	-2	-1
London Bridge	690	693	3	0.4
Tower Bridge	800	799	-1	-0.1
A101 Rotherhithe Tunnel	758	762	4	0.5
A102 Blackwall Tunnel	2623	2645	22	0.8
Woolwich Ferry	117	117	0	0.0
A282 Dartford Crossing	3925	3929	4	0.1
TOTAL	**9106**	**9137**	**31**	**0.1**

Southbound	5 user classes (vehs)	7 user classes (vehs)	abs diff	Difference %
Southwark Bridge	276	281	5	1.8
London Bridge	701	698	-3	-0.4
Tower Bridge	781	781	0	0.0
A101 Rotherhithe Tunnel	570	576	6	1.1
A102 Blackwall Tunnel	2772	2797	25	0.9
Woolwich Ferry	107	107	0	0.0
A282 Dartford Crossing	3914	3908	-6	0.2
TOTAL	**9121**	**9149**	**28**	**0.3**

Table 11.4: Modelled flows across the Thames screenline PM Peak (by direction)

Northbound	5 user classes (vehs)	7 user classes (vehs)	abs diff	Difference %
Southwark Bridge	153	149	-4	-2.3
London Bridge	740	738	-2	-0.3
Tower Bridge	743	755	12	1.6
A101 Rotherhithe Tunnel	1059	1048	-9	-0.8
A102 Blackwall Tunnel	2820	2835	15	0.5
Woolwich Ferry	122	122	0	0.0
A282 Dartford Crossing	4781	4890	109	2.3
TOTAL	**10419**	**10537**	**118**	**1.1**

Southbound	5 user classes (vehs)	7 user classes (vehs)	abs diff	Difference %
Southwark Bridge	246	247	1	0.4
London Bridge	918	913	-5	-0.5
Tower Bridge	1084	1074	-10	-0.9
A101 Rotherhithe Tunnel	1210	1210	0	0.0
A102 Blackwall Tunnel	3595	3593	-2	0.1
Woolwich Ferry	192	192	0	0.0
A282 Dartford Crossing	5493	5493	0	0.0
TOTAL	**12738**	**12722**	**-16**	**-0.1**

12 Summary

12.1 General

This report has documented the work undertaken to update and develop a base year model to test the case for new road crossings of the Thames in East London. The model needed to be able to represent traffic flows and journey times by time of day, trip purpose, and vehicle type on existing river crossings between Tower Bridge and Dartford and on roads which could be affected by new river crossing capacity.

The ELHAM 2009 base year model has been adapted and updated to a November 2012 base.

12.2 Geographic Scope

ELHAM has a simulation area which extends to and includes the M25 on the eastern side, across to Southwark Bridge in the west. The external area is coded as buffer. The simulation area is large enough to cover the areas where traffic flows could be affected by the proposed river crossing scheme which covers a large area due to the congested nature of the network, and this includes the London boroughs of Tower Hamlets, Newham, Hackney, Redbridge, Barking & Dagenham, Havering, Bexley, Greenwich, Lewisham and Waltham Forest.

12.3 Zoning System

ELHAM has 2448 zones covering the whole of the UK. The size of the zone decreases the closer to Greater London it is. Within Greater London the zone size reduces further in the ELHAM simulation area such that this area has the smallest zones.

12.4 Network Structure

Similar to the zoning system, the network structure covers the whole of the UK. Within the M25 all motorways, A roads, B roads and other key local roads are included. Outside of the M25 all motorways and A roads are included and closer to London but still outside of the M25 B roads are included in the network structure. Within the simulation area the network includes all roads from the ITN mapping database and many C roads and unclassified roads.

Within the simulation area capacity restraint has been primarily through the use of junction modelling. In addition, speed/flow curves were applied on motorways and grade-separated dual carriageways within this area. The 'Speed/Flow Area' includes no junction modelling (by definition) and includes speed/flow curves derived from LTS B6.0

12.5 Base Month and Year

The base year model is representative of average weekday traffic flows in November 2012.

12.6 Time Periods

This version of ELHAM represents the AM peak hour (08:00-09:00), PM peak hour (17:00-18:00) and an average Interpeak hour (between 10:00-16:00).

12.7 User Classes

There are seven user classes (after income segmentation) as follows

- Car out of work time - low income (represented with a PCU factor 1);
- Car out of work time - medium income (represented with a PCU factor 1);
- Car out of work time - high income (represented with a PCU factor 1);
- Car in work time (represented with a PCU factor 1);
- Taxi (Hackney carriage) (represented with a PCU factor 1);
- Light Goods Vehicle (represented with a PCU factor 1); and
- Other Goods Vehicle (represented with a PCU factor 2).

In addition, buses in ELHAM are assigned as fixed flows on set routes.

The calibration and validation was carried out at a five user class level, with the 3 income segments combined as one Cars OWT user class.

12.8 Trip Matrices

The starting point was the 2009 ELHAM peak period matrices for five user classes (in-work time or Employers' Business cars, out-of-work time cars, Taxis, LGVs and OGVs). These were synthetic matrices, before any matrix estimation was applied.

The synthetic matrices were constrained to updated origins and destinations (trip ends) and statistically reliable sector level movements derived from the partial trip matrices, which, in turn, had been created from the RSI survey data.

Matrices were then converted from 2009 to 2012 taking account of new housing and employment developments. These additional trips were added to the 2009 prior matrices to give initial 2012 prior matrices. These 2012 prior trip matrices were then multiplied by 1.03 to give the final 2012 prior trip matrices. This factor was based on work carried out by TfL which identified that the peak hour to peak period factors were likely to be under-estimated.

12.9 Assignment Methodology

Wardrop User equilibrium assignment method has been used for ELHAM with SATURN allowing the effects of blocking back and flow metering to be taken into account in the assignment.

12.10 Calibration and Validation

Two kinds of traffic data was collected for use in calibration and validation, namely traffic counts and journey times. Traffic counts were used in matrix estimation and validation with journey times used for network calibration and assignment validation.

12.11 Summary of Standards Achieved

Table 12.1 summarises the model's performance against the criteria in **Chapter 2**. These are the results for the runs that included the River Thames screenline in matrix estimation. The figures in brackets are the results for the runs that held back the River Thames screenline counts for validation.

Table 12.1: Validation Summary Statistics

Measure	Criteria	Acceptability Guidleine	AM Peak	Interpeak	PM Peak
Matrix Validation	Differences between modelled flows and observed counts should less than 5% when summed across a screenline.	All or nearly all screenlines	62% (56%)	89% (91%)	74% (75%)
Link Flow Validation	Individual flows within 100 veh/h of counts for flows less than 700 veh/h	> 85% of cases	75% (75%)	84% (84%)	71% (70%)
	Individual flows within 15% of counts for flows from 700 to 2,700 veh/h				
	Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h				
	GEH < 5 for individual flows	> 85% of cases	65% (65%)	74% (74%)	61% (62%)
Turning Flow Validation	Individual flows within 100 veh/h of counts for flows less than 700 veh/h	> 85% of cases	85%	88%	81%
	Individual flows within 15% of counts for flows from 700 to 2,700 veh/h				
	Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h				
	GEH < 5 for individual flows	> 85% of cases	56%	55%	45%
Journey Time validation	Modelled times along routes should be within 15% of surveyed times (or 1 minute, if higher)	> 85% of routes	76% (65%)	90% (86%)	68% (66%)

.

Appendices

Appendix A. AECOM TN10c – Cruise Speeds

Technical Note 10c: Cruise Speed Analysis

AECOM

Project:	**West London Regional Highway Assignment Model**	Job No:	**60096886**
Subject:	**Cruise Speed Analysis**		
Version:	**2**		
Prepared by:	**Nick Brock, Siu Law**	Date:	**08 June 2010**
Checked by:		Date:	
Approved by:		Date:	

1. Introduction

This note is additional to Technical Note 10, which describes the Journey Time Surveys and data processing conducted for the West London Highway Assignment Model (WeLoHAM). It presents an alternative analysis which determines the cruise speeds typical along each type of road link followed by the journey time surveys. In addition to the further analysis of the West London data, similar analyses were performed on data collected for the Central and North London models.

GPS based journey time data accurately records the survey vehicle's position every three seconds. The elapsed time and distances between each GPS 'fix' enables the average speed over the short interval to be calculated. In the analysis of the GPS data, each road link is allocated a 'Queue' speed based upon the speed limit. This enables a determination to be made of the locations where a vehicle is travelling relatively slowly such that it is more than likely to be in a queue. Queue speeds are higher on a motorway than on a suburban road. Cruise speeds have been calculated for the parts of each link where the vehicle speed is above the specified Queue speed by summing the relevant distances and times.

The links used in the cruise speed analysis were selected on the basis of an exercise to categorise each consistent section of the survey routes using six separate characteristics. Whenever a characteristic changed, this generated a timing point for the journey time analysis and a separate link in that route. A database containing the link characteristics and cruise speeds was created from which the range of speeds on links with identical characteristics could be generated. On the assumption that the observed cruise speeds for a particular link type were normally distributed, Student's distribution was used to determine the 95th percentile confidence interval of the true mean cruise speed, and the level of accuracy achieved in the estimation.

The cruise speeds by link category - as specified for each link in the WeLoHAM model - were compared to the results generated from the journey time survey data and were identified to either lie within or without the corresponding confidence intervals.

The purpose of this technical note is to set out the methodology and results of the cruise speed analysis.

2. Identification of Road Classes

The survey journey time routes stretched across different environments such as rural or urban areas and comprised of different road layouts and characteristics. Timing points were established where physical changes in the route presented.

The surveyed routes were assessed along their lengths using Google Earth (incorporating Google Streetview) and Streetmap. Streetmap provides the Ordnance Survey grid references essential for Journey Time processing. Transport for London (TfL) speed limit data was obtained where available.

The aerial view of Google Earth provides sufficient details to monitor changes in land separation, environment, road type, road layout and number of lanes. Google StreetView, which provides a driver's perspective, is particularly useful for checking more complex sections of the road network and/or checking speed limits. This procedure was undertaken for every route surveyed.

Where changes in network characteristics were observed, the precise locations of such changes were recorded with Ordnance Survey grid references within 5 metres accuracy. These coordinates were the Timing Points for the journey time processing. There was no limit on the number of Timing Point coordinates along any given route, which varied between a handful and several dozen.

The changes in the network taken into account are shown in Table 1.

Table 1 Network Characteristics Observed

Characteristic	Description	Values
No. of Lanes*	Changes in observed no. of lanes	1…6
Speed	Changes in observed speed limit	20, 30, 40, 50, 60 or 70 mph
Road Layout	Changes to road layout	Single C'way, Dual C'way, Slip Road, One way street
Road type	Changes in road type	Motorway, A Road, B Road, Unclassified Road
Environment	changes in landuse	Urban, Suburban, Shopping Street, Rural
Separation	changes in separation	At grade, grade separated (Dual C'ways only)
* In direction of travel		

Timing points and characteristics identified for a typical route are shown in Table 2.

Table 2 Example of a Journey Time Route

	CL_R12_NB						
OSGRE	**OSGRN**	**Lanes**	**Speed**	**Road Layout**	**Road type**	**Environment**	**Separation**
525723	177256	2	30	Single C'way	A Road	Urban	at grade
526055	177595	2	30	Single C'way	A Road	Shopping Street	at grade
526157	177709	1	30	Single C'way	A Road	Shopping Street	at grade
526990	178561	1	30	Single C'way	A Road	Urban	at grade
527159	179113	2	30	Single C'way	A Road	Shopping Street	at grade
527432	179368	1	30	Single C'way	A Road	Shopping Street	at grade
527575	179499	2	30	Single C'way	A Road	Shopping Street	at grade
529508	180626						

After the data had been processed using the specified timing points and queue speeds, the results output to Excel spreadsheets were translated into the MS Access Database format shown in Table 3. The survey lengths in the database format varied for each section between runs as the distance traversed at below the queue speed was deducted. Similarly, the times (shown) also excluded the periods deemed as spent in queues.

Table 3 Cruise Speed Database Input

Excel_File	Time_Period	Run_No	Run_Section	Length	Time	Lanes	Speed_Limit	Road_Layout	Road_Type	Environment	Separation
CL_R12_NB.xls	AM	1	1-2	0.423	00:00:40	2	30	Single C'way	A Road	Urban	at grade
CL_R12_NB.xls	AM	1	2-3	0.099	00:00:13	2	30	Single C'way	A Road	Shopping Street	at grade
CL_R12_NB.xls	AM	1	3-4	1.029	00:01:54	1	30	Single C'way	A Road	Shopping Street	at grade
CL_R12_NB.xls	AM	1	4-5	0.533	00:00:53	1	30	Single C'way	A Road	Urban	at grade
CL_R12_NB.xls	AM	1	5-6	0.357	00:00:44	2	30	Single C'way	A Road	Shopping Street	at grade
CL_R12_NB.xls	AM	1	6-7	0.196	00:00:16	1	30	Single C'way	A Road	Shopping Street	at grade
CL_R12_NB.xls	AM	1	7-8	1.899	00:03:07	2	30	Single C'way	A Road	Shopping Street	at grade
CL_R12_NB.xls	AM	2	1-2	0.446	00:00:39	2	30	Single C'way	A Road	Urban	at grade
CL_R12_NB.xls	AM	2	2-3	0.090	00:00:14	2	30	Single C'way	A Road	Shopping Street	at grade
CL_R12_NB.xls	AM	2	3-4	0.355	00:00:46	1	30	Single C'way	A Road	Shopping Street	at grade
CL_R12_NB.xls	AM	2	4-5	0.553	00:00:57	1	30	Single C'way	A Road	Urban	at grade
CL_R12_NB.xls	AM	2	5-6	0.303	00:00:42	2	30	Single C'way	A Road	Shopping Street	at grade
CL_R12_NB.xls	AM	2	6-7	0.195	00:00:18	1	30	Single C'way	A Road	Shopping Street	at grade
CL_R12_NB.xls	AM	2	7-8	1.992	00:03:06	2	30	Single C'way	A Road	Shopping Street	at grade
CL_R12_NB.xls	AM	3	1-2	0.449	00:00:51	2	30	Single C'way	A Road	Urban	at grade
CL_R12_NB.xls	AM	3	2-3	0.114	00:00:15	2	30	Single C'way	A Road	Shopping Street	at grade
CL_R12_NB.xls	AM	3	3-4	0.842	00:01:43	1	30	Single C'way	A Road	Shopping Street	at grade

3. Cruise Speed Database

All processed survey data from Central London, North London and West London were imported into the Cruise Speed Database. This comprised a total of 69 routes.

The six network characteristics were combined in MS Access queries to generate the list of link types covered by the combined Central, North and West journey time survey routes. For each link type the observed average speeds, standard deviations and 95% Confidence Intervals were calculated. There were a total of 116 separate link types observed.

The link types covered and the corresponding counts of individual cruise speed observations for each type are shown in Table 4. Comparisons of the observed speeds by time periods and survey areas are included in Appendix A.

Table 4 List of Observed Road Classes

Index	Road_Class	count	Average Cruise Speed (kph)
1	Rural_A-Road_Dual C'way_grade separated_3-lane_50mph	210	68
2	Rural_A-Road_Dual C'way_grade separated_3-lane_70mph	249	80
3	Rural_A-Road_One Way System_grade separated_3-lane_40mph	42	36
4	Rural_A-Road_Single C'way_at grade_1-lane_30mph	49	34
5	Rural_A-Road_Single C'way_at grade_1-lane_40mph	48	49
6	Rural_A-Road_Slip Road_at grade_1-lane_30mph	42	60
7	Rural_A-Road_Slip Road_grade separated_1-lane_30mph	117	56
8	Rural_A-Road_Slip Road_grade separated_1-lane_50mph	168	59
9	Rural_A-Road_Slip Road_grade separated_1-lane_70mph	122	74
10	Rural_A-Road_Slip Road_grade separated_2-lane_30mph	42	52
11	Rural_A-Road_Slip Road_grade separated_2-lane_50mph	163	63
12	Rural_A-Road_Slip Road_grade separated_2-lane_70mph	115	62
13	Rural_Motorway_Dual C'way_grade separated_2-lane_40mph	83	61
14	Rural_Motorway_Dual C'way_grade separated_2-lane_60mph	41	70
15	Rural_Motorway_Dual C'way_grade separated_3-lane_70mph	208	87
16	Rural_Motorway_Dual C'way_grade separated_4-lane_70mph	83	82

Index	Road_Class	count	Average Cruise Speed (kph)
17	Rural_Motorway_One Way System_at grade_3-lane_50mph	38	37
18	Rural_Motorway_One Way System_grade separated_3-lane_50mph	38	43
19	Rural_Motorway_Slip Road_grade separated_1-lane_60mph	41	71
20	Rural_Motorway_Slip Road_grade separated_2-lane_50mph	42	61
21	Rural_Motorway_Slip Road_grade separated_2-lane_60mph	122	62
22	Rural_Motorway_Slip Road_grade separated_2-lane_70mph	162	71
23	Rural_Motorway_Slip Road_grade separated_3-lane_50mph	42	48
24	Rural_Motorway_Slip Road_grade separated_3-lane_60mph	39	49
25	Shopping Street_A-Road_Dual C'way_at grade_2-lane_30mph	152	36
26	Shopping Street_A-Road_One Way System_at grade_1-lane_30mph	89	32
27	Shopping Street_A-Road_One Way System_at grade_2-lane_30mph	357	30
28	Shopping Street_A-Road_One Way System_at grade_3-lane_30mph	130	29
29	Shopping Street_A-Road_One Way System_at grade_4-lane_30mph	42	30
30	Shopping Street_A-Road_One Way System_at grade_5-lane_30mph	18	26
31	Shopping Street_A-Road_Single C'way_at grade_1-lane_30mph	4040	32
32	Shopping Street_A-Road_Single C'way_at grade_2-lane_30mph	971	32
33	Shopping Street_A-Road_Single C'way_at grade_3-lane_30mph	78	33
34	Shopping Street_B-Road_Single C'way_at grade_1-lane_30mph	18	34
35	Suburban_A-Road_Dual C'way_at grade_1-lane_30mph	66	36
36	Suburban_A-Road_Dual C'way_at grade_1-lane_50mph	24	62
37	Suburban_A-Road_Dual C'way_at grade_2-lane_30mph	322	43
38	Suburban_A-Road_Dual C'way_at grade_2-lane_40mph	437	49
39	Suburban_A-Road_Dual C'way_at grade_2-lane_50mph	160	62
40	Suburban_A-Road_Dual C'way_at grade_2-lane_60mph	82	62
41	Suburban_A-Road_Dual C'way_at grade_3-lane_40mph	120	42
42	Suburban_A-Road_Dual C'way_at grade_3-lane_50mph	48	62
43	Suburban_A-Road_Dual C'way_grade separated_2-lane_40mph	84	47
44	Suburban_A-Road_Dual C'way_grade separated_2-lane_50mph	166	66
45	Suburban_A-Road_Dual C'way_grade separated_3-lane_50mph	81	60
46	Suburban_A-Road_One Way System_at grade_1-lane_40mph	24	38
47	Suburban_A-Road_One Way System_at grade_2-lane_30mph	24	39
48	Suburban_A-Road_One Way System_at grade_2-lane_40mph	21	36
49	Suburban_A-Road_One Way System_at grade_3-lane_40mph	102	33
50	Suburban_A-Road_One Way System_at grade_5-lane_40mph	22	31
51	Suburban_A-Road_One Way System_at grade_6-lane_40mph	71	34
52	Suburban_A-Road_One Way System_grade separated_2-lane_50mph	42	47
53	Suburban_A-Road_Single C'way_at grade_1-lane_30mph	1999	39
54	Suburban_A-Road_Single C'way_at grade_1-lane_40mph	606	47
55	Suburban_A-Road_Single C'way_at grade_1-lane_60mph	215	64
56	Suburban_A-Road_Single C'way_at grade_2-lane_30mph	283	41
57	Suburban_A-Road_Single C'way_at grade_2-lane_40mph	245	49
58	Suburban_A-Road_Slip Road_at grade_2-lane_30mph	24	50
59	Suburban_B-Road_Dual C'way_at grade_2-lane_30mph	128	46
60	Suburban_B-Road_Single C'way_at grade_1-lane_30mph	379	39
61	Suburban_B-Road_Single C'way_at grade_1-lane_60mph	77	57
62	Suburban_Motorway_Dual C'way_grade separated_3-lane_50mph	84	64
63	Suburban_Motorway_One Way System_grade separated_3-lane_50mph	41	56
64	Suburban_Unclassified Road_Single C'way_at grade_1-lane_30mph	83	35
65	Urban_A-Road_Dual C'way_at grade_1-lane_30mph	358	37
66	Urban_A-Road_Dual C'way_at grade_2-lane_30mph	963	40

Index	Road_Class	count	Average Cruise Speed (kph)
67	Urban_A-Road_Dual C'way_at grade_2-lane_40mph	720	47
68	Urban_A-Road_Dual C'way_at grade_2-lane_50mph	42	71
69	Urban_A-Road_Dual C'way_at grade_3-lane_30mph	378	42
70	Urban_A-Road_Dual C'way_at grade_3-lane_40mph	432	57
71	Urban_A-Road_Dual C'way_at grade_3-lane_50mph	103	65
72	Urban_A-Road_Dual C'way_grade separated_2-lane_30mph	86	49
73	Urban_A-Road_Dual C'way_grade separated_2-lane_40mph	212	55
74	Urban_A-Road_Dual C'way_grade separated_2-lane_50mph	126	64
75	Urban_A-Road_Dual C'way_grade separated_3-lane_40mph	335	55
76	Urban_A-Road_Dual C'way_grade separated_3-lane_50mph	373	68
77	Urban_A-Road_Dual C'way_grade separated_4-lane_50mph	24	70
78	Urban_A-Road_Dual C'way_grade separated_5-lane_50mph	48	74
79	Urban_A-Road_One Way System_at grade_1-lane_30mph	646	33
80	Urban_A-Road_One Way System_at grade_2-lane_20mph	16	29
81	Urban_A-Road_One Way System_at grade_2-lane_30mph	1371	35
82	Urban_A-Road_One Way System_at grade_2-lane_40mph	145	36
83	Urban_A-Road_One Way System_at grade_3-lane_30mph	746	32
84	Urban_A-Road_One Way System_at grade_3-lane_40mph	82	40
85	Urban_A-Road_One Way System_at grade_4-lane_30mph	208	30
86	Urban_A-Road_One Way System_at grade_5-lane_30mph	17	27
87	Urban_A-Road_One Way System_at grade_6-lane_30mph	42	27
88	Urban_A-Road_One Way System_at grade_6-lane_40mph	274	37
89	Urban_A-Road_One Way System_grade separated_1-lane_50mph	35	38
90	Urban_A-Road_One Way System_grade separated_2-lane_30mph	18	26
91	Urban_A-Road_One Way System_grade separated_2-lane_50mph	18	38
92	Urban_A-Road_Single C'way_at grade_1-lane_30mph	6793	36
93	Urban_A-Road_Single C'way_at grade_1-lane_40mph	393	43
94	Urban_A-Road_Single C'way_at grade_1-lane_50mph	41	52
95	Urban_A-Road_Single C'way_at grade_2-lane_30mph	2729	37
96	Urban_A-Road_Single C'way_at grade_2-lane_40mph	392	43
97	Urban_A-Road_Single C'way_at grade_3-lane_30mph	146	33
98	Urban_A-Road_Single C'way_Varies_2-lane_30mph	18	54
99	Urban_A-Road_Slip Road_at grade_2-lane_30mph	77	45
100	Urban_A-Road_Slip Road_grade separated_1-lane_30mph	24	41
101	Urban_A-Road_Slip Road_grade separated_1-lane_40mph	42	55
102	Urban_A-Road_Slip Road_grade separated_2-lane_30mph	42	54
103	Urban_A-Road_Slip Road_grade separated_2-lane_40mph	259	45
104	Urban_A-Road_Slip Road_grade separated_2-lane_50mph	294	52
105	Urban_B-Road_Dual C'way_at grade_2-lane_30mph	42	40
106	Urban_B-Road_Single C'way_at grade_1-lane_30mph	250	33
107	Urban_Motorway_Dual C'way_grade separated_2-lane_40mph	83	56
108	Urban_Motorway_Dual C'way_grade separated_4-lane_70mph	41	90
109	Urban_Motorway_Slip Road_grade separated_1-lane_40mph	41	47
110	Urban_Motorway_Slip Road_grade separated_1-lane_70mph	40	78
111	Urban_Motorway_Slip Road_grade separated_2-lane_40mph	41	51
112	Urban_Motorway_Slip Road_grade separated_2-lane_70mph	82	71
113	Urban_Other Road_One Way System_at grade_2-lane_30mph	81	33
114	Urban_Unclassified Road_One Way System_at grade_1-lane_30mph	10	42
115	Urban_Unclassified Road_One Way System_at grade_2-lane_30mph	12	28
116	Urban_Unclassified Road_Single C'way_at grade_1-lane_30mph	84	34

4. West London Highway Assignment Model (WeLoHAM) Link Types

The objective of the cruise speed analysis is to compare the speeds used in the West London Assignment Model with that of the observed for the comparable types of highways links.

With reference to TN14d, Table 5 shows the link types as defined in the WeLoHAM model and the counts of each coded in the model.

Table 5 WeLoHAM Link Types

Model Link Type	Link Description	Road Type	Speed Limit mph	Lanes	Cruise Speed kph	count
1131	A Road	A Rd	30	1	35	419
1132	A Road	A Rd	30	2	38	141
1133	A Road	A Rd	30	3	38	50
1134	A Road	A Rd	30	4	38	30
1135	A Road	A Rd	30	5	38	5
1136	A Road	A Rd	30	6	38	2
1141	A Road	A Rd	40	1	50	61
1142	A Road	A Rd	40	2	55	62
1143	A Road	A Rd	40	3	64	50
1144	A Road	A Rd	40	4	64	9
1151	A Road	A Rd	50	1	75	9
1152	A Road	A Rd	50	2	80	12
1153	A Road	A Rd	50	3	80	3
1161	A Road	A Rd	60	1	96	4
1231	A Road (Good)	A Rd	30	1	42	200
1232	A Road (Good)	A Rd	30	2	48	51
1233	A Road (Good)	A Rd	30	3	48	17
1234	A Road (Good)	A Rd	30	4	48	12
2121	B road	B Rd	20	1	28	7
2122	B road	B Rd	20	2	28	2
2131	B road	B Rd	30	1	32	500
2132	B road	B Rd	30	2	35	87
2133	B road	B Rd	30	3	35	15
2141	B road	B Rd	40	1	56	39
2142	B road	B Rd	40	2	61	12
2143	B road	B Rd	40	3	61	5
2151	B road	B Rd	50	1	77	5
3121	Other roads	Other Rd	20	1	26	216
3122	Other roads	Other Rd	20	2	26	5
3131	Other roads	Other Rd	30	1	24	956
3132	Other roads	Other Rd	30	2	24	10
3133	Other roads	Other Rd	30	3	26	2
4131	Major Shopping	Shopping Rd	30	1	25	103
4132	Major Shopping	Shopping Rd	30	2	28	23
5131	S2 Small Town-Typical	SCW	30	1	28	20
5132	Urban-Non-Central	SCW	30	2	28	3
5141	S2 Suburban	SCW	40	1	61	25
5142	S2 Good	SCW	40	2	64	2
5231	S2 Small Town-Typical (Good)	SCW	30	1	35	45

Model Link Type	Link Description	Road Type	Speed Limit mph	Lanes	Cruise Speed kph	count
5241	S2 Suburban Unclassified	SCW	40	1	57	4
5242	S4 Suburban	SCW	40	2	61	1
5331	S2 Urban-Non-Central	SCW	30	1	28	18
6131	D1AP Urban	DCW	30	1	35	3
6132	D2AP Suburban	DCW	30	2	35	36
6133	D3AP Suburban	DCW	30	3	47	11
6134	D4AP Suburban At-Grade	DCW	30	4	47	4
6141	D1AP Urban	DCW	40	1	44	4
6142	D2AP Urban	DCW	40	2	44	68
6143	D3AP Urban	DCW	40	3	44	32
6152	D2AP Suburban At-Grade	DCW	50	2	80	38
6153	D3AP Suburban Grade-Separated	DCW	50	3	85	49
6154	D4AP Suburban Grade-Separated	DCW	50	4	85	4
6155	D5AP Suburban Grade-Separated	DCW	50	5	85	1
6162	D2AP Suburban Grade-Separated (Good)	DCW	60	2	97	3
6163	D3AP Suburban Grade-Separated	DCW	60	3	96	6
6173	D3AP Suburban Grade-Separated	DCW	70	3	111	4
6231	D1AP Suburban	DCW	30	1	35	4
6241	D1AP Suburban	DCW	40	1	64	6
6242	D2AP Suburban	DCW	40	2	64	25
6243	D3AP Suburban	DCW	40	3	64	20
6244	D4AP Suburban At-Grade	DCW	40	4	64	2
6252	D2AP Suburban Grade-Separated (Average)	DCW	50	2	85	13
6342	D2AP Suburban (Bad)	DCW	40	2	58	1
6343	D3AP Suburban Grade-Separated	DCW	40	3	70	3
6352	D2AP Suburban Grade-Separated (Good)	DCW	50	2	85	1
6442	D2AP Suburban (Good)	DCW	40	2	64	57
6542	D2AP Suburban Grade-Separated (Bad)	DCW	40	2	70	7
7172	D2M	Motor way	70	2	104	4
7173	D3M	Motor way	70	3	109	8
7174	D4M	Motor way	70	4	109	2
8141	Slip-dual/motorway	Slip Rd	40	1	45	25
8151	Slip-dual/motorway	Slip Rd	50	1	80	9
8242	Slip-dual/motorway	Slip Rd	40	2	45	42
8252	Slip-dual/motorway	Slip Rd	50	2	80	22
8262	Slip-dual/motorway	Slip Rd	60	2	97	8

5. Matching Observed with Modelled Link Types

In order to compare the observed and modelled link speeds, queries were built in the MS Access Cruise Speed Database to select the observed road characteristics that matched, as closely as possible, the modelled link types, and hence calculate the corresponding observed average cruise speeds.

For example: for WeLoHAM A roads with various number of lanes and speed limits (types 1131 to 1161), with reference to the network characteristics listed in Table 1, relevant observed data were selected based on the criteria shown in Table 6.

Table 6 Select Query for Link Types 1131 to 1161

Road_Type	Road_Layout	Environment	Separation
A-Road	Not "Dual C'way"	Not "Shopping Street"	Not "grade separated"

The query produced a list of observed data fulfilling the above conditions which is summarised below in Table 7.

Table 7 Observed Data Fulfilling Query Criteria

Road_Type	Lanes	Speed_Limit	Road_Layout	Environment	Separation	CountOfRoad_Type
A-Road	1	30	One Way System	Urban	at grade	639
A-Road	1	30	Single C'way	Suburban	at grade	1982
A-Road	1	30	Single C'way	Urban	at grade	6772
A-Road	1	40	One Way System	Suburban	at grade	24
A-Road	1	40	Single C'way	Suburban	at grade	604
A-Road	1	40	Single C'way	Urban	at grade	393
A-Road	1	50	Single C'way	Urban	at grade	41
A-Road	1	60	Single C'way	Suburban	at grade	215
A-Road	2	20	One Way System	Urban	at grade	16
A-Road	2	30	One Way System	Suburban	at grade	24
A-Road	2	30	One Way System	Urban	at grade	1357
A-Road	2	30	Single C'way	Suburban	at grade	283
A-Road	2	30	Single C'way	Urban	at grade	2725
A-Road	2	30	Single C'way	Urban	Varies	18
A-Road	2	30	Slip Road	Suburban	at grade	24
A-Road	2	30	Slip Road	Urban	at grade	74
A-Road	2	40	One Way System	Suburban	at grade	21
A-Road	2	40	One Way System	Urban	at grade	144
A-Road	2	40	Single C'way	Suburban	at grade	245
A-Road	2	40	Single C'way	Urban	at grade	386
A-Road	3	30	One Way System	Urban	at grade	742
A-Road	3	30	Single C'way	Urban	at grade	146
A-Road	3	40	One Way System	Suburban	at grade	102
A-Road	3	40	One Way System	Urban	at grade	79
A-Road	4	30	One Way System	Urban	at grade	206
A-Road	5	30	One Way System	Urban	at grade	17
A-Road	5	40	One Way System	Suburban	at grade	21
A-Road	6	30	One Way System	Urban	at grade	42
A-Road	6	40	One Way System	Suburban	at grade	71
A-Road	6	40	One Way System	Urban	at grade	274

The selection was checked for validity for the model link types concerned. When necessary, separate queries were set up to ensure a robust calculation of observed average speeds for link types of particular network characteristics.

The results shown in Table 7 were summarised into Table 8 to correspond with the model link characteristics and average speed and confidence interval were calculated.

Table 8 Selected Observed Link Types Correspond to WeLoHAM types 1131 to 1161

Road_Type	Lanes	Speed_Limit mph	Average_Speed _kph	StdDevn_Speed _Kph	Count_of_Speed_Records
A-Road	1	30	36	6	9393
A-Road	1	40	45	9	1021
A-Road	1	50	52	3	41
A-Road	1	60	64	6	215
A-Road	2	20	29	6	16
A-Road	2	30	37	9	4505
A-Road	2	40	44	11	796
A-Road	3	30	32	8	888
A-Road	3	40	34	8	181
A-Road	4	30	31	6	206
A-Road	5	30	27	4	17
A-Road	5	40	33	6	21
A-Road	6	30	27	7	42
A-Road	6	40	36	6	345

The procedures of query design and selection summary were repeated to account for all modelled link types. The queries were designed principally based on the road types defined in the model. The categorisations of queries and the conditions applied for each are included in Appendix B.

6. Results of Cruise Speed Analysis

The results of comparing the modelled link cruise speeds with those of the observed are summarised in Table 9.

All defined link types were included, with a zero count for those that were not used in the WeLoHAM model. For some modelled link types no corresponding observed data was available, such as WeLoHAM Link Type 6173 (D3AP Suburban Grade-Separated of 70mph speed limit).

The 95% confidence limits for the true mean cruise speed, calculated using Student's t-distribution were also determined and a check undertaken to identify whether or not the modelled cruise speed lay within that confidence limit. The check revealed that the modelled cruise speed lay within the confidence limit for just two link types. As a result, it was decided to adopt the following method of result presentation.

The differences between modelled and observed were used to identify whether the current modelled values appeared to be either too low or too high. The variance with the observed is presented in 5 kph bands. For example: the modelled cruise speed for link type 1151 (A class road, 50 mph speed limit and one lane) of 75kph would appear, on the basis of the observed results, to be between 20 and 25 kph higher than empirical evidence suggests.

Detailed results of the analysis are included in Appendix B.

Table 9 Comparisons between Modelled and Observed Cruise Speeds

Model Link Type	Link Description	Road Type	Speed Limit (mph)	Lanes	Count of link type in model	Modelled Cruise Speed (kph)	Low by (kph)	High by (kph)
1131	A Road	A Rd	30	1	419	35	0-5	
1231	A Road (Good) Rural	A Rd	30	1	200	42	0-5	
1141	A Road	A Rd	40	1	61	50		0-5
1151	A Road	A Rd	50	1	9	75		20-25
1161	A Road	A Rd	60	1	4	96		30-35
1132	A Road	A Rd	30	2	141	38		0-5
1232	A Road (Good) Rural	A Rd	30	2	51	48		
1142	A Road	A Rd	40	2	62	55		10-15
1152	A Road	A Rd	50	2	12	80		
1162	A Road	A Rd	60	2	0	96		
1133	A Road	A Rd	30	3	50	38		5-10
1233	A Road (Good) Rural	A Rd	30	3	17	48		
1143	A Road	A Rd	40	3	50	64		30-35
1153	A Road	A Rd	50	3	3	80		
1134	A Road	A Rd	30	4	30	38		5-10
1234	A Road (Good) Rural	A Rd	30	4	12	48		
1144	A Road	A Rd	40	4	9	64		
1135	A Road	A Rd	30	5	5	38		10-15
1136	A Road	A Rd	30	6	2	38		10-15
2121	B road	B Rd	20	1	7	28		
2131	B road	B Rd	30	1	500	32	0-5	
2141	B road	B Rd	40	1	39	56		
2151	B road	B Rd	50	1	5	77		
2161	B road	B Rd	60	1	0	97		35-40
2122	B road	B Rd	20	2	2	28		
2132	B road	B Rd	30	2	87	35		
2142	B road	B Rd	40	2	12	61		
2152	B road	B Rd	50	2	0	77		
2162	B road	B Rd	60	2	0	97		
2123	B road	B Rd	20	3	0	28		
2133	B road	B Rd	30	3	15	35		
2143	B road	B Rd	40	3	5	61		
2153	B road	B Rd	50	3	0	80		
2163	B road	B Rd	60	3	0	97		
3121	Other roads	Other Rd	20	1	216	26		
3131	Other roads	Other Rd	30	1	956	24		
3122	Other roads	Other Rd	20	2	5	26		
3132	Other roads	Other Rd	30	2	10	24	5-10	
3133	Other roads	Other Rd	30	3	2	26		
4131	Major Shopping	Shopping Rd	30	1	103	25	5-10	
4132	Major Shopping	Shopping Rd	30	2	23	28	0-5	
4142	D2 Urban Shopping	Shopping Rd	40	2	0	38		
5121	S2 Urban Non-Central (Bad)	SCW	20	1	0	25		
5131	S2 Small Town-Typical	SCW	30	1	20	28	5-10	
5231	S2 Small Town-Typical (Good)	SCW	30	1	45	35	0-5	
5331	S2 Urban-Non-Central	SCW	30	1	18	28	5-10	

Model Link Type	Link Description	Road Type	Speed Limit (mph)	Lanes	Count of link type in model	Modelled Cruise Speed (kph)	Low by (kph)	High by (kph)
5141	S2 Suburban	SCW	40	1	25	61		10-15
5241	S2 Suburban Unclassified	SCW	40	1	4	57		10-15
5132	Urban-Non-Central	SCW	30	2	3	28	5-10	
5142	S2 Good	SCW	40	2	2	64		15-20
5242	S4 Suburban	SCW	40	2	1	61		10-15
5143	S6 Suburban	SCW	40	3	0	61		
6131	D1AP Urban	DCW	30	1	3	35	0-5	
6231	D1AP Suburban	DCW	30	1	4	35	0-5	
6141	D1AP Urban	DCW	40	1	4	44		
6241	D1AP Suburban	DCW	40	1	6	64		
6132	D2AP Suburban	DCW	30	2	36	35	5-10	
6142	D2AP Urban	DCW	40	2	68	44	5-10	
6242	D2AP Suburban	DCW	40	2	25	64		15-20
6342	D2AP Suburban (Bad)	DCW	40	2	1	58		5-10
6442	D2AP Suburban (Good)	DCW	40	2	57	64		15-20
6542	D2AP Suburban Grade-Separated (Bad)	DCW	40	2	7	70		20-25
6152	D2AP Suburban At-Grade	DCW	50	2	38	80		15-20
6252	D2AP Suburban Grade-Separated (Average)	DCW	50	2	13	85		15-20
6352	D2AP Suburban Grade-Separated (Good)	DCW	50	2	1	85		15-20
6162	D2AP Suburban Grade-Separated (Good)	DCW	60	2	3	97		
6172	D2AP Suburban Grade-Separated (Good)	DCW	70	2	0	111		
6133	D3AP Suburban	DCW	30	3	11	47		
6143	D3AP Urban	DCW	40	3	32	44	5-10	
6243	D3AP Suburban	DCW	40	3	20	64		20-25
6343	D3AP Suburban Grade-Separated	DCW	40	3	3	70		
6153	D3AP Suburban Grade-Separated	DCW	50	3	49	85		25-30
6163	D3AP Suburban Grade-Separated	DCW	60	3	6	96		
6173	D3AP Suburban Grade-Separated	DCW	70	3	4	111		
6134	D4AP Suburban At-Grade	DCW	30	4	4	47		
6144	D3AP Suburban Grade-Separated	DCW	40	4	0	85		
6244	D4AP Suburban At-Grade	DCW	40	4	2	64		
6154	D4AP Suburban Grade-Separated	DCW	50	4	4	85		
6174	D4AP Suburban Grade-Separated	DCW	70	4	0	111		
6155	D5AP Suburban Grade-Separated	DCW	50	5	1	85		
6165	D5AP Urban Grade-Separated	DCW	60	5	0	96		
6175	D5AP Suburban Grade-Separated	DCW	70	5	0	111		
7171	D1M	Motor way	70	1	0	104		25-30
7172	D2M	Motor way	70	2	4	104		30-35
7173	D3M	Motor way	70	3	8	109		20-25
7174	D4M	Motor way	70	4	2	109		20-25
7175	D5M	Motor way	70	5	0	111		
8141	Slip-dual/motorway	Slip Rd	40	1	25	45	0-5	
8151	Slip-dual/motorway	Slip Rd	50	1	9	80		
8161	Slip-dual/motorway	Slip Rd	60	1	0	97		25-30

Model Link Type	Link Description	Road Type	Speed Limit (mph)	Lanes	Count of link type in model	Modelled Cruise Speed (kph)	Low by (kph)	High by (kph)
8242	Slip-dual/motorway	Slip Rd	40	2	42	45	5-10	
8252	Slip-dual/motorway	Slip Rd	50	2	22	80		15-20
8262	Slip-dual/motorway	Slip Rd	60	2	8	97		30-35

7. Conclusions

The information presented in Table 9 has been summarised in Table 10. The numbers of link types for which the cruise speeds appear to be either too low or too high are each represented by a square. For example: There are seven link types for roads with a speed limit of 30 mph for which the cruise speed appears to be low by between 0 and 5 kph.

Table 10 Summary of Cruise Speed Comparisons

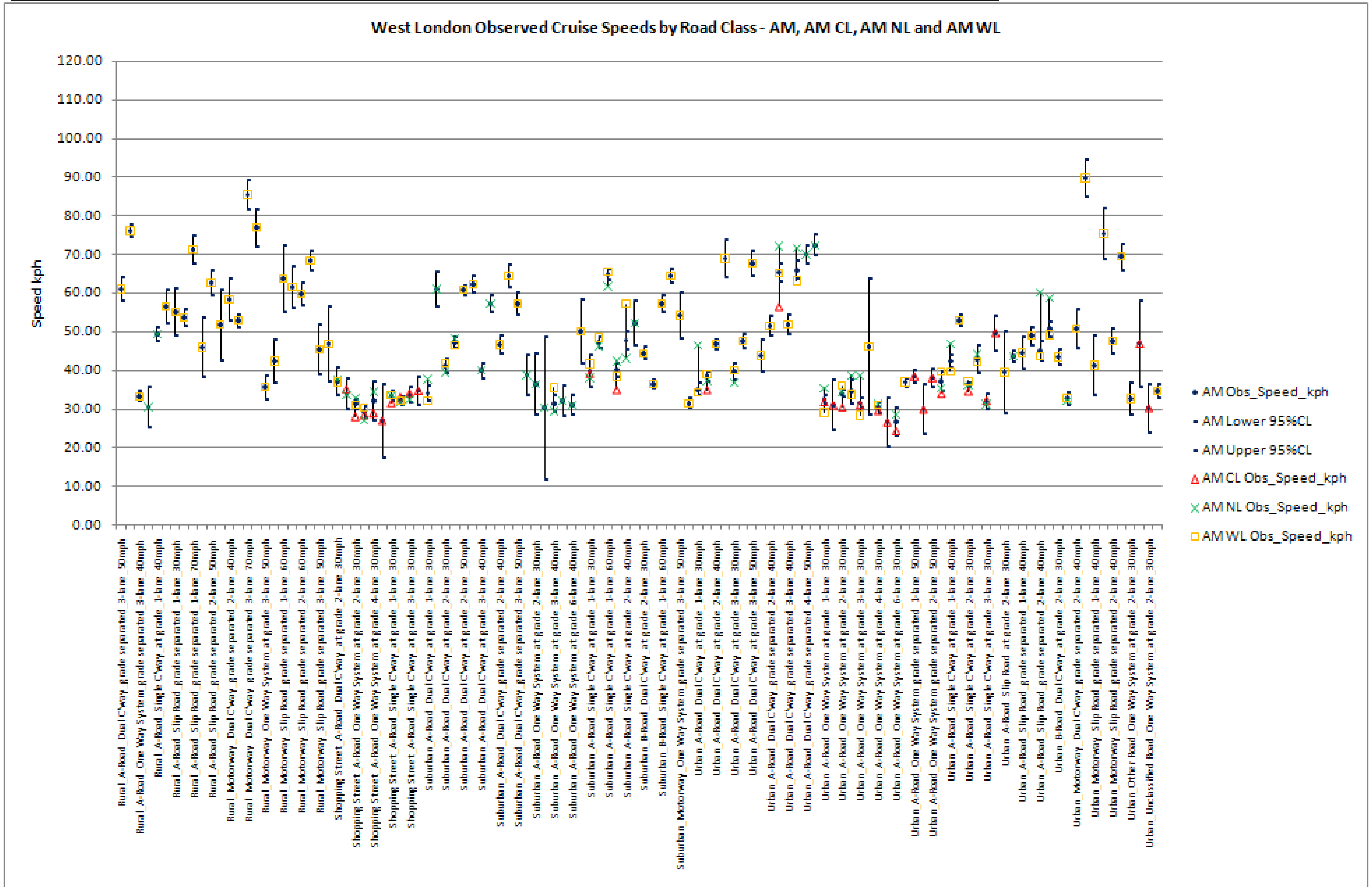
Speed Limit (mph)	The Modelled Cruise Speeds appear to be too….									
	….low by (kph)		….high by (kph)							
	5-10	0-5	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40
20										
30	■■■■■■	■■■■■■■	■	■■	■■					
40	■■■	■	■	■	■■■■	■■■	■■		■	
50						■■■■	■	■		
60								■	■■	■
70							■■	■	■	

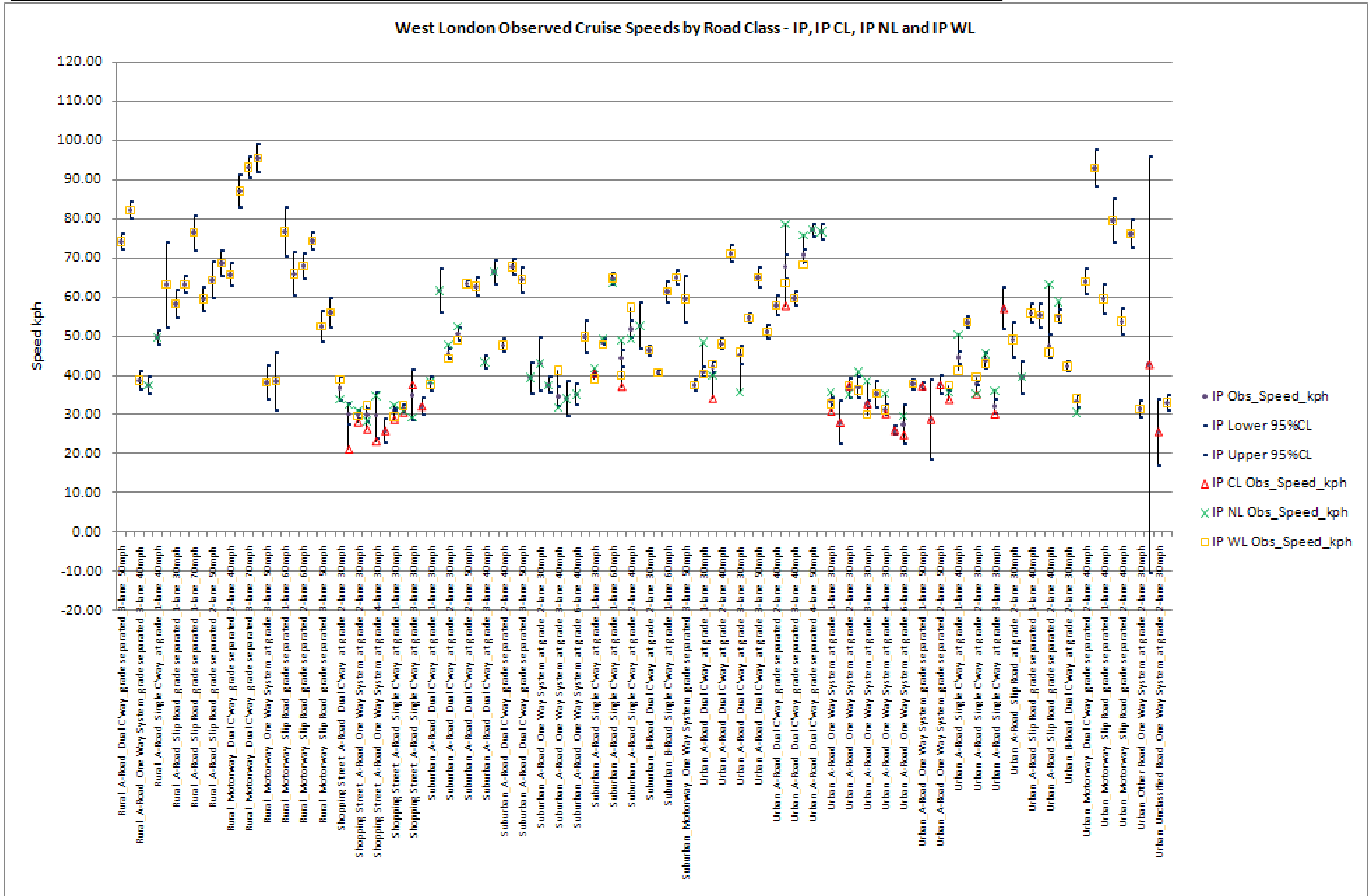
The results in this table suggest that, on the whole, the modelled cruise speeds for link types representing roads with a 30 mph speed limit are slightly low, while for roads with a 40mph speed limit the modelled cruise speeds are either too low or too high. For roads with speed limits of 50 mph or greater, the empirical evidence suggests that all the modelled cruise speeds are too high by, on average, 25 kph (or thereabouts).

8. Recommendation

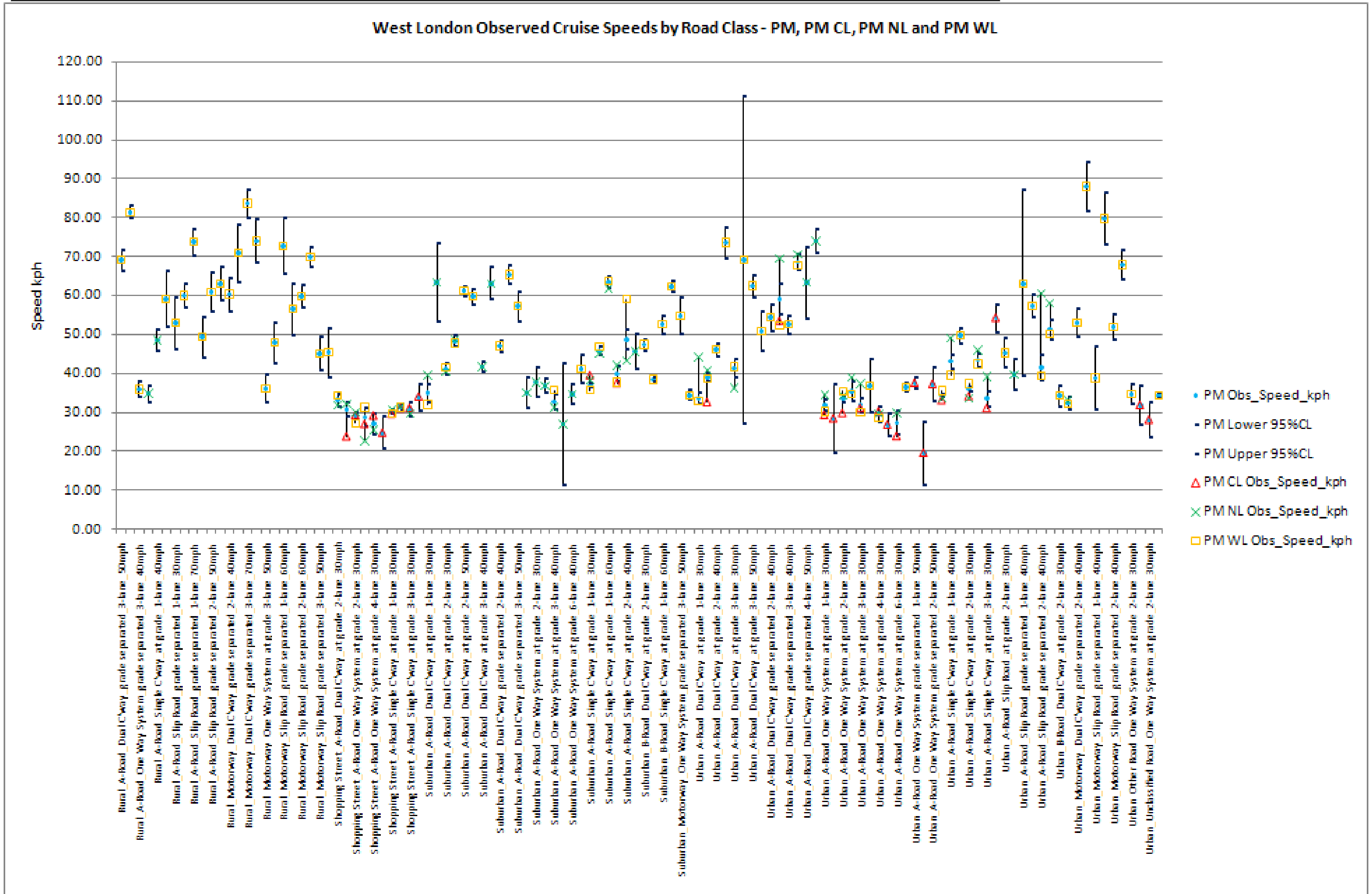
Based upon the evidence presented, it is recommended that the cruise speeds for a number of link types in the WeLoHAM model should be reviewed and adjusted, to reduce the variance between the modelled and observed speeds.

Appendix A
Observed Average Speeds by Road Classes, Time Periods and Survey Areas


West London Observed Cruise Speeds by Road Class - AM, AM CL, AM NL and AM WL
Speed kph
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
AM Obs_Speed_kph
AM Lower 95%CL
AM Upper 95%CL
AM CL Obs_Speed_kph
AM NL Obs_Speed_kph
AM WL Obs_Speed_kph


West London Observed Cruise Speeds by Road Class - IP, IP CL, IP NL and IP WL
Speed kph
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
-10.00
-20.00
IP Obs_Speed_kph
IP Lower 95%CL
IP Upper 95%CL
IP CL Obs_Speed_kph
IP NL Obs_Speed_kph
IP WL Obs_Speed_kph

AECOM


West London Observed Cruise Speeds by Road Class - PM, PM CL, PM NL and PM WL
Speed kph
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
PM Obs_Speed_kph
PM Lower 95%CL
PM Upper 95%CL
PM CL Obs_Speed_kph
PM NL Obs_Speed_kph
PM WL Obs_Speed_kph

Appendix B
Detailed Results of Cruise Speed Analysis

Model Link Type	Link Description	Road Type	Speed Limit mph	Lanes	Cruise Speed kph	count	qry	Road_Type	Road_Layout	Environment	Separation	Speed_Limit_mph	Lanes	Count_of_Speed_Records	StdDevn_Speed_Kph	Average_Speed_kph	Lower 95%CL	Upper 95%CL	Low (kph)	High (kph)
1131	A Road	A Rd	30	1	35	419	1131	A-Road				30	1	9393	6.46	35.83	35.70	35.96	0-5	
1231	A Road (Good) Rural	A Rd	30	1	42	200	1231	A-Road		rural		30	1	89	13.88	45.62	42.70	48.54	0-5	
1141	A Road	A Rd	40	1	50	61	1141	A-Road				40	1	1021	8.64	45.38	44.85	45.91		0-5
1151	A Road	A Rd	50	1	75	9	1151	A-Road				50	1	41	3.28	52.21	51.18	53.24		20-25
1161	A Road	A Rd	60	1	96	4	1161	A-Road				60	1	215	6.26	64.27	63.43	65.11		30-35
1132	A Road	A Rd	30	2	38	141	1132	A-Road				30	2	4505	8.72	36.55	36.29	36.80		0-5
1232	A Road (Good) Rural	A Rd	30	2	48	51														
1142	A Road	A Rd	40	2	55	62	1142	A-Road				40	2	796	11.02	43.74	42.97	44.51		10-15
1152	A Road	A Rd	50	2	80	12														
1162	A Road	A Rd	60	2	96	0														
1133	A Road	A Rd	30	3	38	50	1133	A-Road				30	3	888	8.10	32.10	31.57	32.64		5-10
1233	A Road (Good) Rural	A Rd	30	3	48	17														
1143	A Road	A Rd	40	3	64	50	1143	A-Road				40	3	181	7.72	33.78	32.65	34.91		30-35
1153	A Road	A Rd	50	3	80	3														
1134	A Road	A Rd	30	4	38	30	1134	A-Road				30	4	206	6.35	30.71	29.83	31.58		5-10
1234	A Road (Good) Rural	A Rd	30	4	48	12														
1144	A Road	A Rd	40	4	64	9														
1135	A Road	A Rd	30	5	38	5	1135	A-Road				30	5	17	3.77	26.55	24.61	28.48		10-15
1136	A Road	A Rd	30	6	38	2	1136	A-Road				30	6	42	6.76	27.24	25.14	29.35		10-15
2121	B road	B Rd	20	1	28	7														
2131	B road	B Rd	30	1	32	500	2131	B-Road				30	1	629	6.70	36.30	35.78	36.82	0-5	
2141	B road	B Rd	40	1	56	39														
2151	B road	B Rd	50	1	77	5														
2161	B road	B Rd	60	1	97	0	2161	B-Road				60	1	77	6.84	57.10	55.55	58.65		35-40
2122	B road	B Rd	20	2	28	2														
2132	B road	B Rd	30	2	35	87														
2142	B road	B Rd	40	2	61	12														
2152	B road	B Rd	50	2	77	0														
2162	B road	B Rd	60	2	97	0														
2123	B road	B Rd	20	3	28	0														
2133	B road	B Rd	30	3	35	15														
2143	B road	B Rd	40	3	61	5														
2153	B road	B Rd	50	3	80	0														
2163	B road	B Rd	60	3	97	0														
3121	Other roads	Other Rd	20	1	26	216														
3131	Other roads	Other Rd	30	1	24	956														
3122	Other roads	Other Rd	20	2	26	5														
3132	Other roads	Other Rd	30	2	24	10	3132	Other Road				30	2	80	7.09	33.38	31.80	34.96	5-10	
3133	Other roads	Other Rd	30	3	26	2														
4131	Major Shopping	Shopping Rd	30	1	25	103	4131			Shopping Street		30	1	4124	6.41	31.21	31.02	31.41	5-10	
4132	Major Shopping	Shopping Rd	30	2	28	23	4132			Shopping Street		30	2	1472	6.72	31.71	31.37	32.06	0-5	
4142	D2 Urban Shopping	Shopping Rd	40	2	38	0														

Model Link Type	Link Description	Road Type	Speed Limit mph	Lanes	Cruise Speed kph	count	qry	Road_Type	Road_Layout	Environment	Separation	Speed_Limit_mph	Lanes	Count_of_Speed_Records	StdDevn_Speed_Kph	Average_Speed_kph	Lower 95%CL	Upper 95%CL	Low (kph)	High (kph)
5121	S2 Urban Non-Central (Bad)	SCW	20	1	25	0														
5131	S2 Small Town-Typical	SCW	30	1	28	20	5131		Single C'way			30	1	9598	6.37	36.03	35.90	36.15	5-10	
5131	S2 Small Town-Typical (Good)	SCW	30	1	35	45	5131		Single C'way			30	1	9598	6.37	36.03	35.90	36.15	0-5	
5331	S2 Urban-Non-Central	SCW	30	1	28	18	5331		Single C'way	Urban		30	1	7106	6.23	35.26	35.11	35.40	5-10	
5141	S2 Suburban	SCW	40	1	61	25	5141		Single C'way	Suburban		40	1	604	7.29	46.99	46.41	47.58		10-15
5141	S2 Suburban Unclassified	SCW	40	1	57	4	5141		Single C'way	Suburban		40	1	604	7.29	46.99	46.41	47.58		10-15
5132	Urban-Non-Central	SCW	30	2	28	3	5132		Single C'way	Urban		30	2	2743	8.10	36.89	36.59	37.20	5-10	
5142	S2 Good	SCW	40	2	64	2	5142		Single C'way			40	2	631	10.57	45.78	44.95	46.61		15-20
5242	S4 Suburban	SCW	40	2	61	1	5242		Single C'way	Suburban		40	2	245	10.72	49.42	48.07	50.77		10-15
5143	S6 Suburban	SCW	40	3	61	0														
6131	D1AP Urban	DCW	30	1	35	3	6131		Dual C'way	Urban		30	1	358	8.67	36.57	35.67	37.47	0-5	
6231	D1AP Suburban	DCW	30	1	35	4	6231		Dual C'way	Suburban		30	1	66	4.92	35.67	34.47	36.88	0-5	
6141	D1AP Urban	DCW	40	1	44	4														
6241	D1AP Suburban	DCW	40	1	64	6														
6132	D2AP Suburban	DCW	30	2	35	36	6132		Dual C'way	Suburban		30	2	446	6.54	43.99	43.38	44.60	5-10	
6142	D2AP Urban	DCW	40	2	44	68	6142		Dual C'way	Urban		40	2	926	11.04	49.05	48.34	49.76	5-10	
6242	D2AP Suburban	DCW	40	2	64	25	6242		Dual C'way	Suburban		40	2	520	8.45	48.55	47.83	49.28		15-20
6242	D2AP Suburban (Bad)	DCW	40	2	58	1	6242		Dual C'way	Suburban		40	2	520	8.45	48.55	47.83	49.28		5-10
6242	D2AP Suburban (Good)	DCW	40	2	64	57	6242		Dual C'way	Suburban		40	2	520	8.45	48.55	47.83	49.28		15-20
6542	D2AP Suburban Grade-Separated (Bad)	DCW	40	2	70	7	6542		Dual C'way	Suburban	grade separated	40	2	84	4.69	47.14	46.12	48.16		20-25
6152	D2AP Suburban At-Grade	DCW	50	2	80	38	6152		Dual C'way	Suburban	at grade	50	2	160	4.24	61.84	61.17	62.50		15-20
6252	D2AP Suburban Grade-Separated (Average)	DCW	50	2	85	13	6252		Dual C'way	Suburban	grade separated	50	2	166	9.03	65.93	64.54	67.31		15-20
6252	D2AP Suburban Grade-Separated (Good)	DCW	50	2	85	1	6252		Dual C'way	Suburban	grade separated	50	2	166	9.03	65.93	64.54	67.31		15-20
6162	D2AP Suburban Grade-Separated (Good)	DCW	60	2	97	3														
6172	D2AP Suburban Grade-Separated (Good)	DCW	70	2	111	0														
6133	D3AP Suburban	DCW	30	3	47	11														
6143	D3AP Urban	DCW	40	3	44	32	6143		Dual C'way	Urban		40	3	765	11.11	52.23	51.44	53.02	5-10	
6243	D3AP Suburban	DCW	40	3	64	20	6243		Dual C'way	Suburban		40	3	120	5.25	41.72	40.77	42.67		20-25
6343	D3AP Suburban Grade-Separated	DCW	40	3	70	3														
6153	D3AP Suburban Grade-Separated	DCW	50	3	85	49	6153		Dual C'way	Suburban	grade separated	50	3	81	8.92	59.78	57.81	61.76		25-30
6163	D3AP Suburban Grade-Separated	DCW	60	3	96	6														
6173	D3AP Suburban Grade-Separated	DCW	70	3	111	4														
6134	D4AP Suburban At-Grade	DCW	30	4	47	4														
6144	D3AP Suburban Grade-Separated	DCW	40	4	85	0														
6244	D4AP Suburban At-Grade	DCW	40	4	64	2														
6154	D4AP Suburban Grade-Separated	DCW	50	4	85	4														
6174	D4AP Suburban Grade-Separated	DCW	70	4	111	0														
6155	D5AP Suburban Grade-Separated	DCW	50	5	85	1														
6165	D5AP Urban Grade-Separated	DCW	60	5	96	0														
6175	D5AP Suburban Grade-Separated	DCW	70	5	111	0														
7171	D1M	Motor way	70	1	104	0	7171	Motorway				70	1	40	10.49	78.16	74.80	81.51		25-30
7172	D2M	Motor way	70	2	104	4	7172	Motorway				70	2	244	9.28	70.99	69.82	72.16		30-35
7173	D3M	Motor way	70	3	109	8	7173	Motorway				70	3	208	14.25	87.37	85.42	89.32		20-25
7174	D4M	Motor way	70	4	109	2	7174	Motorway				70	4	124	14.09	84.71	82.21	87.22		20-25
7175	D5M	Motor way	70	5	111	0														
8141	Slip-dual/motorway	Slip Rd	40	1	45	25	8141		Slip Road			40	1	41	14.57	46.77	42.17	51.37	0-5	
8151	Slip-dual/motorway	Slip Rd	50	1	80	9														
8161	Slip-dual/motorway	Slip Rd	60	1	97	0	8161		Slip Road			60	1	41	13.56	70.92	66.65	75.20		25-30
8242	Slip-dual/motorway	Slip Rd	40	2	45	42	8242		Slip Road			40	2	41	6.13	51.08	49.15	53.01	5-10	
8252	Slip-dual/motorway	Slip Rd	50	2	80	22	8252		Slip Road			50	2	42	10.55	61.35	58.06	64.63		15-20
8262	Slip-dual/motorway	Slip Rd	60	2	97	8	8262		Slip Road			60	2	122	10.01	62.47	60.67	64.26		30-35

Appendix B. AECOM – Partial Matrix Technical Notes

Technical Note

AECOM

Project:	**TfL Highway Assignment Models**	Job No:	**60193936**
Subject:	**Specification of Partially Observed Highway Demand Matrices v5.5**		
Prepared by:	**Mark Jones**		**9th September 2011**
Checked by:	**Mark Dazeley**		**28th October 2011**
Approved by:	**Paul Hanson**		**2nd November 2011**

1 Introduction

This specification details the work which has been undertaken to develop the partially observed highway demand matrices for the TfL Highway Assignment Models (HAMs). The specification covers the following areas:

- the development of unified zone system (Section 2);
- the use of LATS 2001 and North/Central London 'missing' site data (Section 3);
- the methodology used to construct matrices from RSI data (Section 4);
- the methodology used to report matrix variance estimates (Section 5); and
- the processing of additional RSI data to those sourced from the original HAM developments (Section 6).

This note should be used in conjunction with '*Treatment of Variability in Assembling Partial Observed Trip Matrices v5*' which sets out how errors (both sampling and non-sampling) have been processed in matrix development and how multiple observations for a given 'cell' of the matrix have been combined based on ERICA guidance.

2 Task 1.1: Develop Unified Zone System

2.1 Initial Development

An initial unified zone system was developed based upon the zoning systems in the core simulation areas for each of the HAMs, combined with LTS zones outside London. LTS zones that are partially within the HAM simulation and speed flow areas were disaggregated. This was then refined as explained below. Mappings between postcodes/coordinates and zones were established and the raw survey data were geocoded to the unified zone system.

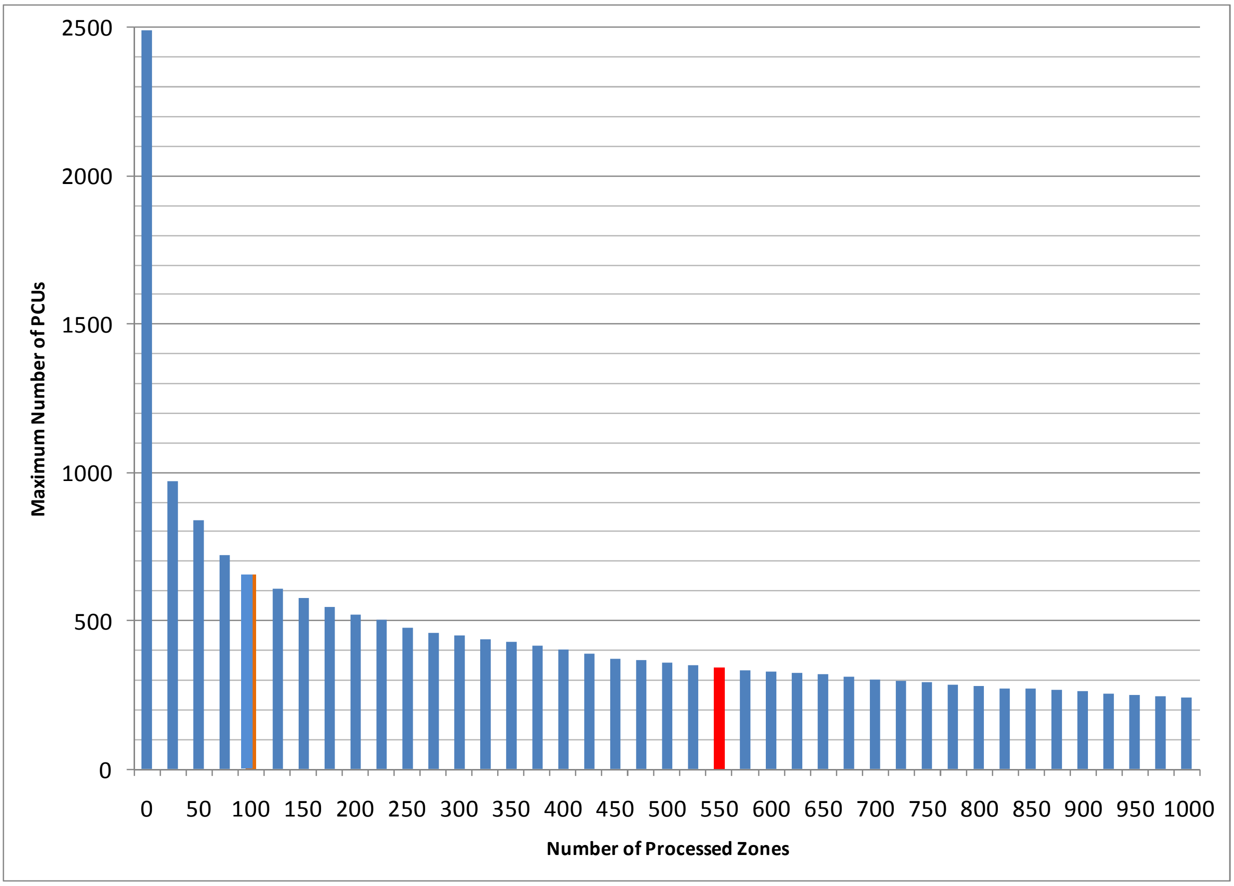
2.2 Further Development – Splitting of Initial Unified Zoning within GLA Boundary

Subsequent to the development of the initial unified zoning mentioned above, TfL in conjunction with The Denvil Coombe Practice (DCP), specified a further refinement that, ideally, no more than 200-300 passenger car units (PCUs) should load into/out of any one zone in a given peak hour (aggregated across all assignment user classes).

To do this, AECOM took the unified zone system within the GLA for each HAM, and the corresponding trip end totals from both the AM and PM peak hour post matrix-estimation HAM demand matrices. Zones were then sorted and the top 550 (budget restrained) zones with origins/destinations over 341 PCUs (see Figure 2.1 and next paragraph for details) were split using only output area boundaries. Zones which would require splitting into sub-output area entities were identified and listed, but no action taken.

Figure 2.1 shows the number of zones that needed to be split in order to have a given maximum number of PCUs loading into/out of a zone. Splitting 550 zones was judged to give a satisfactory maximum number of PCUs per zone, 341. The diminishing returns if splitting a higher number of zones in order to get under the ideal 200-300 maximum PCU limit was deemed unnecessary given budget constraints.

Figure 2.1: Number of zones requiring splitting to result in a given maximum number of PCUs loading into/out of a zone (within GLA)



Where there were a large number of OAs comprising a unified zone, the zone was split into *aggregations* of OAs. This was assessed on a case-by-case basis with OAs aggregated taking account of underlying land use.

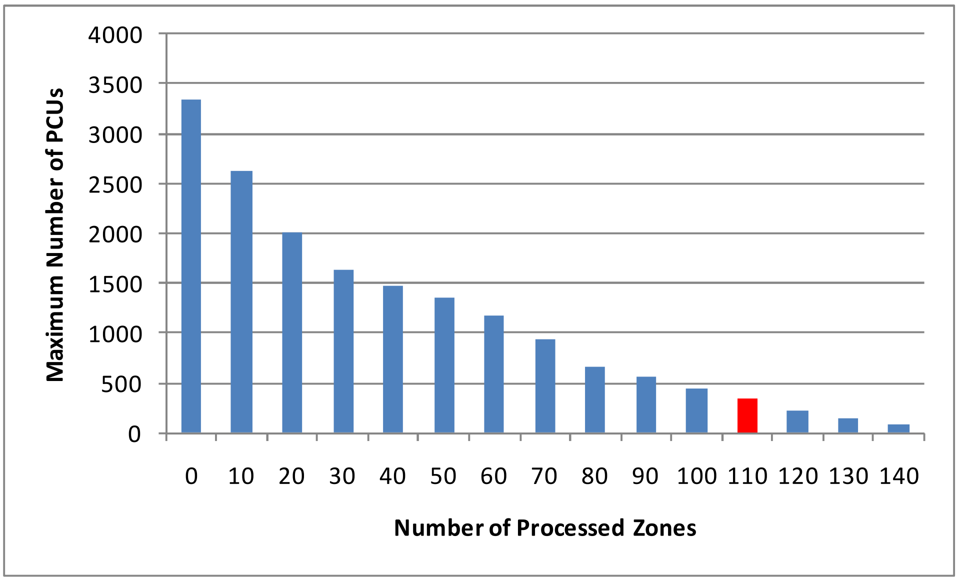
A small number of zones needed to be split subsequent to the above, to correct errors in cordon definitions in the original HAM work. See Section 4.2.

2.3 Splitting of Initial Unified Zoning outside GLA Boundary

The HAMs include a representation of the highway network outside the GLA boundary to better reflect routeing for trips accessing the London network. In this area the zone boundaries were defined in the initial unified zoning layer by LTS zones. The threshold of a maximum of ~350 PCUs per zone was used to determine further zones to be disaggregated.

In the area between the GLA boundary and the M25, there were 137 of these zones inherited from LTS, most of which needed either disaggregating, or in some cases, aggregating. A similar analysis to that undertaken in Section 2.2 was applied to these zones between the GLA and M25. As before, trip end data from the HAMs were used for this analysis, though they were allocated to LTS zones using area-based proportions where apportioning. The resultant distribution of zones in terms of the maximum number of trip end PCUs is shown in Figure 2.2.

Figure 2.2: Number of zones requiring splitting to result in a given maximum number of PCUs loading into/out of a zone (between GLA and M25)



In the area between the M25 and the edge of the i) simulation area and ii) speed-flow area, a similar exercise was undertaken, using the same rationale, but using trip ends from the LTS model, as these were considered to provide a better reflection of the level of demand to and from these more peripheral zones. These zones followed LTS boundaries, using Output Area boundaries where possible. Output Areas were split where necessary to preserve the integrity of the LTS zones.

3 Task 1.3: Use of LATS 2001 Data, Select Link Data and Treatment of Minor Screenline Holes

3.1 LATS RSI Sites - Central London

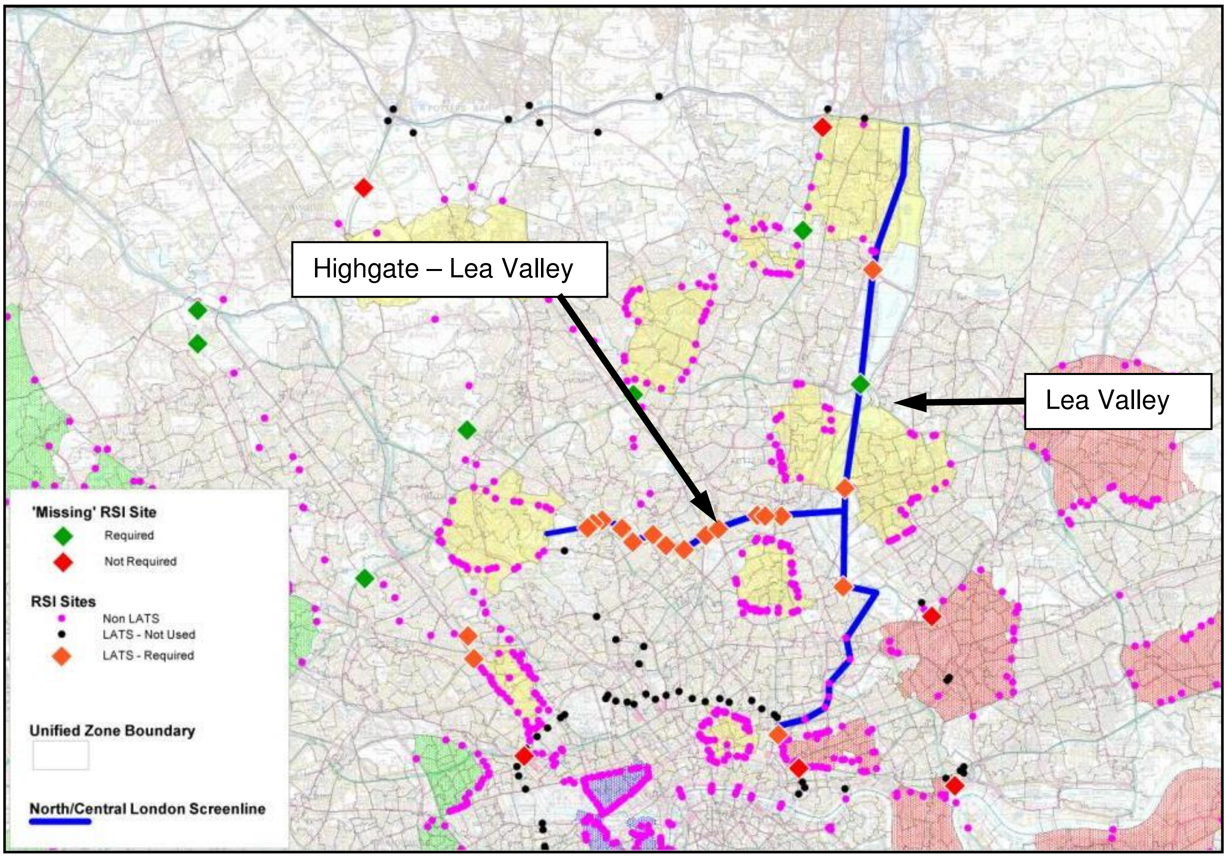
Both the North and Central London HAM models used 2001 LATS RSI data. These data were collected prior to the introduction of the central London congestion charge, meaning the balance of origins and destinations of trips recorded at sites that relate to central London would be expected to have changed materially. Therefore, no LATS RSI sites on the central London cordon were used; these are represented by black dots in Figure 3.1.

3.2 LATS RSI Sites - Outside Central London

3.2.1 Highgate-Lea Valley and Lea Valley Screenlines

Outside central London, LATS sites displayed as red diamonds in Figure 3.1 were used to create two screenlines comprised almost entirely of LATS data. High level analysis showed less than 9% of trips through these sites interact with the congestion zone area, so there should not have been a significant alteration in trip origins/destinations due to the implementation of the congestion charge, though of course the data are still 10 years old.

Figure 3.1: Two screenlines in North London which have a significant amount of LATS RSI sites.

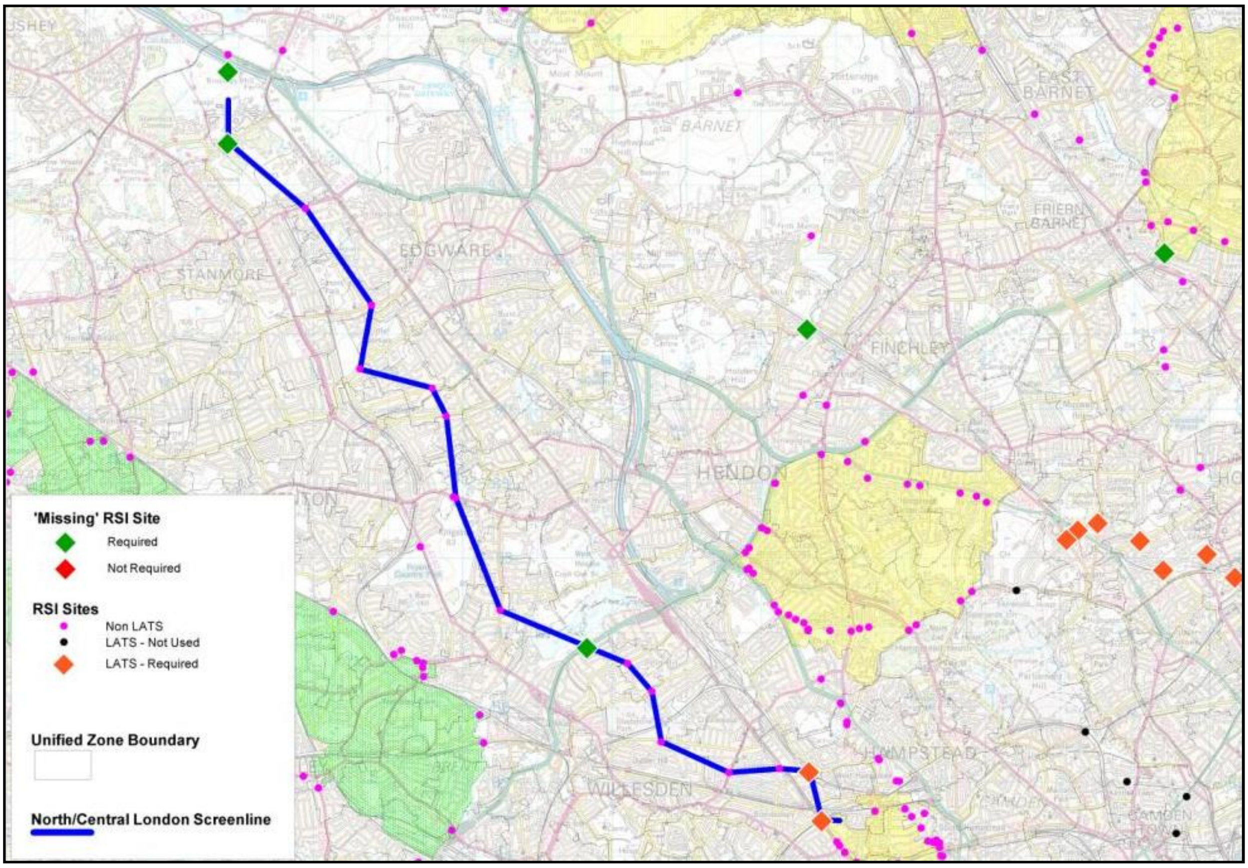


It was considered that, despite the age of the data, the inclusion of these screenlines would give a better estimate of trips compared with the alternative of omitting the screenline and letting subsequent matrix synthesis determine the travel patterns.

3.2.2 *St John's Wood to Stanmore Screenline*

Two further LATS sites were used on the screenline running from St John's Wood to Stanmore. While this screenline primarily comprises 2008/9 survey data, the inclusion of the two LATS sites shown in Figure 3.2 is necessary in order to complete the screenline.

Figure 3.2: Screenline running from Stanmore to St John's Wood (blue line) which uses two LATS sites (orange diamonds) in order to complete the screenline.



3.3 Select Link Data - High Flow 'Missing' Sites on North/Central London Screenlines

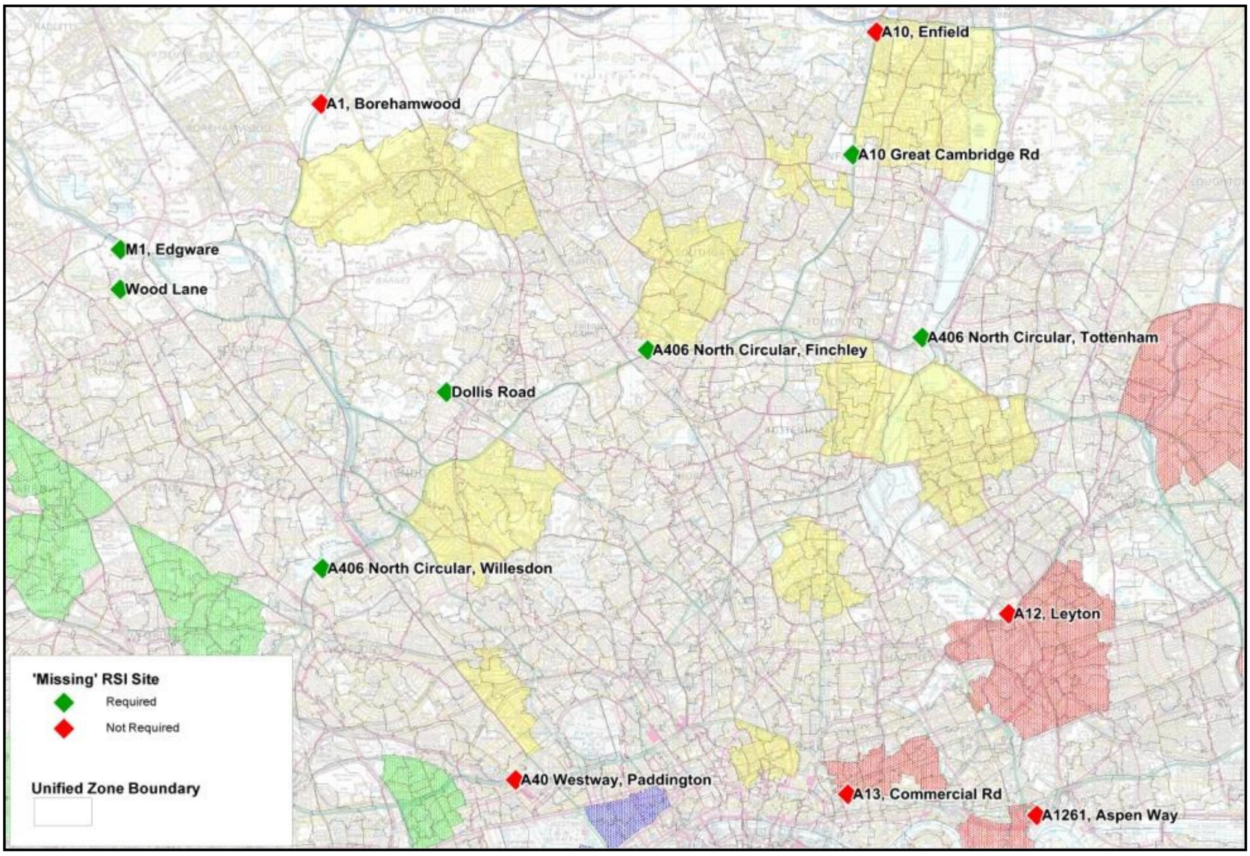
There are several significant holes in the screenlines used in the North/Central London HAMs. These holes were infilled in the original HAM work by undertaking select link analysis using an estimate of demand to create synthetic RSI sites, commonly referred to as 'missing' sites.

The LTS B6.2 PVC demand matrices were assigned on the NoLHAM assigned paths; these PVC demand matrices are segmented by the 6 purposes needed for the partial matrix build, for periods (or average period hours). As these PVC matrices do not include delta or fixed trip matrices, they were scaled to traffic counts.

The select link analysis generates many records. These range from zone pairs near the site where the site is the dominant route to zone pairs distant from the site where a small proportion of trips route through the site. The select link outputs comprise many records representing all combinations of trip purposes and zone pairs. It would be possible to include many thousands of records each representing a small fraction of a trip. However these would add to the data file size but add almost no value. We therefore applied a cut off of 0.1 trips to restrict the number of records generated from the select link analysis. The counts used for expansion came from the HAMs count database produced by MVA Consultancy; MCC proportions of car (which includes minicabs) were applied to ATC totals.

Relative area was used as a means of disaggregation of the demand from LTS zones to NoLHAM zones.

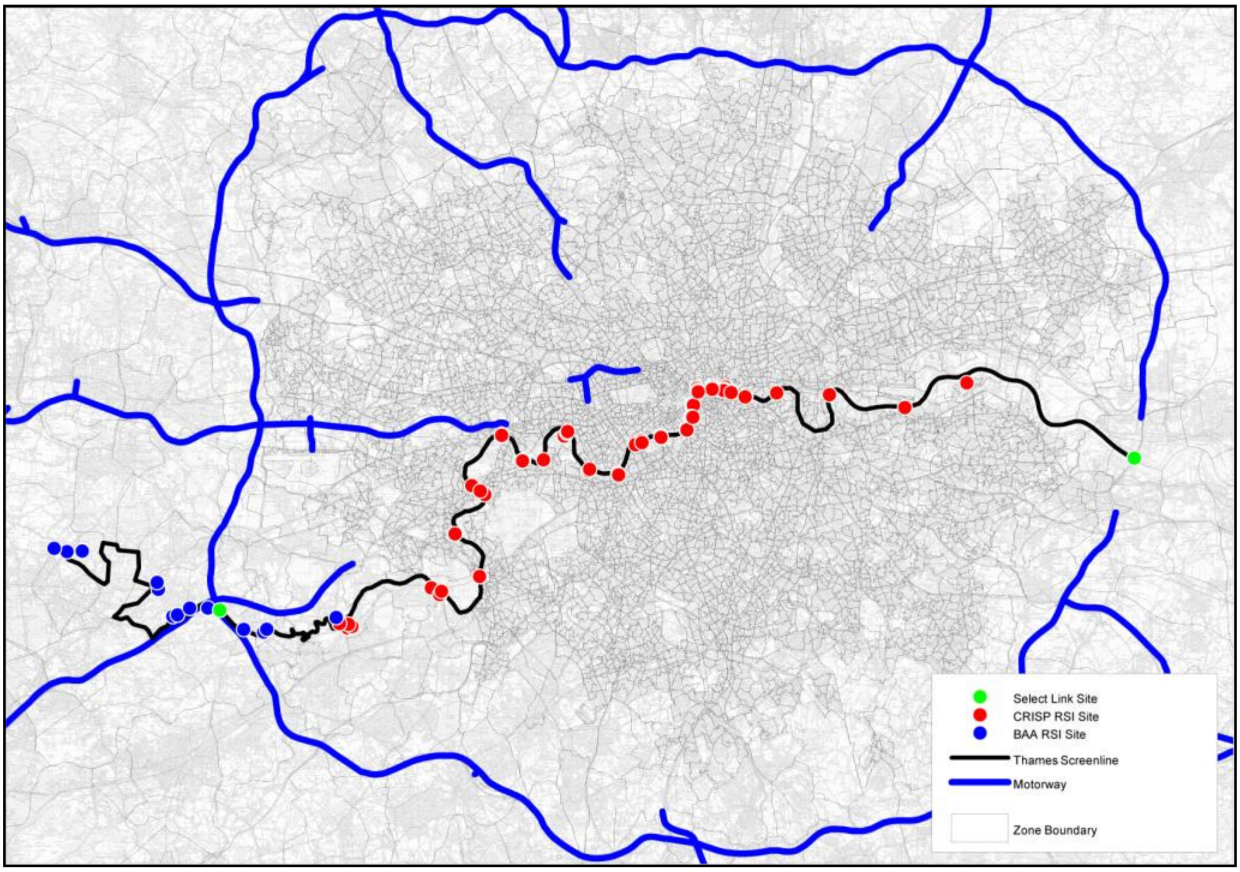
Figure 3.3: Location of 'missing' sites in the north and central London area; green diamonds represent sites used to complete screenlines, whereas red sites were not required.



3.4 Select Link Data – Thames Screenline

As well as the 46 CRISP enclosures and the screenlines mentioned in the previous section, RSI sites running along the River Thames were used to from a screenline. This screenline is made up from CRISP RSI sites, complemented by RSI sites undertaken by BAA to extend the screenline towards the west. This is shown in Figure 3.4.

Figure 3.4: Thames screenline and associated RSI sites



As shown in Figure 3.4, the screenline crosses the M25 both at the Dartford Crossing in the east and between junctions 11 and 12 in the West. At both of these sites a select link procedure was undertaken to complete the screenline.

LTS B6.2 PVC average hour matrices were assigned on the LTS network. These matrices are segmented by the six purposes that were used to develop the partially observed matrices. As described in Section 3.3, a cut off was needed to exclude small fractions of trips in certain matrix cells; for data management reasons the cut off used was 0.05 trips. This excluded between 5 and 10% of demand and over 50% of the trip records for these sites, similar to cut off adopted for the North London select links.

The resultant select link matrices were expanded to counts from the HAMs count database, and relative area was used as a means of disaggregating from LTS zones to LoHAM zones.

3.5 Treatment of Minor Holes in Cordons/Screenlines

As well as the high flow holes, there were numerous lower flow holes in the cordons/screenlines used for matrix development. AECOM used the following methodology to infill these holes.

A review of the location of minor holes was undertaken in order to cluster them by short sections, for example between two major routes, in broadly the same direction. We then reviewed the zone detail and location of RSI sites adjacent to this cluster of holes.

Survey records (and transposed records) were copied from the surveyed RSI sites to create ‘pseudo’ trips records. Where the holes represented minor roads that would normally be used for access (i.e. with flows less than 100 vehicles per hour and judged by inspection) the approach was to limit the pseudo trip records only to records that originated (and for transposed records terminated) within the enclosure. For sites on other routes trips through the enclosure were retained. If the holes provided direct access to different zones to the surveyed RSI sites, we recoded the origins or destinations of trip records to reflect zones adjacent to the site locations. This only applied to trips from / to zones close (within 1-2km) of the surveyed RSI site.

The 'pseudo' trip records were then re-expanded to the estimated count for the unobserved sites. This count came from the HAMs count database created by MVA Consultancy. In this database, a 'likely' count through the hole has been estimated by time period, and this is the count that was used.

Observed factors (see Section 4.1.1) were applied to imply a similar sampling rate for the hole to the surveyed RSI site. Assumptions used for trip synthesis were applied to reflect non sample error, see '*Treatment of Variability in Assembling Partial Observed Trip Matrices v5*'.

3.6 Treatment of Specific Holes – Hanger Lane

In the CRISP RSI data set, several RSI sites were surveyed around all access points onto the A406, Hanger Lane, Ealing. This was in order to get a complete sample of traffic leading onto Hanger Lane; unfortunately there was one road leading onto an industrial estate that was not surveyed.

As a result, in the West London matrix build, a select link analysis (SLA) was undertaken on the final prior matrices. This was then added to the final matrices before matrix estimation, to infill the hole. AECOM has infilled the LoHAM matrices using a similar methodology.

The Hanger Lane SLA matrices were available for the AM peak hour, PM peak hour and interpeak average hour, all split by work and non-work user classes. These matrices were first aggregated by time period to form one matrix.

Purpose splits came from the West London prior matrices before the Hanger Lane SLA was applied; these were available for the 6 purposes that are used in the LoHAM partially observed matrix build.

Period matrices were then created by applying the peak hour factors used in the WeLHAM development. These were available by purpose for HBE, HBEB, HBO, NHEB and NHO as matrix-wide factors; and by CIOX sector for HBW.

To convert the matrices from West London model to LoHAM zoning, disaggregation based on area was used.

4 Methodology used to Construct Matrices from RSI Data

The note *'Treatment of Variability in Assembling Partial Observed Trip Matrices v5'* that accompanies this note details the database design that has been used to implement the methodology set out in this section. The note also sets out the formulae that have been used to undertake the calculations set out here.

4.1 Consolidation of Raw Data and Application of Traffic Factors

TfL provided RSI data processed by all HAMs. Each RSI record included:

- journey purpose and time of survey;
- origin and destination postcode or coordinates;
- indication of whether the record had been transposed; and
- an expansion factor which expanded the record to a count at the RSI site.

Initial data processing was undertaken for the original development of each HAM. In addition to the updating of LATS coding and the synthetic ('missing' site) data used for North London (discussed in Section 3), the following actions were undertaken to consolidate the data:

- derivation of an 'observed factor' (see below) for each RSI record and all transposed records in order to calculate sample size at each RSI site[1];
- application of traffic factors to ensure all RSI records were factored to a neutral November 2009 average weekday; and
- adjustment to East London expansion factors to account for only Monday-Thursday counts being used for expansion (all other HAMs used Monday-Friday counts).

4.1.1 Derivation of the 'Observed Factor': Sample Size Calculations

Referring to *'Treatment of Variability in Assembling Partial Observed Trip Matrices v5',* in order to calculate the sample error at each RSI site, we must know the sampling factor; this is the number of interviews divided by the number of trips. This needs to be done in both directions at each RSI site.

The various HAM teams used return time probabilities to reverse an RSI record into multiple time periods creating several synthetic reverse records. Thus counting the number of records in the reverse direction at each RSI site is difficult. We have attempted to calculate an 'observed factor' for each reversed RSI record, which represents how many reverse records each observation has created.

For example, suppose we observe 1 'Home to Work' car trip at 0800. Let us then say that there is a 50% chance of that trip returning at 1500, and 50% of it returning at 1800. Thus 2 'Work to Home' synthetic records will be created, each with an 'observed factor' of 0.5. When we then count the number of records in the reverse direction to calculate the sample error, we sum the 'observed factors', which in this case will be 0.5+0.5=1. Clearly in the interview direction, the observed factor is always 1.

This approach was used to count the number of records at the RSI site and thus calculate sample error.

However, there are instances where using this approach yields more RSI records than expanded trips. This is because of:

- TARA infilling of trips; and
- methods used by the various HAM teams to further infill records where it was deemed the sample size was too low.

Where the number of RSI records is greater than the number of expanded trips, the sample error will clearly be nonsensical. Thus we put a cap on the maximum number of records at each RSI site (i.e. a cap on the maximum sample size at each site), which only comes into effect where the sampling factor is very high (and where the number of RSI records is greater than the number of expanded trips) which is symptomatic of the infilling processes mentioned above. These caps are as follows:

[1] As discussed below the 'observed factor' is used to reconcile records in the database against individual survey records in cases where processing of the data has resulted in multiple records in the database for a single observation

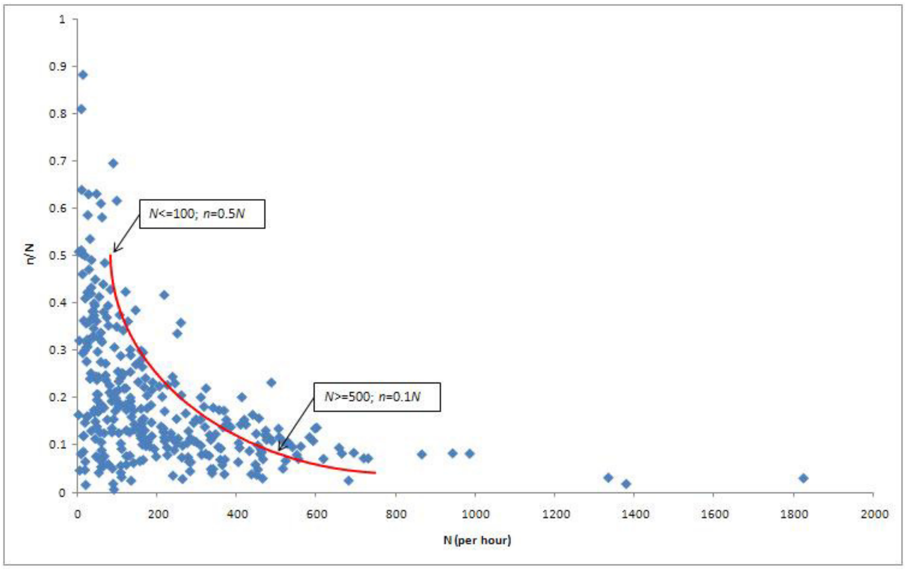
- n=0.5N for N<=100
- n=50 for 100<N<500
- n=0.1N for N>=500

where:

n = number of RSI records in an hour
N = number of expanded trips per hour (i.e. the count at the RSI site)

These caps have been derived by looking at some pre-TARA RSI data (see Figure 4.1) to see how the sampling factor (n/N) varies with N. For the mid-range (100<N<500), n=50 represents the likely maximum number of interviews an RSI site could undertake in an hour.

Figure 4.1: Analysis of pre-TARA RSI data, showing the variation of sample size *n*/*N* with the population size *N*.



4.1.2 *Application of Traffic Factors*

Matrices created from this process must represent an average weekday in November 2009. Each of the HAMs were based to the following month/season/years.

Table 4.1: Base year for each HAM.

HAM	Base Year
Central	Autumn 2008
North	Autumn 2008
East	November 2009
South	November 2009
West	Spring 2009

TfL has provided the following factors that have been used to adjust the relevant expansion factors[2]:

- ratio of monthly average daily traffic flow to the annual average daily traffic flow (all motor vehicles) for 2009, supplied separately for area (north, south etc) of London; and
- yearly scaling factors from 2008 to 2009 for cars in London, supplied separately for the AM, IP and PM peak periods.

The monthly factors have been averaged by season for each area of London, and a ratio created between these seasonal averages to the November factor. The result has then been multiplied by the 2008 to 2009 yearly factor for each time period, which results in an AM, IP and PM peak period factor to convert from any season in 2008 to November 2009. These factors have then been applied to the Central and North HAM expansion factors as appropriate. For West London the yearly factors have not been included, so one factor has been created to convert from Spring 2009 to November 2009. A summary of the factors using the methodology defined above is provided below.

Table 4.2: Factors for adjusting each HAM base model to November 2009.

HAM	Base Year	Time Period	Factor
Central	Autumn 2008	AM	1.000
		IP	1.006
		PM	0.984
North	Autumn 2008	AM	1.007
		IP	1.013
		PM	0.991
West	Spring 2009	(All)	0.984

4.1.3 *Adjustment to East London Expansion Factors*

ELHAM RSI records have been expanded to an MCC undertaken at the survey site. The counts derived from MCCs are less accurate than those derived from ATCs.

Some ATCs were undertaken at the ELHAM RSI sites. These were generally undertaken over two weeks, and so an average flow has been taken which gives a more accurate representation of an average weekday traffic flow through the RSI site.

Where ATCs were undertaken, AECOM has applied RSI site-specific factors of ATC/MCC counts in each direction of the RSI site, separately for the AM, interpeak and PM peak periods. These factors have been applied to individual trip record expansion factors, so that the expansion factors match the ATC. No change has been made to sites that have been expanded to MCCs for which there is no ATC.

These factors have been developed by MVA and are reported on the following page.

[2] The same factors have also be applied by MVA to update the count database

Table 4.3: ELHAM MCC/ATC correction factors.

CRISP Site No.	Location	Compass Direction	MCC to ATC (Nov 09) Factor AM	IP	PM
6011	Woolwich Ferry	N	0.470	0.586	0.456
6011	Woolwich Ferry	S	0.690	0.673	0.622
6022	London Bridge	N	0.658	0.777	0.794
6022	London Bridge	S	0.775	0.712	0.596
6009	A101 Rotherhithe Tunnel	N	0.913	0.906	0.864
6009	A101 Rotherhithe Tunnel	S	0.952	0.852	0.893
6007	Tower Bridge	N	1.099	1.100	1.065
6007	Tower Bridge	S	0.995	0.893	1.030
3304	Hainault Road (A132)	N	1.035	1.065	1.008
3304	Hainault Road (A132)	S	1.063	1.019	1.039
3601	Lewisham Road A2211	N	1.084	1.042	1.006
3601	Lewisham Road A2211	S	1.132	1.145	1.032
3621	Catford Hill	S	0.912	0.861	0.770
3621	Catford Hill	N	0.856	0.862	0.754
3629	Brownhill Road (A205)	E	0.810	0.999	0.757
3629	Brownhill Road (A205)	W	0.952	1.311	0.902
3640	Lee High Road (A20)	E	1.118	1.143	0.949
3640	Lee High Road (A20)	W	1.094	1.398	1.241
3644	Lee Terrace	E	1.568	1.091	1.180
3644	Lee Terrace	W	0.896	0.883	0.925
3320	Southend Road (A1400)	W	0.611	0.808	0.775
3320	Southend Road (A1400)	E	0.913	0.883	0.824
2901	Shooters Hill/ Bellegrove Road	W	0.863	1.010	0.974
2901	Shooters Hill/ Bellegrove Road	E	0.977	0.927	0.675
2906	Upper Wickham Lane	N	0.804	0.846	0.944
2906	Upper Wickham Lane	S	1.082	1.031	0.867
3703	Ilford Hill / Chapel Road	W	1.852	1.955	2.010
3703	Ilford Hill	E	0.922	0.870	0.793
3702	Eastern Avenue A12	W	0.778	0.851	0.813
3702	Eastern Avenue A12	E	0.862	0.856	0.798
3805	Hawley Road (A225)	S	1.048	1.057	0.950
3805	Hawley Road (A225)	N	1.074	1.091	1.005
3807	Lowfield Street	N	1.034	1.075	1.049
3807	Lowfield Street	S	1.283	1.336	1.192
3814	Maidstone Road (B2173)	E	0.989	0.998	0.753
3814	Maidstone Road (B2173)	W	0.961	1.032	0.658

CRISP Site No.	Location	Compass Direction	MCC to ATC (Nov 09) Factor AM	IP	PM
3315	Woodford Avenue (A1400)	S	0.945	0.904	0.961
3315	Woodford Avenue (A1400)	N	0.684	0.759	0.645
3411	Goosehays Drive	S	1.077	1.052	1.103
3411	Goosehays Drive	N	1.176	1.100	1.249
3201	London Road (A124)	W	0.973	0.982	0.989
3201	London Road (A124)	E	0.848	1.002	0.974
3204	Longbridge Road (A124)	E	0.995	1.002	0.971
3204	Longbridge Road (A124)	W	0.846	0.993	0.931
1802	Preston's Road (A1206)	N	0.890	0.874	0.831
1802	Preston's Road (A1206)	S	0.820	1.003	1.027
1805	Westferry Road A1206	N	1.491	1.199	0.873
1805	Westferry Road A1206	S	0.756	0.885	0.950
1806	Westferry Road	S	1.938	2.401	2.934
901	Mile End Road	E	1.156	0.996	0.967
901	Mile End Road	W	1.216	0.942	1.060
903	Cambridge Heath Road	N	0.627	0.672	0.648
903	Cambridge Heath Road	S	0.954	1.064	1.622
909	Vallance Road	N	1.047	0.922	1.069
909	Vallance Road	S	1.071	1.488	1.199
928	New Road	S	1.662	1.249	1.267
928	New Road	N	1.258	1.338	1.681
3215	Porters Avenue (A1153)	N	1.080	1.118	1.072
3215	Porters Avenue (A1153)	S	1.008	1.027	1.046
3224	Lodge Avenue (A1153)	S	0.958	0.929	0.848
3224	Lodge Avenue (A1153)	N	0.850	0.878	0.876
3101	High Street (A11)	W	0.867	0.912	0.849
3101	High Street (A11)	E	0.686	0.662	0.531
3103	Plaistow Road (A112)	E	0.945	0.943	0.827
3103	Plaistow Road (A112)	W	0.977	1.030	0.969
3112	Romford Road (A118)	E	1.354	0.909	0.884
3112	Romford Road (A118)	W	0.770	0.985	1.071
3311	Cranbrook Road (A123)	S	0.941	0.936	0.885
3311	Cranbrook Road (A123)	N	0.903	0.922	0.816
3121	High Road Leyton (A112)	N	0.966	1.202	1.130
3121	High Road Leyton (A112)	S	0.965	1.047	0.844

4.2 Task 1.4: Establish Cordon/Screenline Matrices

Task 1.1 established for each cordon (inbound and outbound direction) a list of which zone-to-zone movements are likely to be observed for the cordon. Taking an enclosure as example, we expect to observe movements from zones within the enclosure to zones outside the enclosure, provided the RSI surveys were undertaken on the zone boundary.

Initial work highlighted two discrepancies with these definitions. First, there were some minor discrepancies where zones had been allocated as being inside a cordon when in fact they are outside (and vice versa). We corrected this simply by reallocating the zone to be inside or outside the cordon, as necessary. The second type of discrepancy was that some RSI sites were located in the middle of a zone and not on the zone boundary; thus making the definition of which cordon that zone belongs to ambiguous. The only solution to this problem was to split the zone at the RSI site. In accordance with the methodology used to split zones as mentioned in Section 2, OA boundaries were respected where zones needed to be split to correct for these discrepancies.

Figure 4.2: Enclosure boundaries with discrepancies in the definition of which enclosure zones

Parent HAM	Enclosure Name	Cordon Definition Discrepancies?	Zones Affected (Parent HAM Zone Number)
North	Barnet	Y	7100
North	Clerkenwell	Y	1608, 1628, 1629
North	Enfield East	N	N
North	Enfield Town	Y	7414, 7516, 7537, 7539
North	Golders Green	Y	7014, 7066, 7067
North	Palmers Green	Y	7525, 7529
North	St Johns Wood	Y	1527
North	Stoke Newington	N	N
North	Tottenham	Y	7281, 7312 (Significant Holes)
North	Walthamstow	N	N
East	Barking	N	N
East	Barkingside	N	N
East	Bexley	N	N
East	Canary Wharf	Y	2071
East	Harold Hill	Y	4007
East	Hornchurch	N	N
East	Lewisham	N	N
East	Stepney	N	N
East	Stratford	Y	2023
East	Woolwich	N	N
South	Benhilton	Y	5296
South	Bromley	Y	4803
South	Croydon	N	N
South	Dulwich	N	N
South	Kingston	Y	5723, 5725 (Significant Holes)
South	Lambeth	Y	2925
South	Orpington	Y	4830 (Significant Holes)
South	Richmond	N	N
South	Spring Park	N	N
South	St Paul's Cray	N	N
South	Thornton Heath	N	N
South	Wimbledon	Y	5531
South	Woodlands	N	N
West	Ealing	N	N
West	Hammersmith	N	N
West	Harrow	N	N
West	Hayes	N	N
West	Heston	N	N
West	Northwood	N	N
West	Notting Hill	N	N
West	Wembley	N	N
Central	Belgravia/Pimlico	N	N
Central	Mayfair/Soho	N	N
Central	Westminster	Y	1304

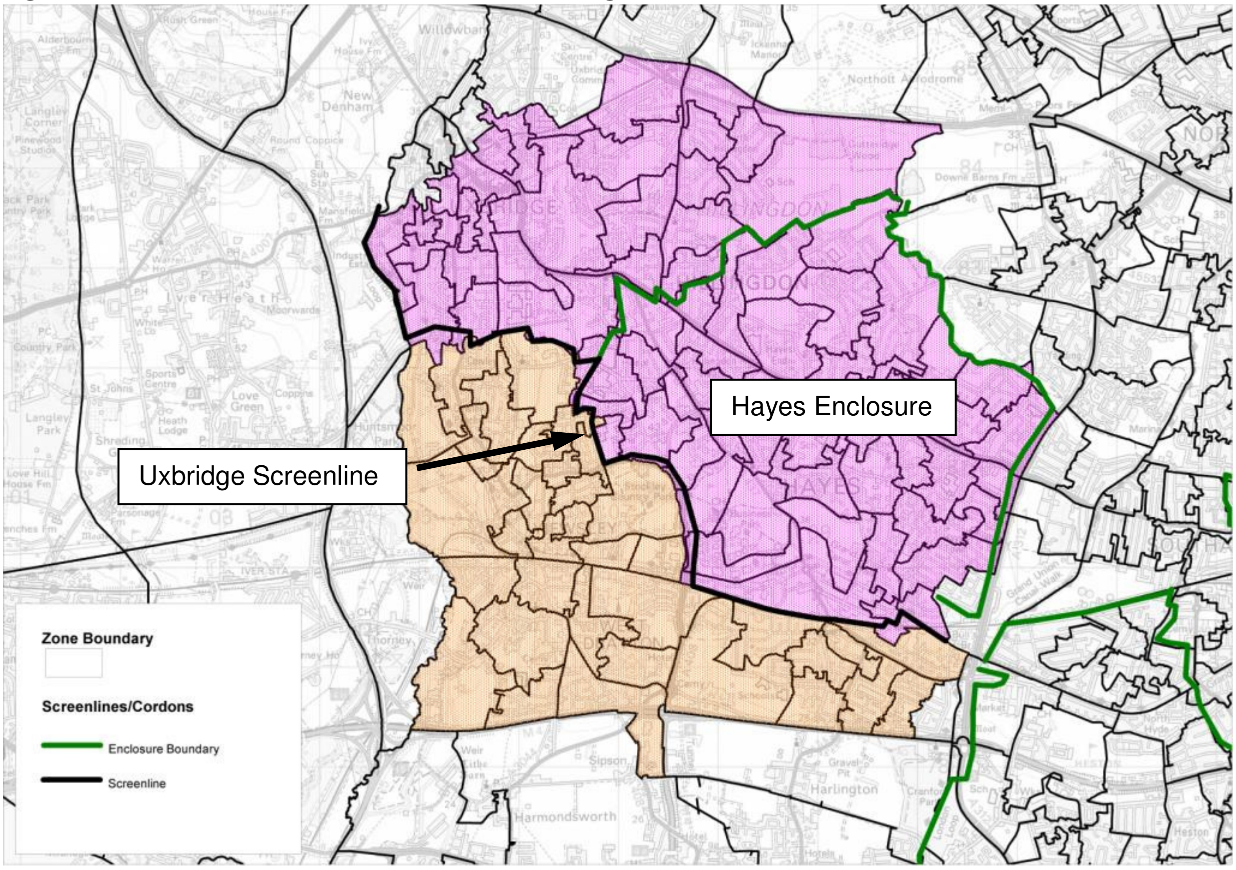
No Discrepancy
Minor Discrepancy
Significant Discrepancy

.

The list in Figure 4.2 highlights the enclosure boundaries where there were discrepancies in the definition of which zones lay within an enclosure. This happened for the two reasons outlined in the preceding paragraph. Enclosures highlighted in red are where RSI sites were not on zone boundaries, the solution to which was to split the zone. Enclosures highlighted in orange are where a zone had been included/not included in the enclosure definition when it should not or should have been. The remedy for this was to include/not include the zone in the enclosure definition.

For each screenline (in the interview and reverse directions) we used screenline definitions from the HAMs to establish the combination of zone-to-zone movements that are likely to cross the screenline, avoiding those movements which might route around the ends of the screenline. Using the example of the Uxbridge Screenline shown in Figure 4.3, we expect to observe any movements between a pink to orange zone (and vice versa). These two groups of zones have been selected so as not to include movements that would route around the screenline. Note that in this case the trips originating within the Hayes enclosure (also shown in pink in Figure 4.2 would be represented as observed (from the enclosure) rather than crossing the screenline as the sites are shared - explained further below.

Figure 4.3: Observed movements for the Uxbridge Screenline



The cordons/screenlines that AECOM has used are: all 46 CRISP enclosures; the LATS screenlines displayed in Section 3; the Uxbridge and Thames screenlines (which are both partly formed of BAA RSI sites, see Annex), South London screenline, West London screenline and Inner London (west and East) screenlines. Where enclosure cordons form part of a screenline, the list of fully observed zone-to-zone movements (see previous paragraph) were refined as follows: taking the Thames screenline as an example, this screenline borders several enclosures along the Thames. Thus RSI sites are ‘shared’ on both the enclosure and Thames screenline. Using the methodology set out below would mean too much weight would be placed on these ‘shared’ sites, falsely indicating the errors on these data were less than other sites on the screenline/enclosure. Therefore, we have not included any enclosure which borders either a LATS or the Thames screenline in the list of likely zone-to-zone movements observed for that screenline.

Having established lists of observed zone-to-zone movements for each cordon/screenline, the following steps were undertaken.

- For each cordon/screenline matrix cell (including cells with no observed trips) estimate variance based on sample rate and observed trips, see *'Treatment of Variability in Assembling Partial Observed Trip Matrices v5'* for details.
- Apply ERICA guidance on additional variation attributable to transposed records and calculate variance for each cordon/screenline matrix estimate of trips. This additional estimate of variance attributed to transposing trip records is added to the variance attributable to sampling error. We have assumed that the counts have been undertaken to a similar standard across all sites and therefore making site specific adjustments to reflect count accuracy would not have a significant effect on the resulting trip matrix. See *'Treatment of Variability in Assembling Partial Observed Trip Matrices v5'* for details.
- At this point we have the observed number of trips (accumulated from individual sites on the relevant cordon/screenline) on an OD basis, together with the variance of this observation:
  - this is defined for the zone-to-zone movements we class as observed for each cordon/screenline (see first two paragraphs of this section);
  - for vehicles/car drivers;
  - for each time period (AM/IP/PM) and for the 0800-0900 and 1700-1800 peak hours; and
  - for each purpose (HBW, HBE, HBEB, HBO, NHBEB and NHBO).

4.3 Task 1.5: Combine Cordon/Screenline Matrices

The cordon/screenline matrices provide one or more estimates of the number of expanded trips for each zone-to-zone movement that is classified as observed, for each direction of the cordon (i.e. inbound and outbound for enclosures). This step weights the multiple observations according to their respective indices of dispersion, this is again described in detail in *'Treatment of Variability in Assembling Partial Observed Trip Matrices v5'*. Note that the application of ERICA and similar processes is structured on the basis of establishing explicit mappings that specify which movements have been intercepted (observed) crossing specific screenlines or cordons. The use of partial matrices where unobserved movements are excluded achieves the same without the need manually to define such mappings.

Total trips to and from individual enclosures have been tabulated and compared with reported values from the original HAM development work to verify data.

4.4 Task 1.6: Results

A simple database procedure summarises the partially observed matrices on the basis of the unified zone system. This has some standard reporting queries that report origins and destinations across all purposes to and from each enclosure, by each time period.

5 Variance of Trip Estimates

5.1 Context

The partially observed matrices described in this specification will be used in the creation of prior trip matrices. During trip matrix synthesis, the deterrence functions fitted to the partially observed matrices will be fitted to both origin and destination trip ends, as well as sector level trip totals.

To derive sector level trip totals it will be necessary to know the variance (or error/confidence) in the number of trips in each cell of the matrix, such that trip estimates at the matrix cell level can be aggregated as appropriate.

The methodology that AECOM has used to calculate the variance for each cell of the partially observed matrix is detailed in the following section.

5.2 Methodology used to Create Variance Matrices for Trip Estimates

Referring to '*Treatment of Variability in Assembling Partial Observed Trip Matrices v5',* for each trip observation (i.e. each RSI record, both interviewed and transposed directions), an index of dispersion has been calculated; which is a measure of error on the estimate of trips. This error takes into account such things as the transposition of RSI records, age of data, whether RSI records have been expanded to ATC or MCC counts etc.

Indices of dispersion have been summed for sites on a given cordon, to provide an index of dispersion (by direction) for each cordon; only where an observation (or an observation has been transposed) has taken place.

Each cordon, has a set of 'likely' observed movements – for an enclosure, we would expect to observe all movements from inside to outside the enclosure (and vice versa). For all likely observed movements where an observation has not taken place, the average index of dispersion for the cordon is used.

Thus for each likely observed movement, an index of dispersion has been calculated. This is defined as:

$$I_a^c = \frac{{}^{Total}V_a^c}{T_a^c}$$

Where:

- ${}^{Total}V$ is total error/variance;
- I is the index of dispersion;
- T is the trip estimate;
- a denotes a given cell of the matrix, for a specific purpose/time period combination; and
- c denotes a cordon.

Thus to calculate variance of a cordon we simply multiply the index of dispersion by the trip estimate as follows:

$${}^{Total}V_a^c = I_a^c T_a^c$$

In order to merge the variances of trip estimates from each cordon, we assume that the index of dispersion is approximately constant. This is an assumption taken from ERICA guidance that is used to establish the confidence that should be attached to cells with zero trips in them, when they are weighted with cells with non-zero trips in them. Thus we can weight the variances in the same way in which trip estimates are weighted, using the index of dispersion as follows:

$$^{Total}V_a = \frac{\sum_c \frac{V_a^c}{I_a^c}}{\sum_c \frac{1}{I_a^c}}$$

This approach is approximate in that it does not take into account the following two issues.

- *Variance of cells with zero observed movements* - allowing for the variance of cells observed with zero trips would increase the estimate of variance at sector level.
- *We are assuming independence between matrix cells* - allowing for interdependence between individual matrix cells (that if our sample included one cell the chance of observing trips in another cell is lower) will reduce the variance at a sector level.

This approach however should provide an adequate approximation for the intended purpose (accumulating trips and variances to sector level to estimate the confidence with which inter-sector trips have been estimated). A more rigorous approach would review and build on the work undertaken by Kirby in the late 1970s in developing RDMVR and adapt the procedures then developed to address issues where cells are observed with zero trips.

5.3 Creation of 95% Confidence Intervals

5.3.1 Methodology

Assuming the variances can be treated as independent, the variance of a sector is calculated by summing the variance of all cells within the sector:

$$^{Total}V_{Sector} = \sum_{a \epsilon Sector} {}^{Total}V_a$$

This assumption is explicit in the approach taken to estimate the non-sample error for RSI records (see '*Treatment of Variability in Assembling Partial Observed Trip Matrices v5*') and refers to ERICA guidance. The representation of matrix cell variances are defined so that when accumulated i.e. variances are added, the aggregated variance from matrix cells at count sites is consistent with the observed variability in counts: the errors in individual matrix cells are treated as independent.

To calculate the 95% confidence interval, we first calculate the standard deviation (σ) of the sector as:

$$\sigma_{Sector} = \sqrt{^{Total}V_{Sector}}$$

Finally we multiply the standard deviation by 1.96 to calculate the 95% confidence interval.

5.3.2 Worked Example

Suppose for a given sector, we have 100 non-zero cells in our trip matrix, each with 10 trips and each with a variance of 400. We can then derive:

- $T_{Sector} = 100 * 10 = 1{,}000\ Trips$
- $\mathrm{TotalV}_{Sector} = 100 * 400 = 40{,}000$
- $\sigma_{Sector} = \sqrt{40{,}000} = 200$
- $95\%\ CI = 1.96 \times 200 = \pm 392\ Trips$; or

$$95\%\ CI = \frac{\pm 392\ Trips}{1{,}000\ Trips} = \pm 39.2\%$$

6 Processing BAA/HA RSI Site Data

6.1 Summary of Available Data

BAA[3] RSI data were made available to provide additional detail to the west of London, in the Uxbridge and Thames Screenlines (the latter being extended westwards). A summary of these data is provided in Table 6.1.

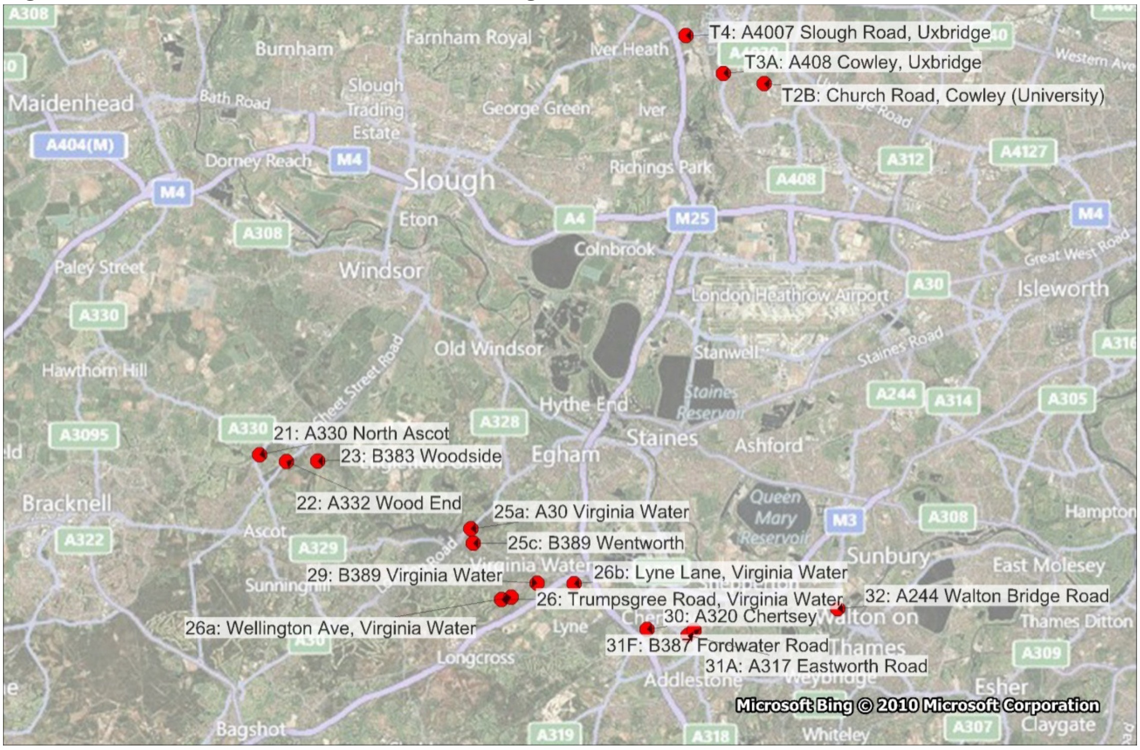
Table 6.1 BAA RSI Survey Sites Available for Uxbridge and Extended Thames Screenlines

Site	Location	OS		RSI Direction	RSI Dates	ATC Dates
21	A330 North Ascot	492111	171087	Westbound	07/10/2009	28/09/2009-17/10/2009 and 16/11/2009-01/12/2009
22	A332 Wood End	492886	170897	Westbound	07/10/2009	28/09/2009-12/10/2009 and 16/11/2009-30/11/2009
23	B383 Woodside	493800	170926	Eastbound	07/10/2009	28/09/2009-14/10/2009 and 16/11/2009-30/11/2009
25a	A30 Virginia Water	498306	169039	Westbound	16/11/2009	02/11/2009-17/11/2009
25c	B389 Wentworth	498379	168630	Westbound	09/11/2009	02/11/2009-17/11/2009
26	Trumpsgree Road, Virginia Water	499247	167011	Southbound	13/11/2009	16/11/2009-01/12/2009
26a	Wellington Ave, Virginia Water	499517	167088	Southbound	24/11/2009	16/11/2009-01/12/2009
26b	Lyne Lane, Virginia Water	501352	167512	Southbound	24/11/2009	16/11/2009-01/12/2009
29	B389 Virginia Water	500267	167496	Southbound	16/11/2009	16/11/2009-01/12/2009
30	A320 Chertsey	503505	166219	Southbound	10/11/2009	02/11/2009-17/11/2009
31A	A317 Eastworth Road	504710	166061	Eastbound	09/11/2009	02/11/2009-11/11/2009
31F	B387 Fordwater Road	504885	166228	Southbound	13/11/2009	02/11/2009-17/11/2009
32	A244 Walton Bridge Road	509063	166941	Southeastbound	10/11/2009	30/09/2009-14/10/2009
T2B	Church Road, Cowley (University)	506594	182131	Southbound	14/10/2009	03/09/2009-15/10/2009
T3A	A408 Cowley, Uxbridge	505399	182411	Southbound	16/09/2009	03/09/2009-30/09/2009
T4	A4007 Slough Road, Uxbridge	504287	183483	Westbound	29/09/2009	22/09/2009-06/10/2009

These sites are also shown spatially in Figure 6.1.

[3] The Highways Agency sourced these data from BAA and shared the information with TfL

Figure 6.1: BAA Data Available for Uxbridge and Extended Thames Screenlines



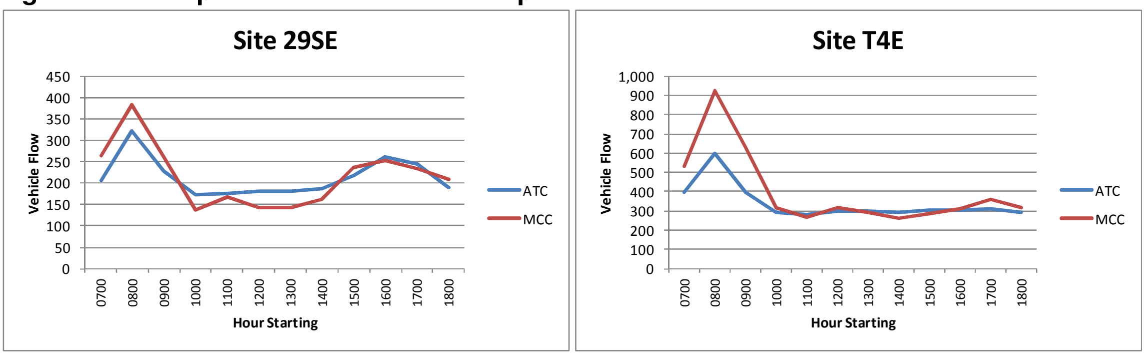
The three sites to the north have been used, in conjunction with sites from the Hayes cordon, to form an Uxbridge screenline. The 13 sites to the south have been used, in conjunction with sites from the Molesey and Kingston cordons, to extend the existing Thames screenline to the west.

6.2 Processing of Data Prior to Use

6.2.1 Checks and Cleaning of Data

Before use, the count data were checked for consistency; the ATC data (typically recorded for a two-week period around the day of the RSI) and the MCC data, recorded on the day of the survey. Checks were made to verify the consistency of the magnitude of the counts, and critically, the profile of the two count series throughout the surveyed day – inconsistencies here usually indicate that the direction attributed to one of the counts is incorrect. Examples of these ATC/MCC comparisons are shown in Figure 6.2.

Figure 6.2: Sample ATC/MCC Count Comparisons



Checks were also made on the recorded origins and destinations, by plotting the location of the origins and the destinations in relation to the location of the RSI site and the surveyed direction, which confirmed that initial data processing and cleaning has been undertaken for BAA and HA..

6.2.2 *Journey Purposes*

Origin and destination journey purposes were coded in the original survey data into the 14 purposes shown in Table 6.2.

Table 6.2 Survey coded journey purposes

Survey Purpose
Home
Usual Workplace
Collect/Deliver Goods
Courier Collection/Delivery
Carry out Maintenance/servicing/construction
Other Work/Employers Business
Shopping/Use Services
Sport/Entertainment/Social
Education
Hotel/Holiday Home
Escort – Work
Escort – Education
Escort – Other
Other non-work purpose

The origin and destination journey purposes were mapped to those journey purposes used in LoHAM: HBW; HBO; HBE; HBEB; NHBO; and NHBEB.

6.2.3 *Expansion of Data*

Interview and transposed interview records were expanded to an average weekday November 2009 ATC, with vehicle splits derived from MCC surveys, as explained below. As the counts from the HAMS were not directly used, we adopted the expansion factors created in the HAMs, adjusting if appropriate.

Total vehicle ATC counts were averaged by hour over their duration, excluding both weekends and the day of the RSI survey from the average. MCC counts were then used to derive a proportion of cars and minicabs. This was applied to the total vehicle ATC average to calculate a car/minicab count as follows.

MCC surveys counted the vehicle types shown in Table 6.3. These vehicle types were summed to create a total vehicle count, and then the categories highlighted in Table 6.3 were summed to create a car and minicabs count. A proportion of cars and minicabs were then derived by hour and applied as explained in the previous paragraph. The result was a count of cars and minicabs by hour in both directions at each RSI site.

Table 6.3 MCC vehicle classifications

Raw RSI Data	LoHAM Classification
Car	Car + Minicab
London Taxi	Black Cab
Other Taxi/Minicab	Car + Minicab
2-wheeled motor vehicle	Other
Pedal cycle	Other
Van (car based)	LGV
Van/ light goods	LGV
HGV (2 axles)	HGV
HGV (3 axles)	HGV
HGV (4+axles)	HGV
Public service bus	Other
Coach or Private Bus	Other
Other	Other

6.2.4 Transposition of Data

The BAA/HA RSI surveys included a question about what time a return journey would be made. AECOM has used this information to transpose RSI interviews into a likely return journey time period as detailed below.

Home-based and non-home-based RSI records have been transposed differently. It has been assumed that all NHB trips return in the same time period as that in which they surveyed. For home-based trips, a return journey time probability has been derived, assessing the probability that a return trip will be made in a given time period.

Preliminary analysis of the proportion of home-based records that have a return journey time recorded on a site by site basis is small. Thus AECOM has tabulated return journey time probabilities by purpose and time period; using the sites that lie on the Uxbridge screenline; and the separately for the sites that lie on the Thames screenline.

These probabilities have then been used to transpose the home-based interviews into one or more time periods. In doing this, the observed factor has been calculated as described in see Section 4.1.1.

6.3 Treatment of Minor Holes in Screenlines

Using the BAA/HA RSI sites to extend the Thames screenline introduces two holes on bridges across the Thames. These are located in Walton-on-Thames and Molesey Lock.

RSI sites on the Molesey enclosure have been used to act as proxy RSI sites to provide origin-destination information for the holes. Proxy RSI records were cleaned such as to only include OD pairs with origins north of the Thames and destinations south of the Thames for southbound cross Thames movements, and vice versa for northbound movements.

These RSI records were then expanded to car (including minicab) counts taken from v17 of the HAMs count database. These counts are adjusted to November 2009.

Technical Note

Project:	**HAM Gravity Models**	Job No:	**60193936**
Subject:	**Treatment of Variability in Assembling Partial Observed Trip Matrices**		
Prepared by:	**Paul Hanson / Mark Jones**	Date:	**23rd March 2011**
Checked by:	**Eddie Strankalis / Mark Dazeley**	Date:	**5th April 2011**
Approved by:	**Paul Hanson**	Date:	**15th April 2011**
		V2	**28th April 2011**
		V3	**6th June 2011**
		V4	**12th July 2011**
		V5	**26th August 2011**

1. Introduction

1.1 Overview

This note describes part of the approach that will be applied to assimilate data for the London-wide partial observed matrices. The purpose of this note is to discuss the treatment of survey data errors in combining alternative estimates between particular matrix cells.

1.2 Approach

The data are processed in the following steps, which are discussed in more detail in the following sections of this note:

- first, the data are processed for individual sites to establish the expanded movements observed through the site and the sampling errors associated with those estimates of movements;
- secondly, the errors associated with the site itself (count quality and transposition) are considered;
- thirdly, the estimates for individual survey sites are accumulated across screenlines and cordons; and
- finally, the estimates from the individual screenlines and cordons are combined.

2. Glossary of Variable Used

Before describing the methodology used to derive the partially observed matrices, it is useful to define a list of variables/suffixes used when describing the matrix development process.

Table 1: Glossary of suffixes and variables used.

Suffix	**Description**
a	Denotes a given cell of the matrix, for a given purpose and time period.
s	Denotes an RSI site.
c	Denotes a cordon (i.e. a collection of sites).
Variable	**Description**
N	Population size (or count of vehicles (i.e. ATC or MCC) at a specified RSI site).
n	Sample size (or number of RSI records at a specified RSI site).
t	Observed number of trips (or number of unexpanded RSI records).
T	Estimate of number of trips (or number of expanded RSI records).
V	Variance/Error.
γ	Coefficient of variation (scale of the count non-sampling errors).
F	Represents degree of independence between individual matrix 'cells' that are accumulated to the count.
I	Index of dispersion, defined as *V/T.*

3. Creation of Partially Observed Matrices

3.1 RSI Site Based Calculations

3.1.1 Site Movement Estimates and Sampling Error

Vehicles intercepted at Road Side Interview (RSI) sites are a sample of all vehicles passing through the site. The derivation of estimates of trips from the sample of interviews and the associated sampling errors is set out in the Traffic Appraisal Manual (TAM), Appendix D13, which, assuming the sample follows a Binomial distribution and reflecting the fact that the sample is a relatively large proportion of the population[1], is as follows.

Let us select data for a defined period. Let T_a^s be the estimate of trips with property '*a*' (where, for example, '*a*' represents a cell of the trip matrix for a specific purpose) at survey site '*s*', then:

$$T_a^s = t_a^s \frac{N^s}{n^s}$$

Where:

- t_a^s is the number of trips in the sample with property '*a*';
- N^s is the population (count of vehicles); and
- n^s is the number of trips comprising the sample.

Note, N^s/n^s is the sampling factor. The variance T_a^s of is:

$$^{Sample}V_a^s = \frac{(N^s - n^s)}{n^s(n^s - 1)} T_a^s (n^s - t_a^s)$$

3.1.2 Count Related Errors (Transposition and Factoring)

As well as the sample error, we must also consider the error associated with quality of the count data and with transposition of RSI records.

A review of errors was undertaken in 1993, led by Russell Harris of the then HETA division of DfT. This defines the error as comprising a sampling error, a term related to the count (non-sampling term), and a product term. The product term represents the effect of uncertainties in the count on sample expansion and, given that it is of smaller magnitude, was judged to be negligible in developing guidance for ERICA.

Drawing on information available on the variability of counts, and assuming that the errors follow the Poisson distribution, as is typically observed and would be expected on theoretical grounds for counts, the non-sampling error term was defined by DfT as follows:

$$^{Count}V_a^s = T_a^s \gamma^2 F$$

[1] The sample is drawn from the population without replacement; an individual will not be surveyed more than once.

Where:

- γ is the coefficient of variation (indicator of scale of non sampling error); and
- *F* represents the degree of independence between individual 'cells' that are accumulated to the count. (Strictly errors for individual matrix cells might be correlated; however, the interpretation of the errors for individual matrix cells implicitly assumes independence. This tension was not fully resolved by DfT.

TAM section 10.3 explains that the 95% confidence interval of MCC counts (single day, cars) is +/-10% and for a 2+ week ATC is +/-5%. Taking the coefficient of variation[2] from these (approximately half) and squaring the index of dispersion[3] is respectively 0.0006 and 0.0025. If we then assume a flow of 1000 vehicles per hour the value of $F\gamma^2$ would be 0.6 for an ATC (of 2 + weeks) and 2.5 for a single day MCC. In the table below the value of *F* is assumed to be 1 and the γ^2 used to imply the overall error. Reading from the first row, the 0.6 for an ATC is rounded to 0.5 and the MCC is 2.5.

DfT's interpretation as set out in the ERICA guidance on the magnitude of error from different sources is set out below:

Table 2: Error sources and their corresponding coefficient of variation.

γ^2	Source	Error source
2.5 0.5	Where interviews are factored to MCC Where interviews factored to (2 week) ATC	Count accuracy
1 0.5 0	Where flow is based on 1 day count Based on a 1 week count Based on 2+ week's data	Day to day variability
1.5 0	If using national / regional data to factor count to average weekday If factoring is based on local data	Systematic Local variations in weekday flows
2.5 0	If using national / regional data to convert count to a different month If not factoring or factoring using local data	Systematic local seasonal/ monthly variations
6 (per year) 0	If factoring using national / regional growth rates If factoring using local data	Growth over time
10 5 0	If interviews are transposed If transposed records are constrained to count In survey direction	Transposing

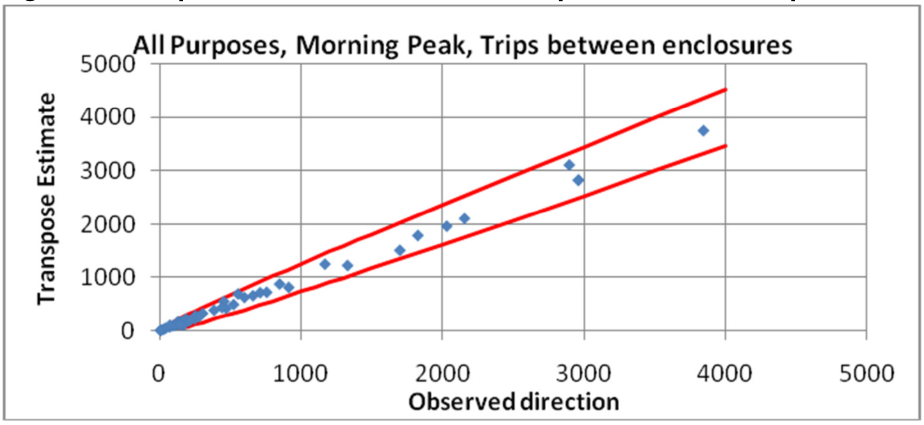
In respect of the data for London the surveys data (except for minor sites with relatively low flows) were expanded to 2 week ATCs. It is noted, however, that the counts were not undertaken at the time of the survey (the MCCs were on a different day to the survey), and where ATCs were undertaken, they were undertaken in a different month. While not covered in the guidance, we judge that that this practice could increase survey error. The guidance indicates a factor of 2.5 where counts are factored to a different month based on regional data and we propose to apply this as an interpretation of survey error. This implies:

- γ^2 = 3.0 = 0.5 +2.5 (interviews surveyed in 2008/9 expanded to 2 week counts, reflecting survey practice) for the observed direction; and
- γ^2 = 8.0 = 0.5 + 2.5 + 5.0 (transposed records are constrained to counts)

[2] Coefficient of Variation is defined as standard deviation divided by mean.
[3] Index of dispersion is defined as variance divided by mean.

In respect of transposed interview records, it is understood that, for cases where counts were available, it was judged that a factor of 5 would be appropriate. Whilst there are arguments that the errors due to transposing trips may be greater, we are not aware of substantive evidence available from which to draw soundly based conclusions. A limited review of the correlation of trips estimates between enclosures was made for WeLHAM. This compared the number of trips in the observed direction outbound from the origin enclosure with the number of trips, estimated after transposition, inbound to the destination enclosure. The figure below compares the two trip estimates; the red lines indicate the 95% confidence interval for the sampling error for the trip estimate from the interview direction data. While the scale of this comparison is insufficient to reach a definitive conclusion, it suggests that the transposition errors are of relatively small scale. We do not therefore propose a change from current guidance in the interpretation of the magnitude of error assumed for transposed trips.

Figure 1: Comparison of interview and transposed direction trip estimates.



In addition to the use of recent survey data, there are instances where we will draw upon 2001 LATS survey data and upon synthetic estimates to develop complete screenlines. While these have been controlled to recent counts, it is to be expected that these data will have greater variance than those derived from the more recent survey data.

With respect to the LATS 2001 data, the ERICA guidance suggests a value of 6 (per year) where growth is factored using national/regional growth rates or zero where local counts are used. Strictly the latter applies, as recent counts have been applied to factor the LATS data. Nevertheless, changes in the road network and in land use will have occurred since the 2001 surveys that may have affected the pattern of movements through individual sites and a value greater than zero would seem appropriate. The guidance also suggests a value of 1.5 reflecting variation between weekdays and 2.5 reflecting month to month variations. We propose therefore to assume a value of 2 per year, being between 1.5 and 2.5, as an indication of the uncertainty attributable to use of LATS 2001 data. Given the 8 years from 2001 to the 2009 base year, this implies a factor of 16. This implies:

- γ^2 = 19.0 = 16 + 0.5 + 2.5 (old data, expanded to 2 week counts converted to model month) for the observed direction; and
- γ^2 = 24.0 = 16 + 0.5 + 2.5 + 5.0 (transposed records are constrained to counts)

The ERICA guidance does not provide advice in respect of the use of synthetic data. Limited research is available on the errors of synthetic trip matrices. An empirical review[4] of errors in trip synthesis fitted a relationship to the additional variance (above that from sampling errors). This relationship implies a

[4] Zonal Trip Flow Error Analysis, J Haskey, MAU Note 241, 1972. A General Investigation into the efficiency of trip distribution models, J Haskey, MAU Note 244, 1973

variance factor of 25. This is slightly larger than the value imputed for use of LATS 2001 data and implies:

- γ^2 = 28.0 = 25.0 + 0.5 + 2.5 (reflecting also count errors as previously discussed; the data are synthetic so the same error applies in both directions through the site)

This is additional to the sampling error and an additional assumption is required to impute an estimate of the factor which is equivalent to the sample variance at surveyed sites. For this we will assume N^s/n^s is about 10%, in line with the typical survey sampling rate in the London data.

3.1.3 Total Error (Sampling and Transposition/Age of Counts)

Combining the sampling and non sampling error terms we have:

$$^{Total}V_a^s = {}^{Sample}V_a^s + {}^{Count}V_a^s$$

3.1.4 Summary of Site Movement Estimates – A Worked Example

Suppose we have a site with (N^s=) 1000 vehicles and a sample of (n^s=) 100, and that there were also 1000 vehicles in the reverse direction. We have one observation from the sample in our cell/purpose. Then we can derive:

Interview Direction:

$T_a^s = \mathbf{10}$

$^{Sample}V_a^s = 9\mathbf{0}$; $^{Count}V_a^s = 3\mathbf{0;}$

$^{Total}V_a^s = 12\mathbf{0}$

Non-Interview Direction:

$T_a^s = \mathbf{10}$

$^{Sample}V_a^s = 9\mathbf{0}$; $^{Count}V_a^s = 8\mathbf{0;}$

$^{Total}V_a^s = 17\mathbf{0}$

If the data were sourced from LATS 2001 data, this would imply:

Interview Direction:

$T_a^s = \mathbf{10}$

$^{Sample}V_a^s = 9\mathbf{0}$; $^{Count}V_a^s = 19\mathbf{0;}$

$^{Total}V_a^s = 28\mathbf{0}$

Non-Interview Direction:

$T_a^s = \mathbf{10}$

$^{Sample}V_a^s = 9\mathbf{0}$; $^{Count}V_a^s = 24\mathbf{0;}$

$^{Total}V_a^s = 33\mathbf{0}$

And similarly where data are synthesised:

Both Directions:

$T_a^s = \mathbf{10}$

$^{Sample}V_a^s = 9\mathbf{0}$; $^{Count}V_a^s = 22\mathbf{0;}$ $^{Total}V_a^s = 31\mathbf{0}$

3.2 Screenline/Cordon Partial Matrices

3.2.1 Expanded Trip Matrices

Enclosures and screenlines were defined covering sites on adjacent/alternative routes. Trip estimates, therefore, are accumulated across screenlines/cordons and, denoting the survey site comprising the screenline or cordon by the suffix '*c*', an estimate of trips derived from all sites on the screenline or cordon is given by:

$$T_a^c = \sum_{s \in c} T_a^s$$

3.2.2 Total Error (Sampling and Transposition/Age of Counts)

Surveys at each RSI site are independent; because of this, we can calculate the total error on the cordon/screenline by summing the error from each RSI site. This is defined as:

$$^{Total}V_a^c = \sum_{s \in c} {}^{Total}V_a^s$$

where the suffix '*s*' is included to denote the estimates of the numbers of trips and the variance of those estimates for each of the sites comprising the screenline or cordon.

3.3 Merging Trip Estimates Across Cordons

Having derived an estimate of trips from two or more screenlines/cordons the next stage is to combine these according with their relative reliability. The enclosure cordons are based on distinct survey sites and are thus independent. For screenlines, however, the enclosure sites are also used where relevant. Duplication will be avoided by excluding matrix cells within such enclosures from the screenline matrices (as these trips are recorded to/from the enclosure cordon).

The error distribution has the Poisson property of the variance increasing with the mean. The variances are therefore first “normalised”; the index of dispersion provides a suitable measure of confidence in the estimate that does not increase with the value of the estimate of trips in the cell:

$$I_a^c = \frac{{}^{Total}V_a^c}{T_a^c}$$

For two cordons the combined estimate is then given by:

$$T_a^{Total} = \frac{\frac{T_a^{c1}}{I_a^{c1}} + \frac{T_a^{c2}}{I_a^{c2}}}{\frac{1}{I_a^{c1}} + \frac{1}{I_a^{c2}}}$$

This can be generalised across all screenlines/cordons that intercept movement ‘*a*’:

$$T_a^{Total} = \frac{\sum_c \frac{T_a^c}{I_a^c}}{\sum_c \frac{1}{I_a^c}}$$

Application requires consideration of matrix cells where no trips were observed. For these cells the index of dispersion is assumed to be the average of the index of dispersion for the cells with observed non-zero trips crossing the cordon.

Appendix C. Matrix sector system analysis

Mott MacDonald

Table C.1: AM 2012 Prior Matrix Cars

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	TOTAL
Rest of UK South River	1	3835280	9552	6161	21918	14471	2312	505	263	229	269	330	778	99	96	61	938	126	99	98	171	796	**3894551**
Essex	2	9740	89526	538	319	166	1014	199	899	2062	3599	57	194	496	1100	26	386	59	67	152	339	295	**111233**
Kent	3	5206	406	103562	373	565	69	12	32	114	295	27	17	156	187	28	194	102	263	1258	3236	2543	**118642**
NW London	4	18054	280	222	116311	4715	2225	2073	295	118	40	2556	800	100	46	587	537	322	87	54	27	102	**149550**
SW London	5	13700	102	440	6031	72314	34	43	34	26	22	131	46	62	18	100	155	2934	1125	262	128	3890	**101596**
Enfield	6	1941	911	34	2571	65	10526	2099	769	360	132	325	270	180	123	30	130	32	7	15	3	10	**20533**
Haringey	7	512	156	2	1966	61	1502	3048	303	85	32	667	395	54	30	45	101	35	13	11	0	2	**9022**
Waltham Forest	8	398	828	32	377	41	662	326	3713	1242	202	176	729	900	253	36	422	34	7	10	6	12	**10407**
Redbridge	9	290	2047	150	244	44	333	138	1469	6585	1199	91	390	1103	1410	37	455	26	11	55	6	20	**16101**
Havering	10	434	2975	429	78	23	114	50	199	1126	9247	23	102	326	1771	16	190	11	1	13	30	21	**17180**
Islington	11	74	14	32	1429	98	102	326	83	23	6	2462	831	36	6	168	209	43	21	20	8	2	**5993**
Hackney	12	267	78	40	717	52	143	309	485	156	32	1031	2747	213	35	124	661	34	16	22	13	24	**7198**
Newham	13	84	491	101	281	73	150	81	704	945	334	148	490	4977	832	97	1084	28	42	58	13	29	**11042**
Barking and Dagenham	14	120	971	201	90	43	86	40	181	1327	1723	30	119	606	3781	19	241	38	16	32	13	17	**9696**
London City	15	19	3	7	413	37	7	16	9	4	2	223	135	22	4	596	197	26	10	11	3	6	**1749**
Tower Hamlets	16	205	100	139	471	98	31	60	200	151	62	345	821	687	132	273	3542	113	41	115	65	32	**7683**
Southwark	17	142	21	38	487	2360	32	24	26	21	12	47	39	36	21	75	120	5004	1152	304	76	291	**10328**
Lewisham	18	197	99	191	241	1056	26	11	15	23	5	32	21	62	19	9	91	1446	4736	1132	404	1575	**11393**
Greenwich	19	120	155	709	151	319	11	11	11	24	19	17	45	118	20	22	214	422	1106	6600	2603	996	**13695**
Bexley	20	281	481	3127	83	241	10	3	5	21	43	3	4	57	20	42	172	256	528	3022	9147	1518	**19063**
Bromley	21	751	221	2036	161	3625	15	3	7	2	23	9	16	44	14	23	141	431	1669	1101	1478	15834	**27603**
TOTAL		**3887814**	**109415**	**118190**	**154711**	**100468**	**19406**	**9377**	**9704**	**14647**	**17296**	**8730**	**8988**	**10334**	**9918**	**2413**	**10181**	**11521**	**11017**	**14346**	**17770**	**28015**	**4574260**

Table C.2: AM 2009 Prior Matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	TOTAL
Rest of UK South River	**1**	176,463	3,950	3,531	22,218	13,235	2,172	498	353	395	269	276	308	186	122	47	421	210	288	124	218	716	**225,999**
Essex	**2**	3,965	22,528	658	392	64	1,054	168	1,006	2,427	4,037	74	299	696	1,276	46	687	83	72	239	333	197	**40,301**
Kent	**3**	3,690	1,253	19,134	89	582	35	17	59	124	597	36	98	176	342	23	401	182	463	1,603	3,543	2,725	**35,173**
NW London	**4**	17,323	302	17	106,467	8,785	2,595	2,603	245	160	34	2,489	838	120	48	621	763	1,109	133	86	22	65	**144,826**
SW London	**5**	13,511	29	387	12,497	64,894	24	39	18	16	6	211	137	48	10	192	365	3,510	1,197	273	117	3,624	**101,106**
Enfield	**6**	1,729	772	16	2,509	49	8,680	1,689	554	392	76	339	288	125	90	42	253	68	27	67	22	15	**17,802**
Haringey	**7**	269	69	7	2,300	79	1,402	2,808	233	84	12	817	436	41	22	71	144	80	16	37	11	8	**8,943**
Waltham Forest	**8**	281	1,046	40	380	57	642	276	3,450	1,599	164	148	591	1,093	246	56	735	59	48	125	35	41	**11,113**
Redbridge	**9**	351	2,282	75	323	98	406	139	1,394	6,961	1,146	98	517	1,540	1,383	87	1,004	132	82	237	78	67	**18,399**
Havering	**10**	284	3,598	305	109	45	127	40	229	1,412	12,796	31	134	365	2,087	24	313	38	25	73	72	66	**22,170**
Islington	**11**	65	14	10	1,622	161	138	441	63	18	4	2,088	619	21	7	157	226	173	22	24	7	9	**5,889**
Hackney	**12**	271	133	28	749	193	195	409	414	260	27	853	1,986	278	42	127	867	102	37	83	38	48	**7,139**
Newham	**13**	113	581	72	272	132	166	68	660	1,253	277	90	415	4,837	670	87	1,488	143	99	270	78	91	**11,864**
Barking and Dagenham	**14**	120	1,190	128	109	44	99	39	206	1,445	1,944	33	132	644	3,720	26	374	45	28	74	35	32	**10,469**
London City	**15**	6	4	1	440	112	8	16	8	7	2	168	101	20	3	454	205	55	9	5	1	4	**1,629**
Tower Hamlets	**16**	78	139	86	445	186	49	65	172	216	57	240	640	631	109	209	3,568	236	77	161	55	56	**7,475**
Southwark	**17**	97	24	85	967	2,349	17	19	15	21	7	115	88	50	11	123	404	5,109	1,334	371	87	342	**11,634**
Lewisham	**18**	153	75	312	212	1,168	12	10	16	22	9	27	36	43	15	19	138	1,572	5,030	1,346	449	1,776	**12,440**
Greenwich	**19**	128	190	1,033	136	340	19	17	47	66	36	40	72	125	34	14	276	408	1,281	6,660	2,968	1,127	**15,018**
Bexley	**20**	218	634	3,231	64	263	14	10	30	43	102	22	54	83	51	11	198	252	627	3,175	8,263	1,749	**19,092**
Bromley	**21**	658	235	2,310	120	3,591	5	4	14	23	128	12	29	59	26	8	113	595	1,804	1,162	1,448	13,061	**25,408**
TOTAL		**219,773**	**39,048**	**31,464**	**152,421**	**96,428**	**17,859**	**9,377**	**9,188**	**16,942**	**21,729**	**8,206**	**7,820**	**11,184**	**10,313**	**2,445**	**12,941**	**14,160**	**12,698**	**16,195**	**17,880**	**25,818**	**753,890**

Table C.3: IP 2012 Prior Matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	TOTAL
Rest of UK South River	1	2648492	6272	4002	11974	9985	1253	230	165	152	160	231	150	81	91	29	126	50	40	45	89	420	**2684037**
Essex	2	6279	59097	531	125	88	475	83	639	1369	2062	13	85	372	552	30	120	30	91	159	492	257	**72950**
Kent	3	3517	508	72429	107	268	26	8	28	113	353	13	17	82	162	22	133	17	73	385	1719	1227	**81207**
NW London	4	13375	175	134	94787	3141	1458	1239	180	102	20	1631	431	73	30	352	378	269	84	57	27	73	**118016**
SW London	5	10236	108	277	3524	58664	34	30	25	25	12	62	43	42	11	39	93	2019	715	151	80	2295	**78485**
Enfield	6	1314	555	26	1325	25	8664	1174	422	275	52	93	121	115	65	37	60	9	11	11	5	4	**14364**
Haringey	7	335	97	8	1298	38	1268	2713	148	71	13	606	329	31	20	53	58	17	10	6	1	4	**7125**
Waltham Forest	8	263	643	29	184	23	344	149	3478	1015	128	72	403	716	141	33	187	16	13	21	10	3	**7870**
Redbridge	9	237	1410	112	140	27	196	72	893	5808	977	38	219	1046	1129	56	249	19	11	26	9	7	**12682**
Havering	10	209	1963	374	31	14	44	13	111	883	9104	6	38	303	1530	36	94	8	1	9	37	11	**14819**
Islington	11	283	14	21	1642	68	129	514	74	30	3	2674	915	36	5	45	209	31	14	8	5	3	**6724**
Hackney	12	187	101	29	500	45	164	352	407	198	34	826	2583	190	35	94	564	26	29	32	6	9	**6411**
Newham	13	176	380	82	145	46	86	32	573	971	265	48	225	5123	565	55	815	30	40	94	22	20	**9795**
Barking and Dagenham	14	237	667	169	41	10	55	21	160	1149	1532	12	55	694	3804	48	134	10	8	30	14	20	**8873**
London City	15	38	34	20	484	42	38	48	27	27	19	80	66	55	30	304	244	57	5	4	8	5	**1634**
Tower Hamlets	16	328	166	155	421	111	29	60	192	181	55	250	677	710	106	196	3677	106	60	133	77	41	**7732**
Southwark	17	99	45	35	302	2062	10	22	17	20	11	28	23	30	17	60	109	4524	916	273	102	250	**8954**
Lewisham	18	230	103	176	88	753	11	14	11	4	1	15	23	39	13	10	45	932	4044	1037	405	1280	**9232**
Greenwich	19	141	172	565	83	267	14	4	22	25	16	12	44	118	33	10	123	299	991	5945	2295	699	**11879**
Bexley	20	187	495	1727	29	104	1	1	14	3	39	2	2	9	28	3	59	87	279	1924	8949	1108	**15051**
Bromley	21	512	290	1289	92	2869	5	1	7	22	11	3	11	24	22	3	31	273	1469	702	1167	13421	**22223**
TOTAL		**2686676**	**73296**	**82192**	**117323**	**78649**	**14304**	**6779**	**7594**	**12445**	**14871**	**6714**	**6459**	**9888**	**8388**	**1516**	**7509**	**8828**	**8905**	**11053**	**15518**	**21157**	**3200063**

Table C.4: 2009 Prior Matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	TOTAL
Rest of UK South River	1	127,025	3,159	2,982	14,601	14,312	1,440	237	205	199	197	192	161	85	66	6	103	47	36	99	102	1,634	**166,886**
Essex	2	3,157	14,776	644	199	23	828	134	776	1,719	3,225	29	115	490	844	5	175	26	33	118	271	119	**27,705**
Kent	3	2,866	1,047	14,793	25	248	14	7	41	79	482	9	45	113	196	2	114	44	209	736	2,612	1,705	**25,389**
NW London	4	16,959	236	16	102,367	7,888	2,264	2,048	178	113	38	1,901	402	91	46	432	376	749	88	49	18	39	**136,297**
SW London	5	12,658	29	303	10,274	65,101	19	31	20	18	7	104	80	52	11	96	231	2,146	943	185	102	2,837	**95,247**
Enfield	6	1,408	557	8	1,828	12	9,269	1,522	406	230	60	194	142	83	79	8	72	15	9	24	12	5	**15,943**
Haringey	7	300	60	4	1,898	32	1,555	2,934	189	62	18	652	299	28	31	24	69	29	7	19	8	4	**8,221**
Waltham Forest	8	224	891	28	276	30	788	329	3,187	1,228	174	103	478	922	227	22	314	36	30	82	39	23	**9,430**
Redbridge	9	297	1,747	63	251	32	486	181	1,210	5,986	1,185	45	255	1,226	1,412	20	369	55	50	130	71	29	**15,099**
Havering	10	184	2,577	251	51	17	92	29	147	1,086	11,980	8	44	269	1,950	5	89	15	12	40	71	41	**18,957**
Islington	11	116	20	15	1,948	148	198	590	82	22	9	2,314	691	27	12	227	215	141	19	21	8	7	**6,831**
Hackney	12	88	165	30	540	98	225	419	439	257	55	749	1,997	323	76	179	828	125	35	80	40	25	**6,773**
Newham	13	110	466	68	132	57	170	69	630	1,063	265	39	245	4,650	661	29	782	91	68	219	107	56	**9,977**
Barking and Dagenham	14	86	922	117	57	22	107	44	210	1,378	1,930	14	69	776	3,925	9	154	23	18	55	42	23	**9,979**
London City	15	5	6	2	527	128	9	20	13	11	3	165	120	34	7	666	252	164	14	9	3	6	**2,165**
Tower Hamlets	16	116	211	117	411	180	79	78	252	291	88	244	748	754	138	271	3,987	345	98	187	96	64	**8,753**
Southwark	17	92	45	63	876	2,235	8	13	25	27	9	60	105	81	17	191	356	4,419	1,097	310	110	282	**10,422**
Lewisham	18	123	74	342	136	890	9	7	24	26	12	15	34	61	14	12	99	1,137	4,391	1,280	532	1,381	**10,599**
Greenwich	19	178	168	856	117	239	16	13	58	66	27	17	73	161	34	17	171	311	1,252	5,740	3,183	814	**13,512**
Bexley	20	181	464	2,378	26	113	7	4	26	73	107	6	32	76	46	4	77	104	422	2,779	9,766	1,391	**18,082**
Bromley	21	488	152	1,892	59	2,969	4	3	13	16	24	4	17	36	12	2	44	294	1,784	978	1,552	13,290	**23,633**
TOTAL		**166,660**	**27,771**	**24,972**	**136,601**	**94,775**	**17,587**	**8,712**	**8,131**	**13,952**	**19,895**	**6,862**	**6,152**	**10,338**	**9,803**	**2,227**	**8,877**	**10,315**	**10,614**	**13,139**	**18,742**	**23,775**	**639,901**

Table C.5: PM 2012 Prior Matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	TOTAL
Rest of UK South River	1	4,108,594	11,690	6,561	21,359	17,189	2,385	569	398	313	301	179	159	127	104	17	95	74	69	107	242	1,002	**4,171,534**
Essex	2	11,051	98,471	568	303	151	972	201	1,057	2,275	3,782	38	170	712	935	6	219	30	117	237	658	356	**122,311**
Kent	3	6,482	626	115,440	199	629	42	3	55	217	578	33	106	163	253	5	216	40	204	897	3,135	2,356	**131,680**
NW London	4	25,369	585	332	134,021	6,512	3,023	2,481	447	260	90	2,095	659	212	68	480	436	477	191	235	94	147	**178,215**
SW London	5	17,469	184	751	5,499	78,537	51	74	42	56	25	122	101	103	43	58	103	2,629	1,132	357	308	4,411	**112,056**
Enfield	6	2,286	1,245	48	2,275	33	11,095	1,837	937	576	181	187	244	276	123	8	89	18	17	16	16	8	**21,516**
Haringey	7	762	233	11	2,014	61	2,025	3,722	342	167	55	530	466	88	37	19	87	35	12	19	11	8	**10,703**
Waltham Forest	8	453	1,133	57	354	30	754	329	4,027	1,834	284	132	685	1,062	237	17	361	43	11	33	11	10	**11,856**
Redbridge	9	296	2,611	130	221	43	426	145	1,504	7,484	1,378	64	318	1,347	1,383	14	364	35	24	56	40	5	**17,888**
Havering	10	656	3,647	366	87	20	146	44	237	1,172	10,941	15	72	455	2,009	4	153	16	10	39	70	29	**20,189**
Islington	11	356	67	19	2,850	154	318	725	180	75	18	2,908	1,140	105	15	292	335	72	21	39	7	8	**9,705**
Hackney	12	205	225	16	842	100	333	517	701	352	85	1,018	2,852	422	68	190	884	61	31	50	14	10	**8,977**
Newham	13	319	617	258	186	102	189	76	876	1,235	408	70	307	5,502	825	30	854	67	84	216	115	64	**12,401**
Barking and Dagenham	14	266	1,328	236	83	21	148	50	284	1,599	2,386	20	81	1,107	4,180	8	230	26	23	89	42	23	**12,228**
London City	15	83	27	21	1,011	142	30	44	27	24	15	308	185	106	19	1,046	362	80	12	25	20	16	**3,605**
Tower Hamlets	16	517	408	320	766	192	165	153	397	368	162	338	917	1,087	217	287	4,156	206	121	225	202	100	**11,303**
Southwark	17	234	100	164	456	3,018	19	36	42	51	20	64	66	58	38	72	155	5,112	1,412	463	248	431	**12,261**
Lewisham	18	184	121	434	133	1,274	-1	13	3	22	7	28	32	52	21	13	64	1,329	5,421	1,245	650	1,948	**12,993**
Greenwich	19	146	198	1,566	138	366	10	23	23	137	26	43	48	79	55	25	140	361	1,309	7,632	3,974	1,114	**17,414**
Bexley	20	315	399	3,807	43	241	16	6	5	31	48	1	29	15	22	15	57	98	426	3,075	11,078	1,750	**21,476**
Bromley	21	831	337	2,511	77	4,486	2	26	28	17	26	3	6	18	15	9	23	376	2,300	1,245	1,874	16,899	**31,109**
TOTAL		**4,176,872**	**124,253**	**133,618**	**172,919**	**113,303**	**22,150**	**11,072**	**11,611**	**18,269**	**20,814**	**8,199**	**8,641**	**13,097**	**10,668**	**2,615**	**9,383**	**11,186**	**12,948**	**16,300**	**22,810**	**30,695**	**4,951,419**

Table C.6: 2009 Prior Matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	TOTAL
Rest of UK South River	1	188,801	4,752	4,057	21,075	16,345	2,308	485	396	382	368	164	123	176	139	8	73	63	74	158	239	1,329	**241,515**
Essex	2	4,546	20,122	1,001	270	54	921	130	1,054	2,178	4,428	25	122	729	1,401	4	164	21	54	192	534	270	**38,221**
Kent	3	3,991	1,190	19,657	33	540	28	9	66	137	748	8	42	152	308	1	100	47	313	958	3,766	2,425	**34,517**
NW London	4	26,140	660	61	112,068	11,370	3,220	2,721	324	220	84	1,871	532	168	94	304	394	778	186	112	58	124	**161,489**
SW London	5	15,238	58	596	10,218	65,426	41	55	24	29	17	107	83	106	31	54	219	2,015	1,245	337	274	3,646	**99,819**
Enfield	6	1,857	936	19	2,200	33	8,074	1,487	543	338	115	199	174	124	102	8	58	25	14	38	24	14	**16,381**
Haringey	7	501	152	13	2,203	65	1,656	2,897	236	87	24	593	334	44	32	20	69	45	15	27	16	10	**9,040**
Waltham Forest	8	402	1,229	40	343	38	657	333	3,407	1,561	228	120	433	1,154	287	12	304	26	26	83	45	38	**10,767**
Redbridge	9	357	2,406	89	243	48	457	164	1,461	6,011	1,401	47	241	1,516	1,611	14	334	47	48	147	98	50	**16,789**
Havering	10	349	3,755	383	67	28	113	24	246	1,328	12,570	7	45	384	2,260	3	87	14	18	57	116	88	**21,942**
Islington	11	265	58	24	2,482	306	294	707	126	56	14	2,126	722	42	24	192	209	221	52	44	25	27	**8,018**
Hackney	12	170	301	61	925	234	319	664	574	438	79	1,053	2,027	535	118	141	808	114	51	101	60	55	**8,829**
Newham	13	182	630	105	166	95	187	74	837	1,337	280	40	243	4,503	679	17	690	62	69	206	109	94	**10,605**
Barking and Dagenham	14	159	1,469	205	75	31	137	43	311	1,559	2,241	18	68	924	3,672	5	163	19	24	72	69	44	**11,309**
London City	15	37	15	11	644	233	28	43	18	18	5	133	126	53	18	453	226	124	29	19	9	22	**2,265**
Tower Hamlets	16	322	480	293	776	409	184	172	465	643	139	332	812	1,133	245	188	3,910	346	155	284	184	160	**11,630**
Southwark	17	266	62	152	950	2,755	23	32	40	55	12	78	74	121	28	74	270	3,982	1,253	450	219	444	**11,340**
Lewisham	18	156	141	511	153	1,322	14	10	45	59	16	17	34	114	20	7	87	1,092	4,287	1,400	725	1,716	**11,927**
Greenwich	19	228	306	1,450	133	397	44	26	119	149	48	31	74	281	59	4	188	318	1,440	6,283	3,810	1,214	**16,602**
Bexley	20	285	856	3,394	35	230	16	9	45	68	151	9	31	110	66	1	73	87	487	2,594	10,650	1,780	**20,977**
Bromley	21	702	327	2,456	84	3,971	11	7	34	44	63	9	23	79	31	2	53	334	2,068	1,226	1,869	12,275	**25,666**
TOTAL		**244,954**	**39,906**	**34,577**	**155,144**	**103,929**	**18,732**	**10,094**	**10,371**	**16,697**	**23,032**	**6,987**	**6,364**	**12,449**	**11,225**	**1,511**	**8,480**	**9,780**	**11,907**	**14,788**	**22,897**	**25,824**	**789,647**

Appendix D. Screenline Analysis

D.1 2009 prior matrix results

Table D.1: 2009 AM peak Prior Matrix results

			Actual Flow (Vehicles)						Demand Flow (Vehicles)					
			Total			Car			Total			Car		
Screenline	Direction	No. of sites	Observed	Modelled	% Diff	Observed	Modelled	% Diff	Observed	Modelled	% Diff	Observed	Modelled	% Diff
BarkingE-W	1	6	3,239	3,831	18%	2,681	3,074	15%	3,239	3,936	22%	2,681	3,157	18%
BarkingE-W	2	6	4,815	4,536	-6%	4,020	3,773	-6%	4,815	4,617	-4%	4,020	3,843	-4%
BarkingN-S	1	17	11,886	10,912	-8%	9,246	8,525	-8%	11,886	11,672	-2%	9,246	9,106	-2%
BarkingN-S	2	17	8,824	9,482	7%	6,860	7,284	6%	8,824	9,723	10%	6,860	7,470	9%
BexleyE-W	1	15	5,420	5,520	2%	4,501	4,903	9%	5,420	5,643	4%	4,501	5,015	11%
BexleyE-W	2	16	4,583	3,951	-14%	3,567	3,345	-6%	4,583	4,075	-11%	3,567	3,455	-3%
BexleyN-S	1	31	10,738	10,599	-1%	8,448	8,520	1%	10,738	10,994	2%	8,448	8,833	5%
BexleyN-S	2	32	9,004	8,929	-1%	7,121	7,226	1%	9,004	9,151	2%	7,121	7,404	4%
BoundaryS	1	7	10,454	10,997	5%	8,108	8,283	2%	10,454	11,413	9%	8,108	8,594	6%
BoundaryS	2	7	8,324	9,431	13%	6,650	7,573	14%	8,324	9,992	20%	6,650	8,015	21%
Deptford	1	6	4,284	4,288	0%	3,051	3,091	1%	4,284	4,529	6%	3,051	3,266	7%
Deptford	2	6	2,656	2,870	8%	2,108	2,170	3%	2,656	2,944	11%	2,108	2,227	6%
HaroldHillN-S	1	8	6,699	5,823	-13%	5,626	4,821	-14%	6,699	6,015	-10%	5,626	4,980	-11%
HaroldHillN-S	2	8	4,343	4,360	0%	3,679	3,606	-2%	4,343	4,442	2%	3,679	3,675	0%
Inner North	1	6	8,440	8,068	-4%	5,862	5,661	-3%	8,440	8,263	-2%	5,862	5,806	-1%
Inner North	2	6	5,572	5,124	-8%	4,019	3,582	-11%	5,572	5,389	-3%	4,019	3,772	-6%
RiverRom	1	10	8,911	9,675	9%	7,012	7,467	6%	8,911	9,979	12%	7,012	7,698	10%
RiverRom	2	9	7,696	8,525	11%	5,980	6,950	16%	7,696	8,760	14%	5,980	7,139	19%
Sidcup	1	14	7,494	8,569	14%	6,196	6,874	11%	7,494	8,931	19%	6,196	7,167	16%
Sidcup	2	14	7,786	8,765	13%	6,221	6,846	10%	7,786	9,095	17%	6,221	7,107	14%
Homerton	1	6	2,662	2,942	11%	2,040	1,947	-5%	2,662	3,104	17%	2,040	2,061	1%
Homerton	2	7	2,122	1,451	-32%	1,640	845	-48%	2,122	1,537	-28%	1,640	903	-45%
GreatEastern (west)	1	16	5,136	6,034	17%	3,644	4,051	11%	5,136	6,360	24%	3,644	4,269	17%
GreatEastern (west)	2	17	5,828	6,784	16%	4,023	4,444	10%	5,828	7,201	24%	4,023	4,719	17%
GreatEastern (east)	1	26	19,293	17,936	-7%	14,940	13,896	-7%	19,293	18,644	-3%	14,940	14,424	-3%
GreatEastern (east)	2	25	20,851	19,726	-5%	16,084	15,109	-6%	20,851	20,120	-4%	16,084	15,418	-4%
Hackney North	1	19	3,438	3,561	4%	2,417	2,489	3%	3,438	3,851	12%	2,417	2,696	12%
Hackney North	2	18	2,961	2,656	-10%	2,238	1,991	-11%	2,961	2,777	-6%	2,238	2,086	-7%
Whitechapel	1	18	5,822	5,698	-2%	3,384	3,533	4%	5,822	6,016	3%	3,384	3,732	10%
Whitechapel	2	18	4,097	4,320	5%	2,797	2,638	-6%	4,097	4,542	11%	2,797	2,786	0%
Ravensbourne	1	4	3,953	4,115	4%	2,726	2,974	9%	3,953	4,344	10%	2,726	3,143	15%
Ravensbourne	2	4	2,425	2,751	13%	1,744	2,111	21%	2,425	2,847	17%	1,744	2,186	25%
LewishamDartford (west)	1	14	10,268	10,305	0%	8,048	8,289	3%	10,268	10,724	4%	8,048	8,629	7%
LewishamDartford (west)	2	14	9,156	8,588	-6%	7,127	6,728	-6%	9,156	8,930	-2%	7,127	6,998	-2%
LewishamDartford (east)	1	20	8,926	8,586	-4%	6,968	6,481	-7%	8,926	9,146	2%	6,968	6,892	-1%
LewishamDartford (east)	2	20	9,071	9,918	9%	7,177	7,679	7%	9,071	10,266	13%	7,177	7,944	11%
Eltham North	1	6	3,265	3,274	0%	2,578	2,656	3%	3,265	3,414	5%	2,578	2,775	8%
Eltham North	2	6	2,453	2,603	6%	1,945	2,270	17%	2,453	2,675	9%	1,945	2,336	20%
Eltham South	1	7	8,247	7,979	-3%	6,560	6,446	-2%	8,247	8,356	1%	6,560	6,752	3%
Eltham South	2	7	6,117	5,938	-3%	4,920	4,665	-5%	6,117	6,160	1%	4,920	4,839	-2%
West of A406	1	11	19,565	17,506	-11%	15,138	14,153	-7%	19,565	18,270	-7%	15,138	14,763	-2%
West of A406	2	11	16,746	16,032	-4%	12,855	12,632	-2%	16,746	16,394	-2%	12,855	12,915	0%
River Screenline	1	7	9,870	10,992	11%	6,626	6,741	2%	9,870	12,145	23%	6,626	7,499	13%
River Screenline	2	7	9,843	10,813	10%	6,037	6,173	2%	9,843	11,280	15%	6,037	6,436	7%

			Actual Flow (Vehicles)						Demand Flow (Vehicles)					
			Total			Car			Total			Car		
Screenline	Direction	No. of sites	Observed	Modelled	% Diff	Observed	Modelled	% Diff	Observed	Modelled	% Diff	Observed	Modelled	% Diff
Screenline A	1	9	3,508	3,554	1%	2,572	2,647	3%	3,508	3,686	5%	2,572	2,747	7%
Screenline A	2	9	4,456	5,088	14%	3,028	3,750	24%	4,456	5,361	20%	3,028	3,952	30%
Screenline C	1	15	12,294	11,563	-6%	8,451	7,846	-7%	12,294	12,228	-1%	8,451	8,298	-2%
Screenline C	2	15	12,831	11,378	-11%	9,650	7,873	-18%	12,831	11,719	-9%	9,650	8,112	-16%
Screenline D	1	2	2,710	3,101	14%	1,970	1,851	-6%	2,710	3,223	19%	1,970	1,924	-2%
Screenline D	2	2	5,611	4,770	-15%	4,150	3,359	-19%	5,611	5,068	-10%	4,150	3,576	-14%
Screenline E	1	7	2,529	2,114	-16%	1,894	1,218	-36%	2,529	2,150	-15%	1,894	1,241	-34%
Screenline E	2	7	2,754	1,699	-38%	2,106	1,019	-52%	2,754	1,765	-36%	2,106	1,062	-50%
Screenline F	1	4	1,919	1,764	-8%	1,492	1,272	-15%	1,919	1,838	-4%	1,492	1,328	-11%
Screenline F	2	4	2,850	3,175	11%	2,023	2,400	19%	2,850	3,393	19%	2,023	2,567	27%
Screenline G	1	7	3,963	4,167	5%	3,000	3,354	12%	3,963	4,476	13%	3,000	3,601	20%
Screenline G	2	7	2,940	3,060	4%	2,104	2,435	16%	2,940	3,183	8%	2,104	2,533	20%
Total			391,652	390,193	0%	297,053	293,540	-1%	361,652	406,756	4%	297,053	305,873	3%
No of Test D Passes					27			31			24			27
Test D Pass Rate					48%			55%			43%			48%

Table D.2: 2009 Interpeak Prior Matrix results

Screenline	Direction	No. of sites	Actual Flow (Vehicles) Total Observed	Actual Flow (Vehicles) Total Modelled	Actual Flow (Vehicles) Total % Diff	Actual Flow (Vehicles) Car Observed	Actual Flow (Vehicles) Car Modelled	Actual Flow (Vehicles) Car % Diff	Demand Flow (Vehicles) Total Observed	Demand Flow (Vehicles) Total Modelled	Demand Flow (Vehicles) Total % Diff	Demand Flow (Vehicles) Car Observed	Demand Flow (Vehicles) Car Modelled	Demand Flow (Vehicles) Car % Diff
BarkingE-W	1	6	3,513	3,618	3%	2,726	2,803	3%	3,513	3,648	4%	2,726	2,826	4%
BarkingE-W	2	6	3,877	3,633	-6%	3,057	2,892	-5%	3,877	3,644	-6%	3,057	2,900	-5%
BarkingN-S	1	17	8,700	8,953	3%	6,327	6,538	3%	8,700	9,033	4%	6,327	6,594	4%
BarkingN-S	2	17	9,356	8,915	-5%	6,800	6,387	-6%	9,356	8,980	-4%	6,800	6,434	-5%
BexleyE-W	1	15	4,483	4,265	-5%	3,446	3,533	3%	4,483	4,270	-5%	3,446	3,538	3%
BexleyE-W	2	16	4,785	4,545	-5%	3,705	3,830	3%	4,785	4,553	-5%	3,705	3,837	4%
BexleyN-S	1	31	7,998	7,606	-5%	5,905	5,585	-5%	7,998	7,631	-5%	5,905	5,603	-5%
BexleyN-S	2	32	8,599	8,323	-3%	6,306	6,235	-1%	8,599	8,353	-3%	6,306	6,258	-1%
BoundaryS	1	7	7,336	7,286	-1%	5,509	5,283	-4%	7,336	7,336	0%	5,509	5,318	-3%
BoundaryS	2	7	7,549	8,082	7%	5,507	5,825	6%	7,549	8,143	8%	5,507	5,868	7%
Deptford	1	6	3,293	3,009	-9%	2,333	2,191	-6%	3,293	3,025	-8%	2,333	2,203	-6%
Deptford	2	6	2,980	2,917	-2%	2,080	1,881	-10%	2,980	2,930	-2%	2,080	1,889	-9%
HaroldHillN-S	1	8	4,481	3,931	-12%	3,542	3,172	-10%	4,481	3,965	-12%	3,542	3,200	-10%
HaroldHillN-S	2	8	4,253	4,107	-3%	3,330	3,195	-4%	4,253	4,118	-3%	3,330	3,203	-4%
Inner North	1	6	6,295	5,525	-12%	4,215	3,713	-12%	6,295	5,556	-12%	4,215	3,735	-11%
Inner North	2	6	6,264	5,977	-5%	3,998	3,731	-7%	6,264	6,067	-3%	3,998	3,788	-5%
RiverRom	1	10	7,404	7,467	1%	5,245	5,614	7%	7,404	7,525	2%	5,245	5,655	8%
RiverRom	2	9	6,960	7,522	8%	5,004	5,556	11%	6,960	7,583	9%	5,004	5,598	12%
Sidcup	1	14	7,214	7,408	3%	5,478	5,465	0%	7,214	7,491	4%	5,478	5,525	1%
Sidcup	2	14	7,114	7,731	9%	5,452	5,760	6%	7,114	7,773	9%	5,452	5,792	6%
Homerton	1	6	2,356	2,309	-2%	1,763	1,350	-23%	2,356	2,389	1%	1,763	1,399	-21%
Homerton	2	7	2,434	2,071	-15%	1,817	1,222	-33%	2,434	2,104	-14%	1,817	1,244	-32%
GreatEastern (west)	1	16	5,625	5,870	4%	3,646	3,391	-7%	5,625	5,953	6%	3,646	3,439	-6%
GreatEastern (west)	2	17	5,199	6,053	16%	3,378	3,631	7%	5,199	6,098	17%	3,378	3,659	8%
GreatEastern (east)	1	26	17,005	16,806	-1%	12,148	12,200	0%	17,005	17,112	1%	12,148	12,406	2%
GreatEastern (east)	2	25	17,512	16,955	-3%	12,482	12,509	0%	17,512	17,050	-3%	12,482	12,580	1%
Hackney North	1	19	2,624	2,162	-18%	1,827	1,406	-23%	2,624	2,225	-15%	1,827	1,449	-21%
Hackney North	2	18	2,921	2,335	-20%	1,953	1,435	-27%	2,921	2,364	-19%	1,953	1,453	-26%
Whitechapel	1	18	4,870	4,482	-8%	2,954	2,742	-7%	4,870	4,515	-7%	2,954	2,763	-6%
Whitechapel	2	18	5,107	4,641	-9%	2,887	2,626	-9%	5,107	4,708	-8%	2,887	2,663	-8%
Ravensbourne	1	4	2,676	2,867	7%	1,863	2,131	14%	2,676	2,883	8%	1,863	2,144	15%
Ravensbourne	2	4	2,838	2,971	5%	1,877	2,087	11%	2,838	2,986	5%	1,877	2,097	12%
LewishamDartford (west)	1	14	7,742	7,379	-5%	5,763	5,248	-9%	7,742	7,442	-4%	5,763	5,293	-8%
LewishamDartford (west)	2	14	8,168	7,910	-3%	5,856	5,742	-2%	8,168	7,953	-3%	5,856	5,773	-1%
LewishamDartford (east)	1	20	7,320	7,261	-1%	5,312	5,281	-1%	7,320	7,297	0%	5,312	5,307	0%
LewishamDartford (east)	2	20	7,131	7,375	3%	5,209	5,289	2%	7,131	7,414	4%	5,209	5,318	2%
Eltham North	1	6	2,440	2,386	-2%	1,851	1,942	5%	2,440	2,389	-2%	1,851	1,945	5%
Eltham North	2	6	2,412	2,408	0%	1,738	1,949	12%	2,412	2,416	0%	1,738	1,954	12%
Eltham South	1	7	5,131	5,106	0%	3,841	3,613	-6%	5,131	5,136	0%	3,841	3,634	-5%
Eltham South	2	7	5,960	5,763	-3%	4,284	4,269	0%	5,960	5,800	-3%	4,284	4,296	0%
West of A406	1	11	14,242	14,460	2%	10,186	10,805	6%	14,242	14,579	2%	10,186	10,892	7%
West of A406	2	11	16,227	15,425	-5%	11,308	11,303	0%	16,227	15,517	-4%	11,308	11,370	1%
River Screenline	1	7	8,937	9,528	7%	5,393	5,737	6%	8,937	10,015	12%	5,393	6,034	12%
River Screenline	2	7	8,943	10,187	14%	5,333	6,253	17%	8,943	10,295	15%	5,333	6,317	18%
Screenline A	1	9	3,672	3,458	-6%	2,331	2,318	-1%	3,672	3,485	-5%	2,331	2,336	0%

Screenline	Direction	No. of sites	Actual Flow (Vehicles)						Demand Flow (Vehicles)					
			Total			Car			Total			Car		
			Observed	Modelled	% Diff	Observed	Modelled	% Diff	Observed	Modelled	% Diff	Observed	Modelled	% Diff
Screenline A	2	9	3,218	3,525	10%	2,180	2,574	18%	3,218	3,543	10%	2,180	2,588	19%
Screenline C	1	15	11,154	10,717	-4%	7,523	6,775	-10%	11,154	10,789	-3%	7,523	6,821	-9%
Screenline C	2	15	11,410	10,550	-8%	7,517	6,969	-7%	11,410	10,652	-7%	7,517	7,035	-6%
Screenline D	1	2	3,426	3,442	0%	2,315	2,024	-13%	3,426	3,470	1%	2,315	2,041	-12%
Screenline D	2	2	3,674	3,725	1%	2,353	2,253	-4%	3,674	3,762	2%	2,353	2,276	-3%
Screenline E	1	7	2,716	2,193	-19%	1,940	1,320	-32%	2,716	2,201	-19%	1,940	1,325	-32%
Screenline E	2	7	2,308	1,553	-33%	1,700	927	-45%	2,308	1,567	-32%	1,700	936	-45%
Screenline F	1	4	2,129	1,846	-13%	1,373	1,276	-7%	2,129	1,856	-13%	1,373	1,283	-7%
Screenline F	2	4	1,934	2,155	11%	1,350	1,585	17%	1,934	2,164	12%	1,350	1,592	18%
Screenline G	1	7	3,300	2,897	-12%	2,313	1,947	-16%	3,300	2,919	-12%	2,313	1,962	-15%
Screenline G	2	7	3,521	3,149	-11%	2,389	2,239	-6%	3,521	3,169	-10%	2,389	2,253	-6%
Total			340,736	334,741	-2%	239,920	235,558	-2%	340,736	337,840	-1%	239,920	237,645	-1%
No of Test D Passes					36			35			35			32
Test D Pass Rate					64%			63%			63%			57%

Table D.3: 2009 PM peak Prior Matrix results

Screenline	Direction	No. of sites	Actual Flow (Vehicles) Total Observed	Actual Flow Total Modelled	Actual Flow Total % Diff	Actual Flow Car Observed	Actual Flow Car Modelled	Actual Flow Car % Diff	Demand Flow (Vehicles) Total Observed	Demand Flow Total Modelled	Demand Flow Total % Diff	Demand Flow Car Observed	Demand Flow Car Modelled	Demand Flow Car % Diff
BarkingE-W	1	6	4,089	4,340	6%	3,512	3,571	2%	4,089	4,537	11%	3,512	3,732	6%
BarkingE-W	2	6	3,983	4,009	1%	3,440	3,315	-4%	3,983	4,074	2%	3,440	3,371	-2%
BarkingN-S	1	17	10,086	9,814	-3%	8,261	7,908	-4%	10,086	10,147	1%	8,261	8,173	-1%
BarkingN-S	2	17	11,760	11,052	-6%	9,616	8,817	-8%	11,760	11,380	-3%	9,616	9,084	-6%
BexleyE-W	1	15	4,633	4,000	-14%	3,848	3,342	-13%	4,633	4,047	-13%	3,848	3,383	-12%
BexleyE-W	2	16	6,164	5,647	-8%	5,296	4,921	-7%	6,164	5,713	-7%	5,296	4,980	-6%
BexleyN-S	1	31	9,703	9,194	-5%	8,039	7,472	-7%	9,703	9,385	-3%	8,039	7,630	-5%
BexleyN-S	2	32	11,807	11,142	-6%	9,759	9,167	-6%	11,807	11,419	-3%	9,759	9,399	-4%
BoundaryS	1	7	10,376	9,592	-8%	8,635	8,005	-7%	10,376	9,792	-6%	8,635	8,172	-5%
BoundaryS	2	7	11,777	11,592	-2%	9,434	9,420	0%	11,777	12,129	3%	9,434	9,861	5%
Deptford	1	6	2,804	2,943	5%	2,353	2,359	0%	2,804	2,996	7%	2,353	2,403	2%
Deptford	2	6	3,398	4,008	18%	2,673	3,150	18%	3,398	4,092	20%	2,673	3,218	20%
HaroldHillN-S	1	8	5,181	4,253	-18%	4,483	3,533	-21%	5,181	4,349	-16%	4,483	3,614	-19%
HaroldHillN-S	2	8	5,851	5,052	-14%	5,055	4,366	-14%	5,851	5,141	-12%	5,055	4,443	-12%
Inner North	1	6	6,560	6,568	0%	5,231	5,288	1%	6,560	6,693	2%	5,231	5,391	3%
Inner North	2	6	8,043	8,174	2%	6,110	5,807	-5%	8,043	8,471	5%	6,110	6,022	-1%
RiverRom	1	10	9,662	8,902	-8%	7,821	7,424	-5%	9,662	9,288	-4%	7,821	7,734	-1%
RiverRom	2	9	8,916	9,340	5%	7,336	7,551	3%	8,916	9,537	7%	7,336	7,711	5%
Sidcup	1	14	8,165	8,298	2%	6,811	6,767	-1%	8,165	8,770	7%	6,811	7,156	5%
Sidcup	2	14	7,721	8,746	13%	6,507	7,043	8%	7,721	9,116	18%	6,507	7,345	13%
Homerton	1	6	2,302	2,481	8%	1,878	1,705	-9%	2,302	2,510	9%	1,878	1,727	-8%
Homerton	2	7	2,666	2,438	-9%	2,157	1,767	-18%	2,666	2,470	-7%	2,157	1,791	-17%
GreatEastern (west)	1	16	6,856	6,872	0%	5,282	4,824	-9%	6,856	7,052	3%	5,282	4,951	-6%
GreatEastern (west)	2	17	5,541	6,651	20%	4,250	4,833	14%	5,541	6,792	23%	4,250	4,941	16%
GreatEastern (east)	1	26	20,318	19,733	-3%	16,436	15,801	-4%	20,318	20,433	1%	16,436	16,358	0%
GreatEastern (east)	2	25	20,453	19,230	-6%	16,540	15,551	-6%	20,453	19,575	-4%	16,540	15,837	-4%
Hackney North	1	19	3,064	2,129	-31%	2,559	1,569	-39%	3,064	2,152	-30%	2,559	1,587	-38%
Hackney North	2	18	3,611	2,861	-21%	2,834	2,004	-29%	3,611	2,892	-20%	2,834	2,027	-28%
Whitechapel	1	18	4,993	3,994	-20%	3,721	2,480	-33%	4,993	4,069	-18%	3,721	2,528	-32%
Whitechapel	2	18	5,835	5,237	-10%	4,005	3,415	-15%	5,835	5,412	-7%	4,005	3,530	-12%
Ravensbourne	1	4	2,676	2,772	4%	2,213	2,287	3%	2,676	2,856	7%	2,213	2,359	7%
Ravensbourne	2	4	4,103	4,050	-1%	3,108	3,345	8%	4,103	4,141	1%	3,108	3,422	10%
LewishamDartford (west)	1	14	9,114	8,671	-5%	7,654	7,041	-8%	9,114	9,004	-1%	7,654	7,315	-4%
LewishamDartford (west)	2	14	11,412	10,589	-7%	9,212	8,780	-5%	11,412	10,924	-4%	9,212	9,062	-2%
LewishamDartford (east)	1	20	9,338	8,977	-4%	7,660	7,265	-5%	9,338	9,219	-1%	7,660	7,461	-3%
LewishamDartford (east)	2	20	8,875	8,763	-1%	7,322	6,852	-6%	8,875	8,903	0%	7,322	6,963	-5%
Eltham North	1	6	2,775	2,975	7%	2,390	2,590	8%	2,775	3,009	8%	2,390	2,621	10%
Eltham North	2	6	3,461	3,506	1%	2,869	2,945	3%	3,461	3,577	3%	2,869	3,006	5%
Eltham South	1	7	6,639	6,351	-4%	5,484	5,169	-6%	6,639	6,541	-1%	5,484	5,325	-3%
Eltham South	2	7	9,149	8,405	-8%	7,137	7,113	0%	9,149	8,724	-5%	7,137	7,381	3%
West of A406	1	11	16,825	17,468	4%	14,070	14,603	4%	16,825	18,011	7%	14,070	15,056	7%
West of A406	2	11	19,908	19,655	-1%	16,047	16,036	0%	19,908	20,171	1%	16,047	16,457	3%
River Screenline	1	7	9,962	10,370	4%	7,144	6,842	-4%	9,962	11,131	12%	7,144	7,341	3%
River Screenline	2	7	11,201	11,878	6%	8,091	8,241	2%	11,201	12,159	9%	8,091	8,444	4%
Screenline A	1	9	4,632	4,604	-1%	3,398	3,721	10%	4,632	4,717	2%	3,398	3,814	12%

Screenline	Direction	No. of sites	Actual Flow (Vehicles)						Demand Flow (Vehicles)					
			Total			Car			Total			Car		
			Observed	Modelled	% Diff	Observed	Modelled	% Diff	Observed	Modelled	% Diff	Observed	Modelled	% Diff
Screenline A	2	9	3,357	3,880	16%	2,767	3,085	12%	3,357	3,971	18%	2,767	3,157	14%
Screenline C	1	15	13,333	11,685	-12%	10,893	8,797	-19%	13,333	11,991	-10%	10,893	9,036	-17%
Screenline C	2	15	11,993	11,218	-6%	9,213	8,358	-9%	11,993	11,503	-4%	9,213	8,572	-7%
Screenline D	1	2	5,047	4,844	-4%	4,268	3,582	-16%	5,047	4,965	-2%	4,268	3,672	-14%
Screenline D	2	2	3,454	3,496	1%	2,794	2,561	-8%	3,454	3,627	5%	2,794	2,657	-5%
Screenline E	1	7	3,384	2,417	-29%	2,754	1,680	-39%	3,384	2,463	-27%	2,754	1,715	-38%
Screenline E	2	7	2,547	1,827	-28%	2,152	1,304	-39%	2,547	1,884	-26%	2,152	1,348	-37%
Screenline F	1	4	2,830	2,818	0%	2,128	2,289	8%	2,830	2,916	3%	2,128	2,371	11%
Screenline F	2	4	2,095	2,203	5%	1,768	1,774	0%	2,095	2,282	9%	1,768	1,840	4%
Screenline G	1	7	3,724	3,220	-14%	3,166	2,583	-18%	3,724	3,360	-10%	3,166	2,695	-15%
Screenline G	2	7	4,974	4,662	-6%	3,907	3,827	-2%	4,974	4,802	-3%	3,907	3,942	1%
Total			413,1127	399,594	-3%	333,493	315,846	-5%	413,127	411,284	0%	333,493	325,130	-3%
No of Test D Passes					35			29			35			34
Test D Pass Rate					63%			52%			64%			61%

Mott MacDonald

D.2 2012 prior matrix results

Table D.4: 2012 AM peak Prior Matrix results

			Actual Flow (Vehicles)						Demand Flow (Vehicles)					
			Total			Car			Total			Car		
Screenline	Direction	No. of sites	Observed	Modelled	% Diff	Observed	Modelled	% Diff	Observed	Modelled	% Diff	Observed	Modelled	% Diff
BarkingE-W	1	6	3,239	3,902	20%	2,681	3,146	17%	3,239	4,010	24%	2,681	3,232	21%
BarkingE-W	2	6	4,815	4,619	-4%	4,020	3,850	-4%	4,815	4,704	-2%	4,020	3,923	-2%
BarkingN-S	1	17	11,886	11,446	-4%	9,246	8,860	-4%	11,886	12,157	2%	9,246	9,396	2%
BarkingN-S	2	17	8,824	9,778	11%	6,860	7,469	9%	8,824	10,044	14%	6,860	7,673	12%
BexleyE-W	1	15	5,420	5,665	5%	4,501	5,019	12%	5,420	5,750	6%	4,501	5,097	13%
BexleyE-W	2	16	4,583	3,854	-16%	3,567	3,285	-8%	4,583	3,958	-14%	3,567	3,377	-5%
BexleyN-S	1	31	10,738	10,799	1%	8,448	8,699	3%	10,738	11,146	4%	8,448	8,977	6%
BexleyN-S	2	32	9,004	9,206	2%	7,121	7,451	5%	9,004	9,431	5%	7,121	7,632	7%
BoundaryS	1	7	10,454	11,162	7%	8,108	8,444	4%	10,454	11,498	10%	8,108	8,698	7%
BoundaryS	2	7	8,324	9,660	16%	6,650	7,758	17%	8,324	10,219	23%	6,650	8,199	23%
Deptford	1	6	4,284	4,537	6%	3,051	3,286	8%	4,284	4,871	14%	3,051	3,533	16%
Deptford	2	6	2,656	3,011	13%	2,108	2,282	8%	2,656	3,107	17%	2,108	2,358	12%
HaroldHillN-S	1	8	6,699	6,129	-9%	5,626	5,072	-10%	6,699	6,321	-6%	5,626	5,233	-7%
HaroldHillN-S	2	8	4,343	4,504	4%	3,679	3,752	2%	4,343	4,586	6%	3,679	3,821	4%
Inner North	1	6	8,440	8,284	-2%	5,862	5,832	-1%	8,440	8,531	1%	5,862	6,015	3%
Inner North	2	6	5,572	5,343	-4%	4,019	3,727	-7%	5,572	5,695	2%	4,019	3,979	-1%
RiverRom	1	10	8,911	10,060	13%	7,012	7,753	11%	8,911	10,364	16%	7,012	7,983	14%
RiverRom	2	9	7,696	8,674	13%	5,980	7,079	18%	7,696	8,879	15%	5,980	7,247	21%
Sidcup	1	14	7,494	8,901	19%	6,196	7,128	15%	7,494	9,264	24%	6,196	7,425	20%
Sidcup	2	14	7,786	9,082	17%	6,221	7,105	14%	7,786	9,407	21%	6,221	7,362	18%
Homerton	1	6	2,662	2,987	12%	2,040	1,969	-3%	2,662	3,171	19%	2,040	2,098	3%
Homerton	2	7	2,122	1,476	-30%	1,640	871	-47%	2,122	1,579	-26%	1,640	941	-43%
GreatEastern (west)	1	16	5,136	6,306	23%	3,644	4,247	17%	5,136	6,679	30%	3,644	4,498	23%
GreatEastern (west)	2	17	5,828	6,901	18%	4,023	4,547	13%	5,828	7,444	28%	4,023	4,907	22%
GreatEastern (east)	1	26	19,293	18,280	-5%	14,940	14,191	-5%	19,293	18,923	-2%	14,940	14,678	-2%
GreatEastern (east)	2	25	20,851	20,190	-3%	16,084	15,474	-4%	20,851	20,619	-1%	16,084	15,806	-2%
Hackney North	1	19	3,438	3,854	12%	2,417	2,707	12%	3,438	4,185	22%	2,417	2,944	22%
Hackney North	2	18	2,961	2,956	0%	2,238	2,216	-1%	2,961	3,114	5%	2,238	2,341	5%
Whitechapel	1	18	5,822	5,760	-1%	3,384	3,521	4%	5,822	6,116	5%	3,384	3,741	11%
Whitechapel	2	18	4,097	4,376	7%	2,797	2,671	-4%	4,097	4,613	13%	2,797	2,824	1%
Ravensbourne	1	4	3,953	4,471	13%	2,726	3,224	18%	3,953	4,799	21%	2,726	3,467	27%
Ravensbourne	2	4	2,425	2,884	19%	1,744	2,208	27%	2,425	3,005	24%	1,744	2,302	32%
LewishamDartford (west)	1	14	10,268	10,452	2%	8,048	8,397	4%	10,268	10,836	6%	8,048	8,709	8%
LewishamDartford (west)	2	14	9,156	8,975	-2%	7,127	7,058	-1%	9,156	9,374	2%	7,127	7,370	3%
LewishamDartford (east)	1	20	8,926	8,993	1%	6,968	6,779	-3%	8,926	9,530	7%	6,968	7,174	3%
LewishamDartford (east)	2	20	9,071	10,232	13%	7,177	7,902	10%	9,071	10,512	16%	7,177	8,118	13%
Eltham North	1	6	3,265	3,344	2%	2,578	2,714	5%	3,265	3,470	6%	2,578	2,821	9%
Eltham North	2	6	2,453	2,678	9%	1,945	2,340	20%	2,453	2,750	12%	1,945	2,405	24%
Eltham South	1	7	8,247	8,164	-1%	6,560	6,618	1%	8,247	8,558	4%	6,560	6,939	6%
Eltham South	2	7	6,117	6,176	1%	4,920	4,866	-1%	6,117	6,404	5%	4,920	5,046	3%

			Actual Flow (Vehicles)						Demand Flow (Vehicles)					
			Total			Car			Total			Car		
Screenline	Direction	No. of sites	Observed	Modelled	% Diff	Observed	Modelled	% Diff	Observed	Modelled	% Diff	Observed	Modelled	% Diff
West of A406	1	11	19,565	18,036	-8%	15,138	14,489	-4%	19,565	18,857	-4%	15,138	15,143	0%
West of A406	2	11	16,746	16,376	-2%	12,855	12,854	0%	16,746	16,838	1%	12,855	13,210	3%
River Screenline	1	7	10,078	11,167	11%	6,774	6,863	1%	10,078	12,384	23%	6,774	7,683	13%
River Screenline	2	7	9,967	11,009	10%	6,117	6,300	3%	9,967	11,534	16%	6,117	6,602	8%
Screenline A	1	9	3,508	3,688	5%	2,572	2,750	7%	3,508	3,873	10%	2,572	2,889	12%
Screenline A	2	9	4,456	5,290	19%	3,028	3,846	27%	4,456	5,627	26%	3,028	4,094	35%
Screenline C	1	15	12,294	11,442	-7%	8,451	7,633	-10%	12,294	12,256	0%	8,451	8,174	-3%
Screenline C	2	15	12,831	11,498	-10%	9,650	7,875	-18%	12,831	11,902	-7%	9,650	8,153	-16%
Screenline D	1	2	2,710	3,313	22%	1,970	1,972	0%	2,710	3,475	28%	1,970	2,069	5%
Screenline D	2	2	5,611	5,092	-9%	4,150	3,522	-15%	5,611	5,396	-4%	4,150	3,738	-10%
Screenline E	1	7	2,529	2,140	-15%	1,894	1,229	-35%	2,529	2,183	-14%	1,894	1,255	-34%
Screenline E	2	7	2,754	1,741	-37%	2,106	1,041	-51%	2,754	1,808	-34%	2,106	1,084	-49%
Screenline F	1	4	1,919	1,879	-2%	1,492	1,363	-9%	1,919	1,969	3%	1,492	1,431	-4%
Screenline F	2	4	2,850	3,417	20%	2,023	2,571	27%	2,850	3,728	31%	2,023	2,808	39%
Screenline G	1	7	3,963	4,384	11%	3,000	3,522	17%	3,963	4,658	18%	3,000	3,740	25%
Screenline G	2	7	2,940	3,384	15%	2,104	2,678	27%	2,940	3,538	20%	2,104	2,801	33%
Total			391,985	401,926	3%	297,281	302,025	2%	391,985	419,652	7%	297,281	315,161	6%
No of Test D Passes					25			26			25			24
Test D Pass Rate					45%			46%			45%			43%

Table D.5: 2012 Interpeak Prior Matrix results

			Actual Flow (Vehicles)						Demand Flow (Vehicles)					
			Total			Car			Total			Car		
Screenline	Direction	No. of sites	Observed	Modelled	% Diff	Observed	Modelled	% Diff	Observed	Modelled	% Diff	Observed	Modelled	% Diff
BarkingE-W	1	6	3,513	3,691	5%	2,726	2,853	5%	3,513	3,724	6%	2,726	2,877	6%
BarkingE-W	2	6	3,877	3,755	-3%	3,057	2,990	-2%	3,877	3,763	-3%	3,057	2,996	-2%
BarkingN-S	1	17	8,700	9,370	8%	6,327	6,821	8%	8,700	9,474	9%	6,327	6,892	9%
BarkingN-S	2	17	9,356	9,220	-1%	6,800	6,602	-3%	9,356	9,272	-1%	6,800	6,638	-2%
BexleyE-W	1	15	4,483	4,297	-4%	3,446	3,571	4%	4,483	4,306	-4%	3,446	3,579	4%
BexleyE-W	2	16	4,785	4,537	-5%	3,705	3,844	4%	4,785	4,549	-5%	3,705	3,855	4%
BexleyN-S	1	31	7,998	7,737	-3%	5,905	5,687	-4%	7,998	7,772	-3%	5,905	5,712	-3%
BexleyN-S	2	32	8,599	8,527	-1%	6,306	6,368	1%	8,599	8,570	0%	6,306	6,401	2%
BoundaryS	1	7	7,336	7,417	1%	5,509	5,345	-3%	7,336	7,504	2%	5,509	5,407	-2%
BoundaryS	2	7	7,549	8,221	9%	5,507	5,867	7%	7,549	8,296	10%	5,507	5,920	8%
Deptford	1	6	3,293	3,110	-6%	2,333	2,253	-3%	3,293	3,122	-5%	2,333	2,262	-3%
Deptford	2	6	2,980	3,094	4%	2,080	1,997	-4%	2,980	3,108	4%	2,080	2,005	-4%
HaroldHillN-S	1	8	4,481	4,122	-8%	3,542	3,310	-7%	4,481	4,165	-7%	3,542	3,344	-6%
HaroldHillN-S	2	8	4,253	4,177	-2%	3,330	3,273	-2%	4,253	4,188	-2%	3,330	3,281	-1%
Inner North	1	6	6,295	5,873	-7%	4,215	3,997	-5%	6,295	5,909	-6%	4,215	4,022	-5%
Inner North	2	6	6,264	6,223	-1%	3,998	3,916	-2%	6,264	6,347	1%	3,998	3,995	0%
RiverRom	1	10	7,404	7,619	3%	5,245	5,731	9%	7,404	7,680	4%	5,245	5,775	10%
RiverRom	2	9	6,960	7,824	12%	5,004	5,782	16%	6,960	7,906	14%	5,004	5,837	17%
Sidcup	1	14	7,214	7,621	6%	5,478	5,587	2%	7,214	7,688	7%	5,478	5,636	3%
Sidcup	2	14	7,114	7,893	11%	5,452	5,856	7%	7,114	7,931	11%	5,452	5,884	8%
Homerton	1	6	2,356	2,374	1%	1,763	1,402	-20%	2,356	2,455	4%	1,763	1,452	-18%
Homerton	2	7	2,434	2,084	-14%	1,817	1,220	-33%	2,434	2,120	-13%	1,817	1,243	-32%
GreatEastern (west)	1	16	5,625	6,296	12%	3,646	3,690	1%	5,625	6,390	14%	3,646	3,745	3%
GreatEastern (west)	2	17	5,199	6,447	24%	3,378	3,909	16%	5,199	6,519	25%	3,378	3,955	17%
GreatEastern (east)	1	26	17,005	16,968	0%	12,148	12,331	2%	17,005	17,341	2%	12,148	12,561	3%
GreatEastern (east)	2	25	17,512	17,139	-2%	12,482	12,649	1%	17,512	17,231	-2%	12,482	12,716	2%
Hackney North	1	19	2,624	2,401	-8%	1,827	1,553	-15%	2,624	2,469	-6%	1,827	1,598	-13%
Hackney North	2	18	2,921	2,590	-11%	1,953	1,535	-21%	2,921	2,621	-10%	1,953	1,554	-20%
Whitechapel	1	18	4,870	4,556	-6%	2,954	2,786	-6%	4,870	4,597	-6%	2,954	2,812	-5%
Whitechapel	2	18	5,107	4,618	-10%	2,887	2,635	-9%	5,107	4,693	-8%	2,887	2,678	-7%
Ravensbourne	1	4	2,676	3,074	15%	1,863	2,301	24%	2,676	3,089	15%	1,863	2,312	24%
Ravensbourne	2	4	2,838	3,227	14%	1,877	2,294	22%	2,838	3,242	14%	1,877	2,306	23%
LewishamDartford (west)	1	14	7,742	7,550	-2%	5,763	5,364	-7%	7,742	7,603	-2%	5,763	5,402	-6%
LewishamDartford (west)	2	14	8,168	8,173	0%	5,856	5,956	2%	8,168	8,232	1%	5,856	5,999	2%
LewishamDartford (east)	1	20	7,320	7,555	3%	5,312	5,467	3%	7,320	7,615	4%	5,312	5,509	4%
LewishamDartford (east)	2	20	7,131	7,637	7%	5,209	5,427	4%	7,131	7,710	8%	5,209	5,479	5%
Eltham North	1	6	2,440	2,497	2%	1,851	2,040	10%	2,440	2,501	2%	1,851	2,043	10%
Eltham North	2	6	2,412	2,458	2%	1,738	1,990	15%	2,412	2,467	2%	1,738	1,998	15%
Eltham South	1	7	5,131	5,327	4%	3,841	3,784	-1%	5,131	5,363	5%	3,841	3,809	-1%
Eltham South	2	7	5,960	5,936	0%	4,284	4,378	2%	5,960	5,980	0%	4,284	4,410	3%
West of A406	1	11	14,242	15,165	6%	10,186	11,355	11%	14,242	15,306	7%	10,186	11,457	12%
West of A406	2	11	16,227	16,123	-1%	11,308	11,893	5%	16,227	16,249	0%	11,308	11,986	6%
River Screenline	1	7	9,149	9,557	4%	5,531	5,757	4%	9,149	10,323	13%	5,531	6,224	13%
River Screenline	2	7	8,943	10,315	15%	5,333	6,354	19%	8,943	10,465	17%	5,333	6,447	21%
Screenline A	1	9	3,672	3,406	-7%	2,331	2,261	-3%	3,672	3,433	-7%	2,331	2,279	-2%

			Actual Flow (Vehicles)						Demand Flow (Vehicles)					
			Total			Car			Total			Car		
Screenline	Direction	No. of sites	Observed	Modelled	% Diff	Observed	Modelled	% Diff	Observed	Modelled	% Diff	Observed	Modelled	% Diff
Screenline A	2	9	3,218	3,419	6%	2,180	2,476	14%	3,218	3,437	7%	2,180	2,489	14%
Screenline C	1	15	11,154	11,035	-1%	7,523	6,970	-7%	11,154	11,137	0%	7,523	7,035	-6%
Screenline C	2	15	11,410	10,532	-8%	7,517	6,941	-8%	11,410	10,642	-7%	7,517	7,014	-7%
Screenline D	1	2	3,426	3,867	13%	2,315	2,352	2%	3,426	3,906	14%	2,315	2,376	3%
Screenline D	2	2	3,674	3,994	9%	2,353	2,464	5%	3,674	4,040	10%	2,353	2,493	6%
Screenline E	1	7	2,716	2,151	-21%	1,940	1,290	-34%	2,716	2,160	-20%	1,940	1,295	-33%
Screenline E	2	7	2,308	1,604	-30%	1,700	955	-44%	2,308	1,620	-30%	1,700	965	-43%
Screenline F	1	4	2,129	2,065	-3%	1,373	1,437	5%	2,129	2,073	-3%	1,373	1,443	5%
Screenline F	2	4	1,934	2,274	18%	1,350	1,661	23%	1,934	2,291	18%	1,350	1,673	24%
Screenline G	1	7	3,300	3,372	2%	2,313	2,358	2%	3,300	3,410	3%	2,313	2,384	3%
Screenline G	2	7	3,521	3,622	3%	2,389	2,644	11%	3,521	3,663	4%	2,389	2,673	12%
Total			340,948	345,740	1%	240,058	243,522	1%	340,948	349,663	3%	240,058	246,132	3%
No of Test D Passes					36			35			37			34
Test D Pass Rate					64%			63%			66%			61%

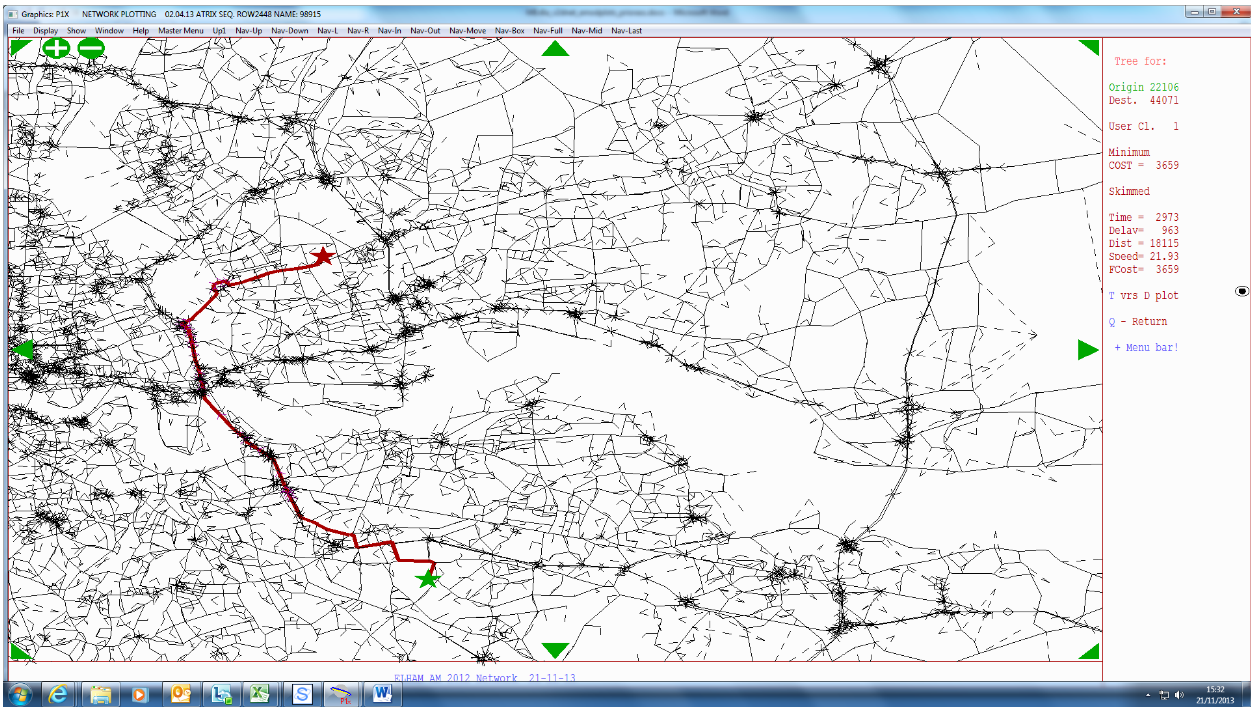
Table D.6: 2012 PM peak Prior Matrix results

			Actual Flow (Vehicles)						Demand Flow (Vehicles)					
			Total			Car			Total			Car		
Screenline	Direction	No. of sites	Observed	Modelled	% Diff	Observed	Modelled	% Diff	Observed	Modelled	% Diff	Observed	Modelled	% Diff
BarkingE-W	1	6	4,089	4,428	8%	3,512	3,643	4%	4,089	4,641	14%	3,512	3,818	9%
BarkingE-W	2	6	3,983	4,097	3%	3,440	3,394	-1%	3,983	4,165	5%	3,440	3,452	0%
BarkingN-S	1	17	10,086	10,084	0%	8,261	8,100	-2%	10,086	10,403	3%	8,261	8,352	1%
BarkingN-S	2	17	11,760	11,335	-4%	9,616	9,019	-6%	11,760	11,664	-1%	9,616	9,283	-3%
BexleyE-W	1	15	4,633	4,015	-13%	3,848	3,354	-13%	4,633	4,067	-12%	3,848	3,400	-12%
BexleyE-W	2	16	6,164	5,571	-10%	5,296	4,876	-8%	6,164	5,636	-9%	5,296	4,934	-7%
BexleyN-S	1	31	9,703	9,478	-2%	8,039	7,696	-4%	9,703	9,653	-1%	8,039	7,840	-2%
BexleyN-S	2	32	11,807	11,362	-4%	9,759	9,366	-4%	11,807	11,730	-1%	9,759	9,677	-1%
BoundaryS	1	7	10,376	9,904	-5%	8,635	8,259	-4%	10,376	10,056	-3%	8,635	8,387	-3%
BoundaryS	2	7	11,777	11,741	0%	9,434	9,529	1%	11,777	12,294	4%	9,434	9,983	6%
Deptford	1	6	2,804	3,144	12%	2,353	2,514	7%	2,804	3,202	14%	2,353	2,563	9%
Deptford	2	6	3,398	4,326	27%	2,673	3,406	27%	3,398	4,449	31%	2,673	3,507	31%
HaroldHillN-S	1	8	5,181	4,482	-14%	4,483	3,718	-17%	5,181	4,552	-12%	4,483	3,777	-16%
HaroldHillN-S	2	8	5,851	5,168	-12%	5,055	4,462	-12%	5,851	5,251	-10%	5,055	4,533	-10%
Inner North	1	6	6,560	6,764	3%	5,231	5,441	4%	6,560	6,882	5%	5,231	5,538	6%
Inner North	2	6	8,043	8,334	4%	6,110	5,921	-3%	8,043	8,687	8%	6,110	6,176	1%
RiverRom	1	10	9,662	9,125	-6%	7,821	7,643	-2%	9,662	9,528	-1%	7,821	7,964	2%
RiverRom	2	9	8,916	9,545	7%	7,336	7,683	5%	8,916	9,688	9%	7,336	7,803	6%
Sidcup	1	14	8,165	8,452	4%	6,811	6,892	1%	8,165	8,904	9%	6,811	7,265	7%
Sidcup	2	14	7,721	8,894	15%	6,507	7,140	10%	7,721	9,237	20%	6,507	7,418	14%
Homerton	1	6	2,302	2,620	14%	1,878	1,772	-6%	2,302	2,649	15%	1,878	1,794	-4%
Homerton	2	7	2,666	2,537	-5%	2,157	1,818	-16%	2,666	2,565	-4%	2,157	1,840	-15%
GreatEastern (west)	1	16	6,856	7,166	5%	5,282	5,041	-5%	6,856	7,362	7%	5,282	5,179	-2%
GreatEastern (west)	2	17	5,541	6,961	26%	4,250	5,083	20%	5,541	7,107	28%	4,250	5,195	22%
GreatEastern (east)	1	26	20,318	20,190	-1%	16,436	16,206	-1%	20,318	20,652	2%	16,436	16,583	1%
GreatEastern (east)	2	25	20,453	19,617	-4%	16,540	15,874	-4%	20,453	19,926	-3%	16,540	16,128	-2%
Hackney North	1	19	3,064	2,323	-24%	2,559	1,710	-33%	3,064	2,351	-23%	2,559	1,731	-32%
Hackney North	2	18	3,611	3,258	-10%	2,834	2,278	-20%	3,611	3,287	-9%	2,834	2,298	-19%
Whitechapel	1	18	4,993	4,059	-19%	3,721	2,533	-32%	4,993	4,135	-17%	3,721	2,581	-31%
Whitechapel	2	18	5,835	5,204	-11%	4,005	3,389	-15%	5,835	5,364	-8%	4,005	3,494	-13%
Ravensbourne	1	4	2,676	3,111	16%	2,213	2,532	14%	2,676	3,200	20%	2,213	2,606	18%
Ravensbourne	2	4	4,103	4,482	9%	3,108	3,672	18%	4,103	4,595	12%	3,108	3,766	21%
LewishamDartford (west)	1	14	9,114	9,036	-1%	7,654	7,361	-4%	9,114	9,332	2%	7,654	7,606	-1%
LewishamDartford (west)	2	14	11,412	10,900	-4%	9,212	9,066	-2%	11,412	11,339	-1%	9,212	9,436	2%
LewishamDartford (east)	1	20	9,338	9,404	1%	7,660	7,582	-1%	9,338	9,632	3%	7,660	7,768	1%
LewishamDartford (east)	2	20	8,875	9,115	3%	7,322	7,118	-3%	8,875	9,230	4%	7,322	7,209	-2%
Eltham North	1	6	2,775	3,036	9%	2,390	2,639	10%	2,775	3,071	11%	2,390	2,671	12%
Eltham North	2	6	3,461	3,516	2%	2,869	2,954	3%	3,461	3,617	5%	2,869	3,042	6%
Eltham South	1	7	6,639	6,599	-1%	5,484	5,375	-2%	6,639	6,786	2%	5,484	5,528	1%
Eltham South	2	7	9,149	8,581	-6%	7,137	7,297	2%	9,149	8,987	-2%	7,137	7,641	7%
West of A406	1	11	16,825	17,818	6%	14,070	14,891	6%	16,825	18,372	9%	14,070	15,354	9%
West of A406	2	11	19,908	19,946	0%	16,047	16,295	2%	19,908	20,521	3%	16,047	16,762	4%
River Screenline	1	7	10,590	10,772	2%	7,616	7,119	-7%	10,590	11,193	6%	7,616	7,388	-3%
River Screenline	2	7	11,264	11,985	6%	8,139	8,342	2%	11,264	12,414	10%	8,139	8,659	6%
Screenline A	1	9	4,632	4,761	3%	3,398	3,871	14%	4,632	4,900	6%	3,398	3,984	17%

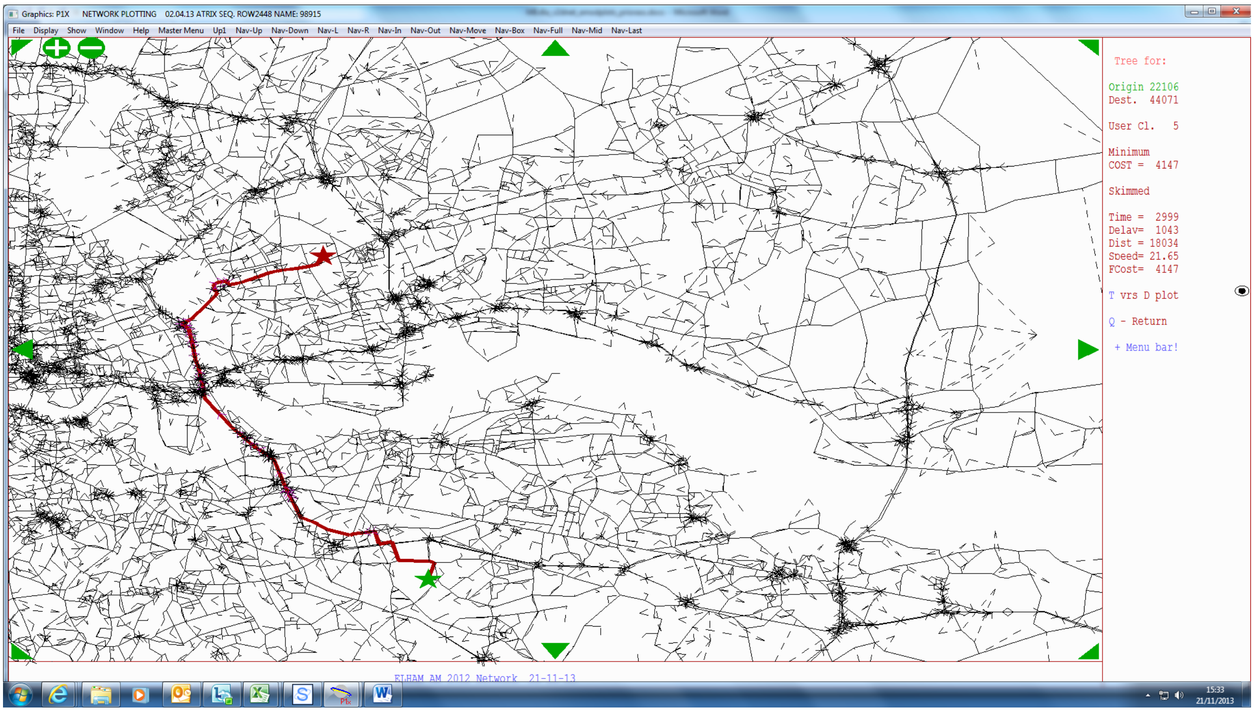
			Actual Flow (Vehicles)						Demand Flow (Vehicles)					
			Total			Car			Total			Car		
Screenline	Direction	No. of sites	Observed	Modelled	% Diff	Observed	Modelled	% Diff	Observed	Modelled	% Diff	Observed	Modelled	% Diff
Screenline A	2	9	3,357	4,071	21%	2,767	3,243	17%	3,357	4,167	24%	2,767	3,320	20%
Screenline C	1	15	13,333	11,714	-12%	10,893	8,791	-19%	13,333	12,026	-10%	10,893	9,032	-17%
Screenline C	2	15	11,993	11,142	-7%	9,213	8,315	-10%	11,993	11,410	-5%	9,213	8,516	-8%
Screenline D	1	2	5,047	5,039	0%	4,268	3,743	-12%	5,047	5,219	3%	4,268	3,879	-9%
Screenline D	2	2	3,454	3,680	7%	2,794	2,698	-3%	3,454	3,817	11%	2,794	2,799	0%
Screenline E	1	7	3,384	2,437	-28%	2,754	1,714	-38%	3,384	2,488	-26%	2,754	1,752	-36%
Screenline E	2	7	2,547	1,849	-27%	2,152	1,326	-38%	2,547	1,898	-26%	2,152	1,364	-37%
Screenline F	1	4	2,830	2,933	4%	2,128	2,393	12%	2,830	3,029	7%	2,128	2,472	16%
Screenline F	2	4	2,095	2,321	11%	1,768	1,849	5%	2,095	2,397	14%	1,768	1,911	8%
Screenline G	1	7	3,724	3,556	-5%	3,166	2,874	-9%	3,724	3,698	-1%	3,166	2,990	-6%
Screenline G	2	7	4,974	4,733	-5%	3,907	3,893	0%	4,974	5,016	1%	3,907	4,125	6%
Total			413,817	410,723	-1%	334,012	324,715	-3%	413,817	422,442	2%	334,012	334,071	0%
No of Test D Passes					34			32			28			30
Test D Pass Rate					61%			57%			50%			54%

Appendix E. Route Choice Calibration Trees

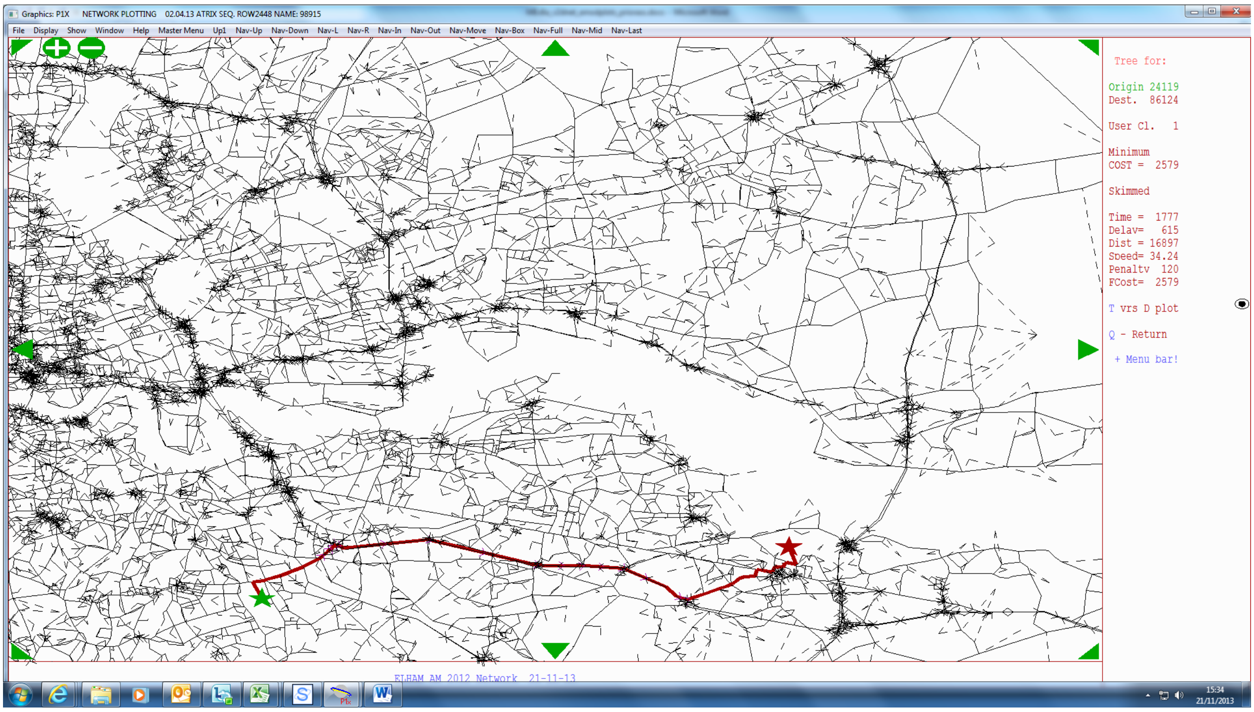
Avery Hill to Wanstead – cars



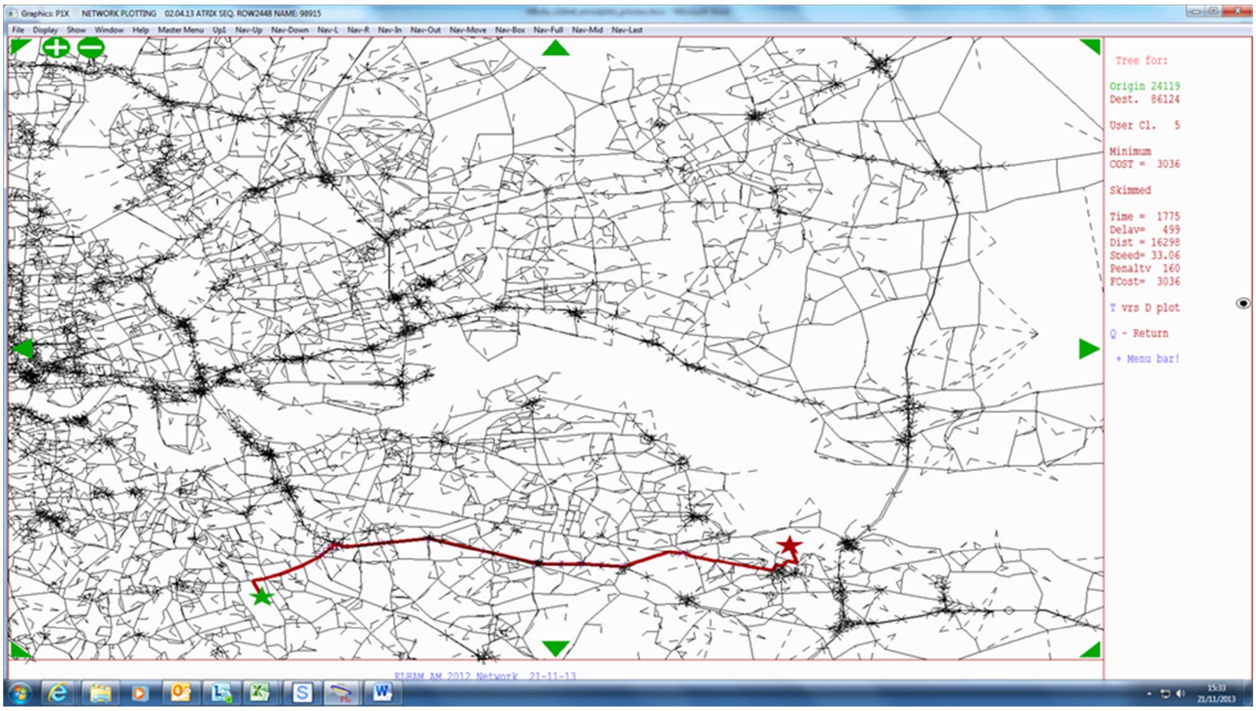
Avery Hill to Wanstead – OGVs



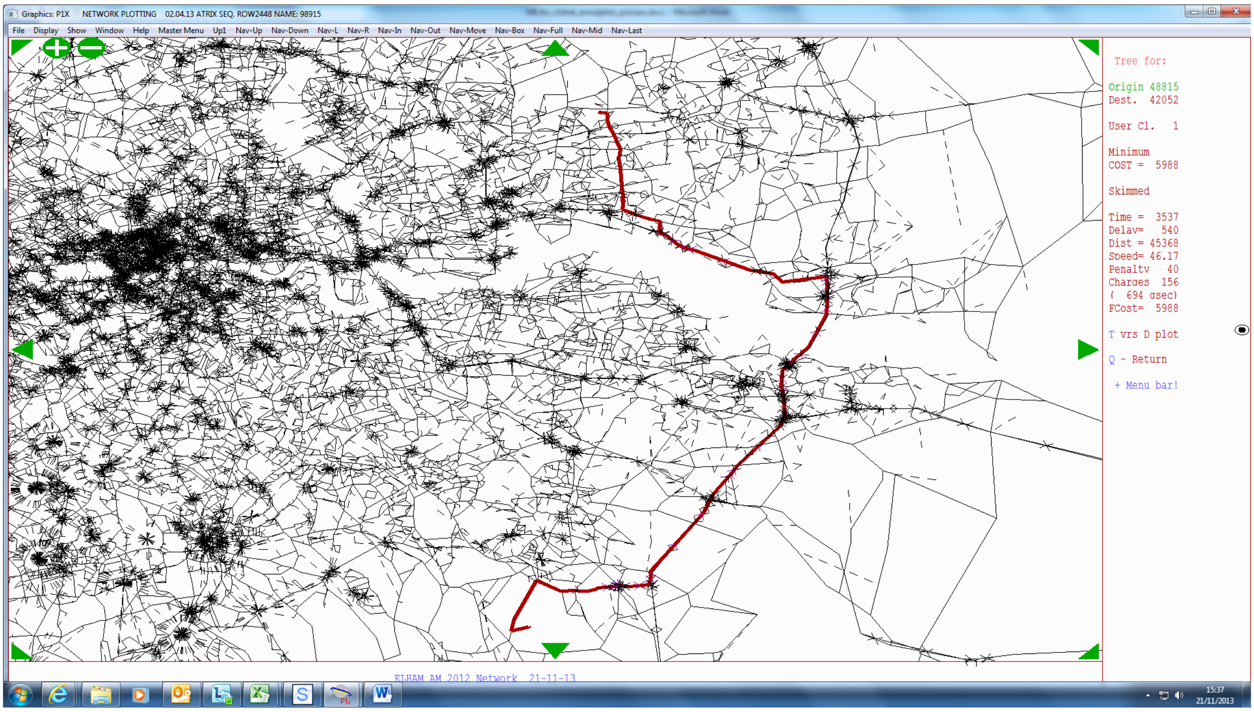
Greenwich to Dartford – cars



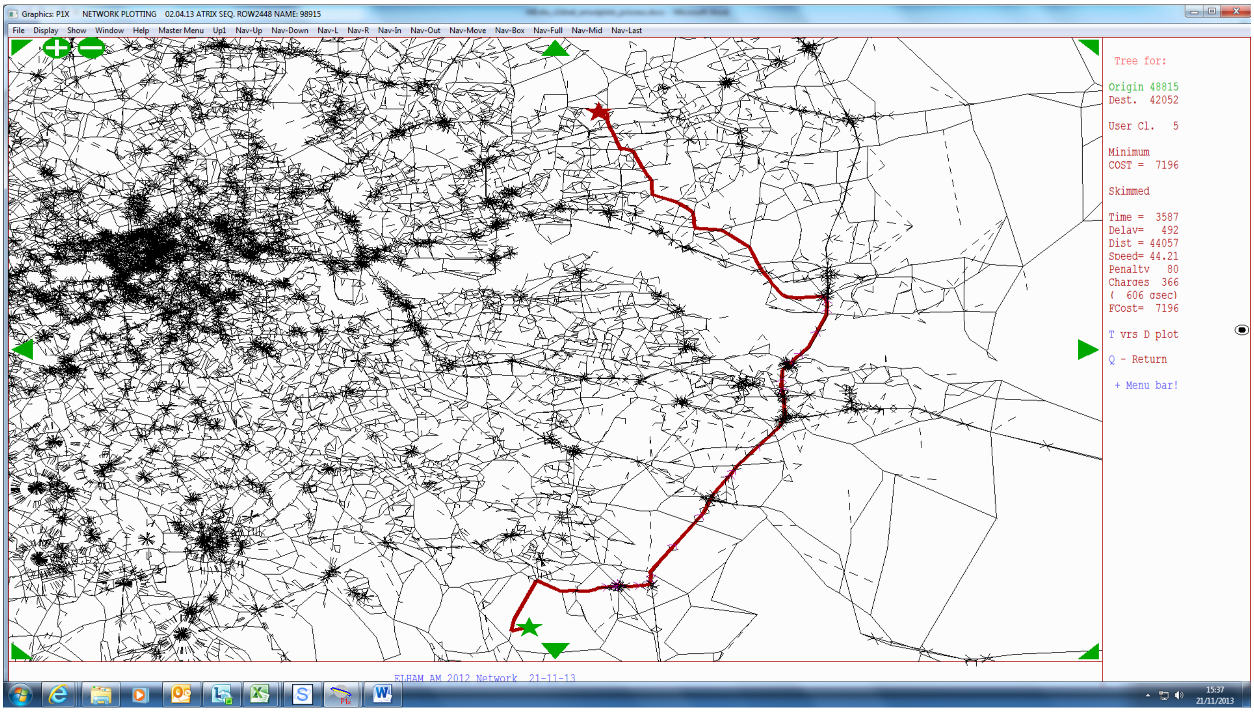
Greenwich to Dartford – OGVs



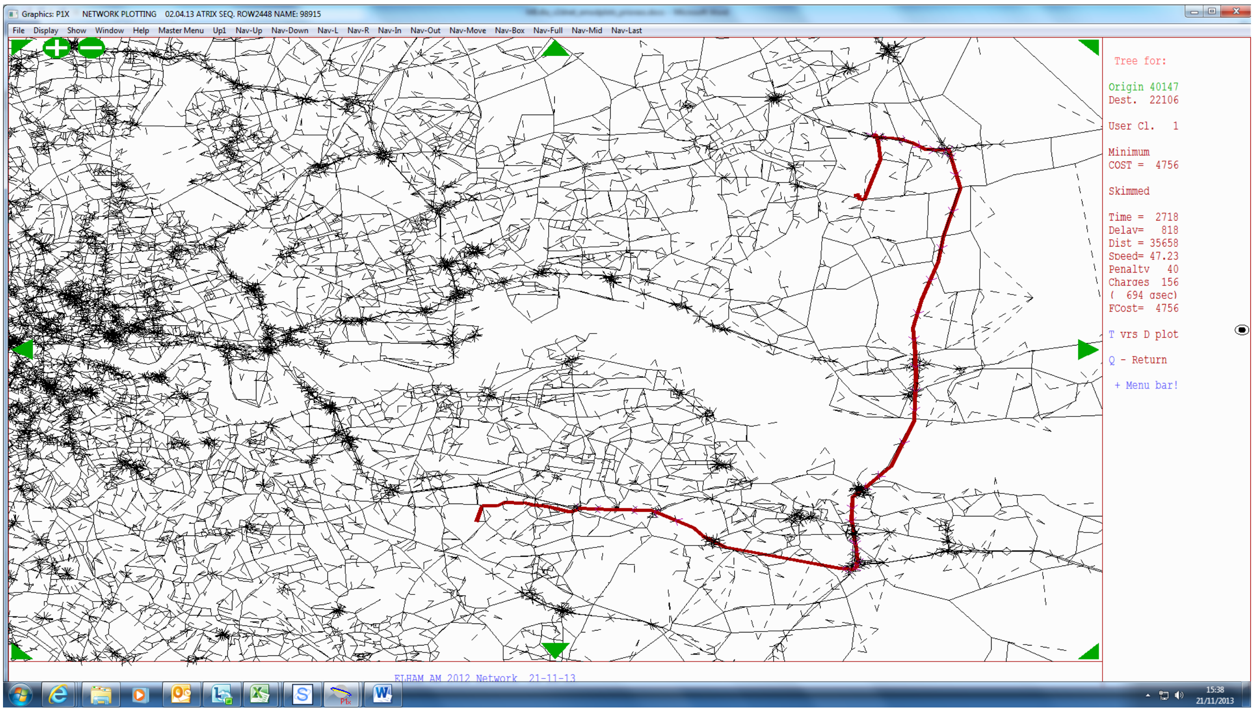
Knockholt to Chadwell Heath – cars



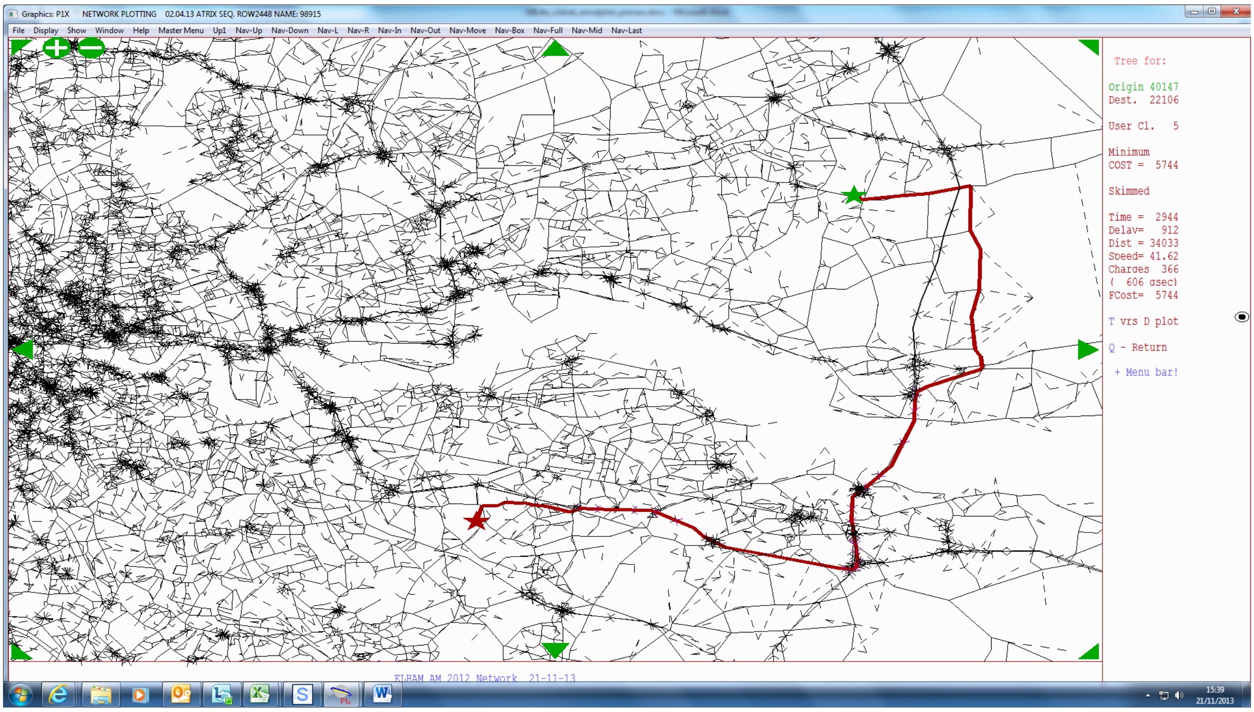
Knockholt to Chadwell Heath – OGVs



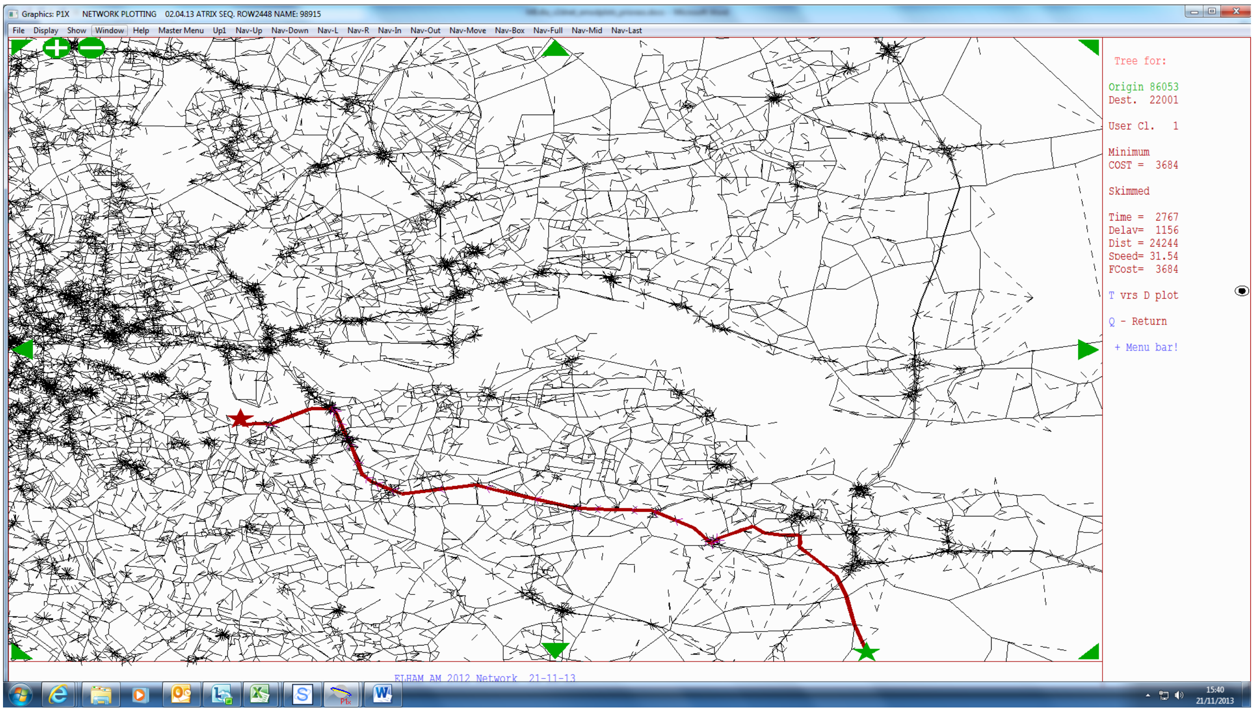
Upminster to Avery Hill – cars



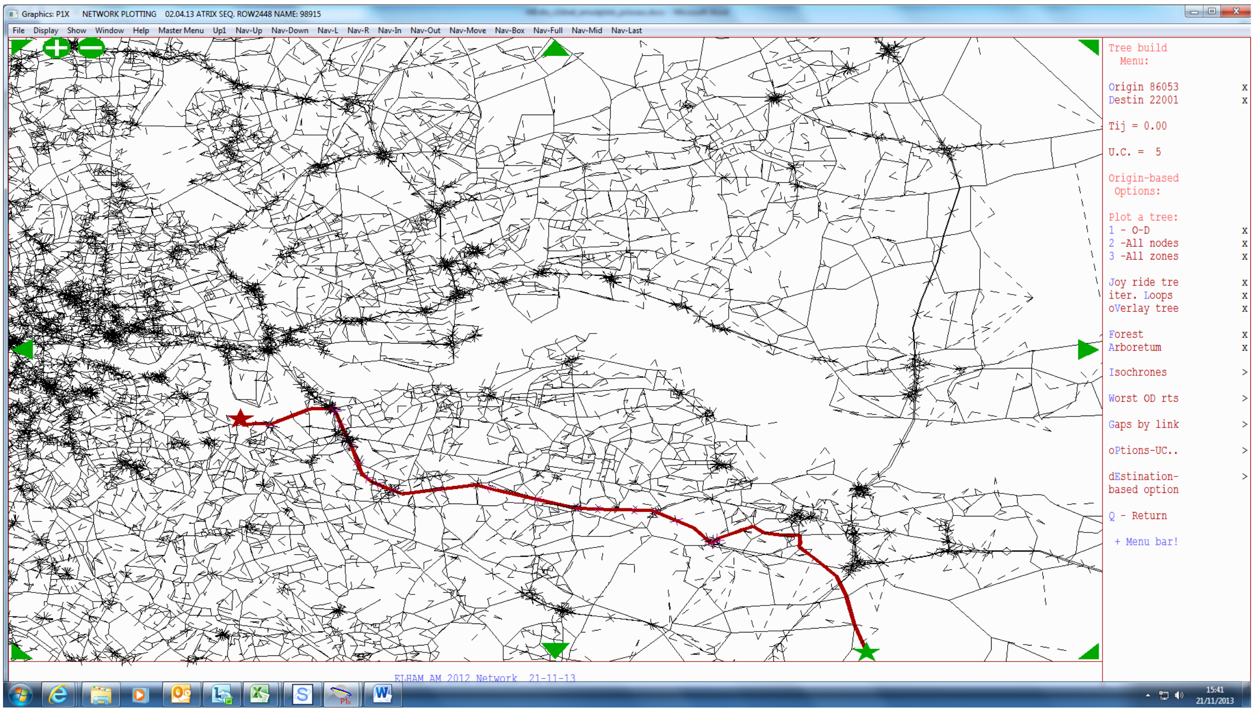
Upminster to Avery Hill – OGVs



South Darenth to Deptford – cars

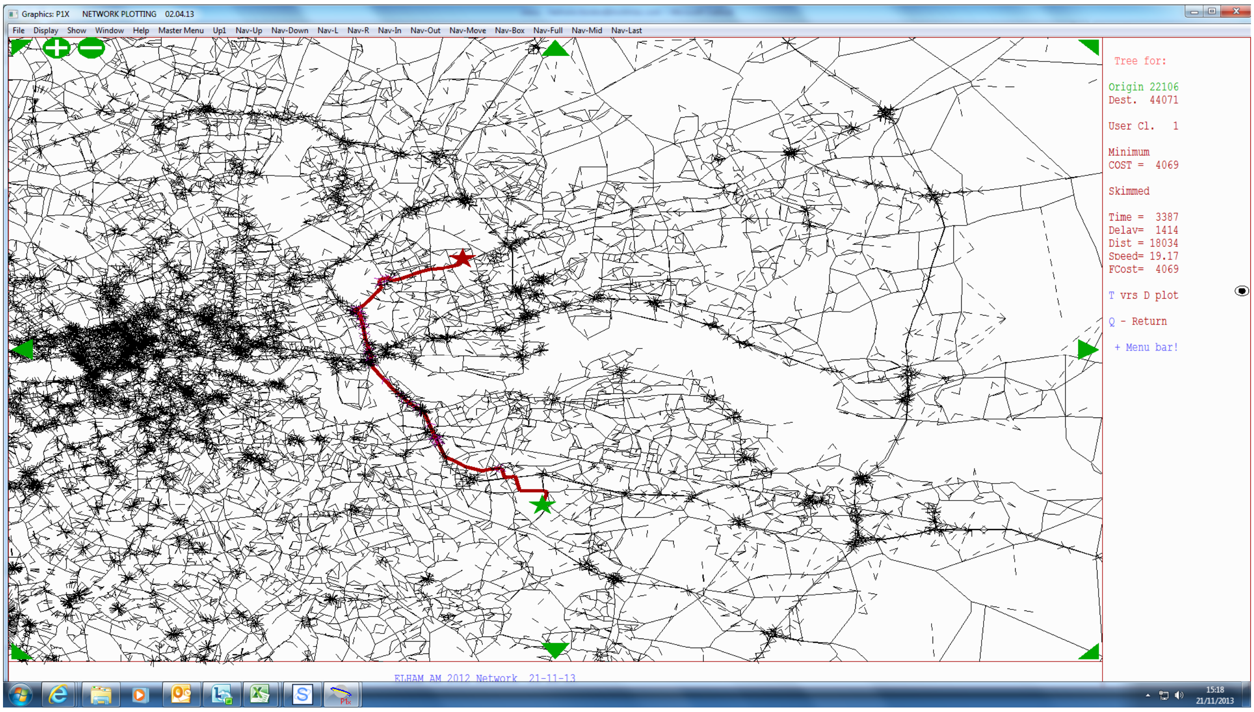


South Darenth to Deptford – OGVs

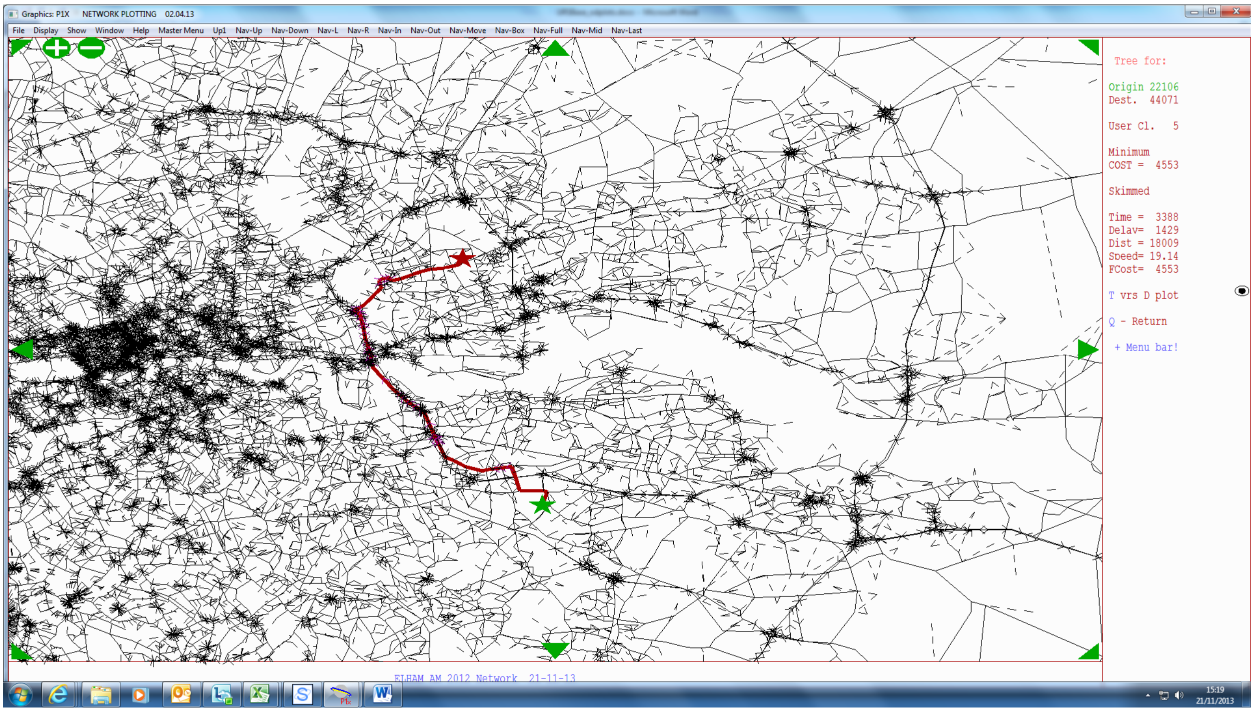


Appendix F. Route Choice Validation Trees

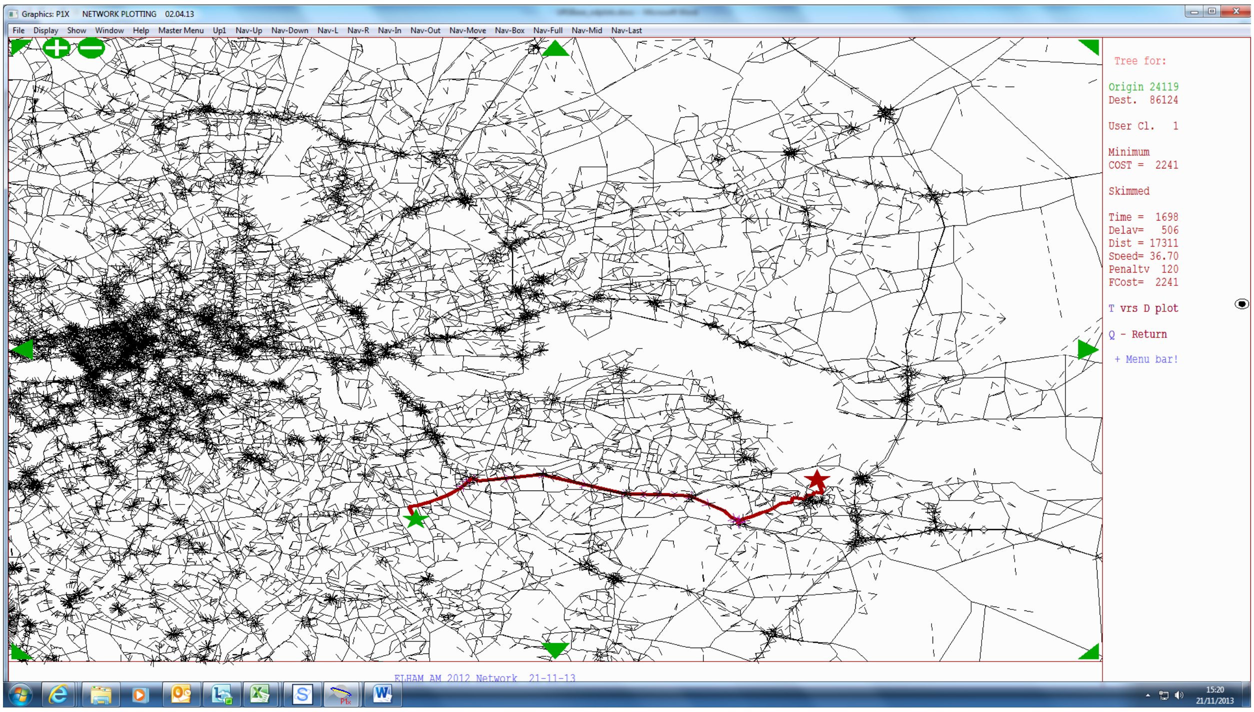
Avery Hill to Wanstead – cars



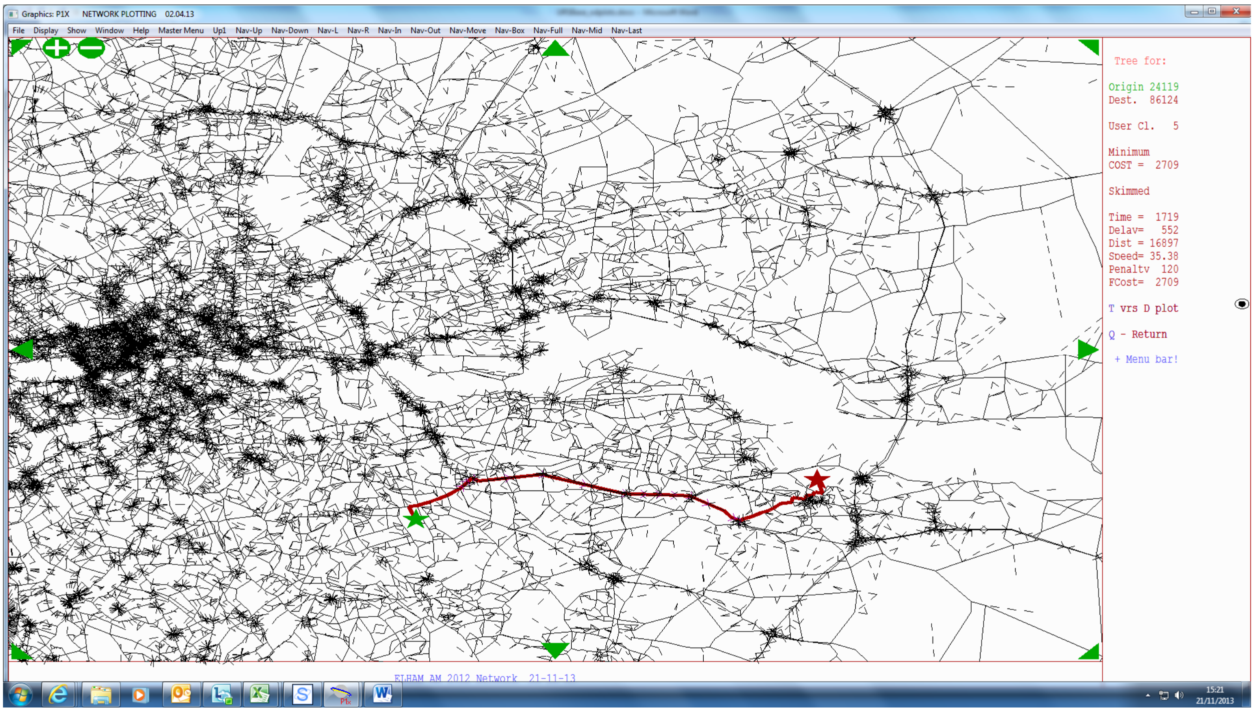
Avery Hill to Wanstead – OGVs



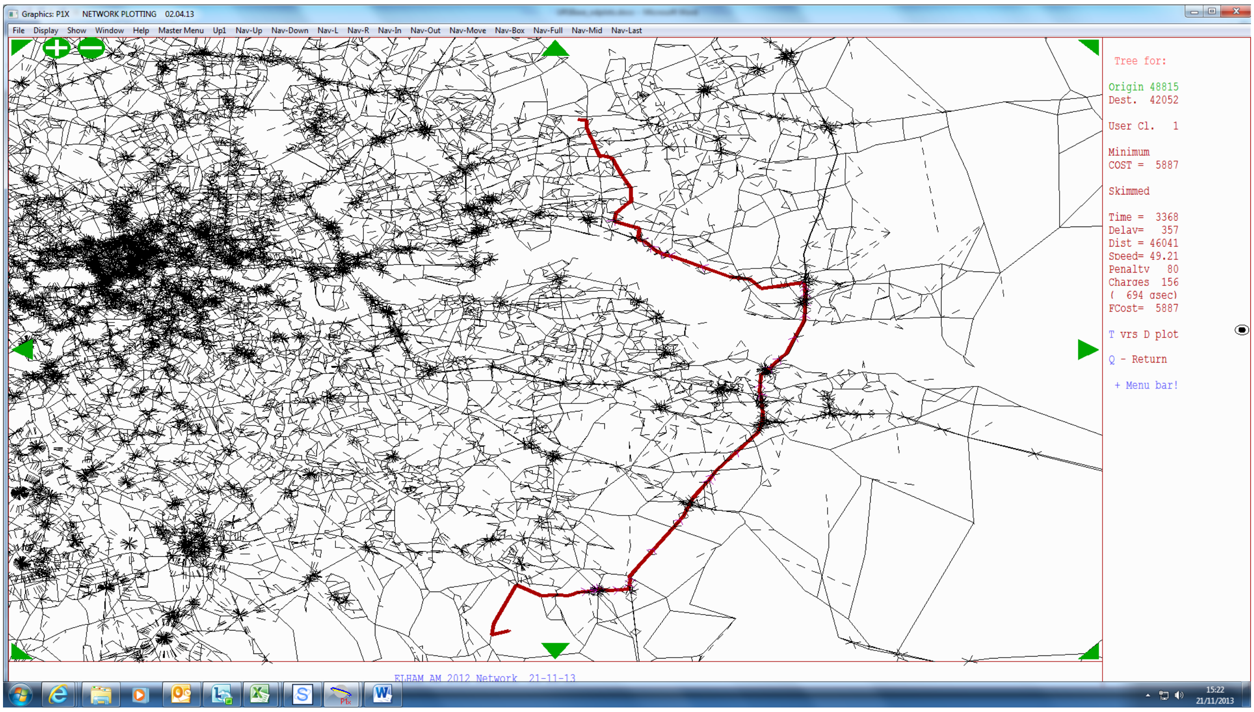
Greenwich to Dartford – cars



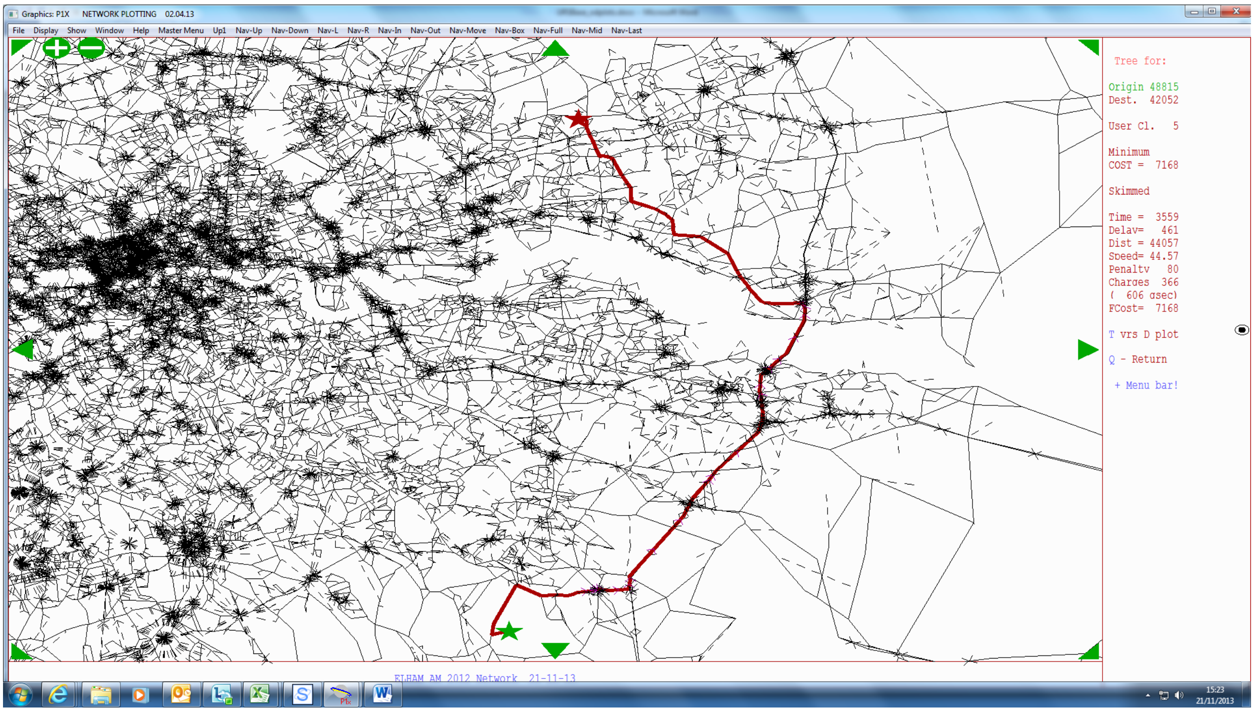
Greenwich to Dartford – OGVs



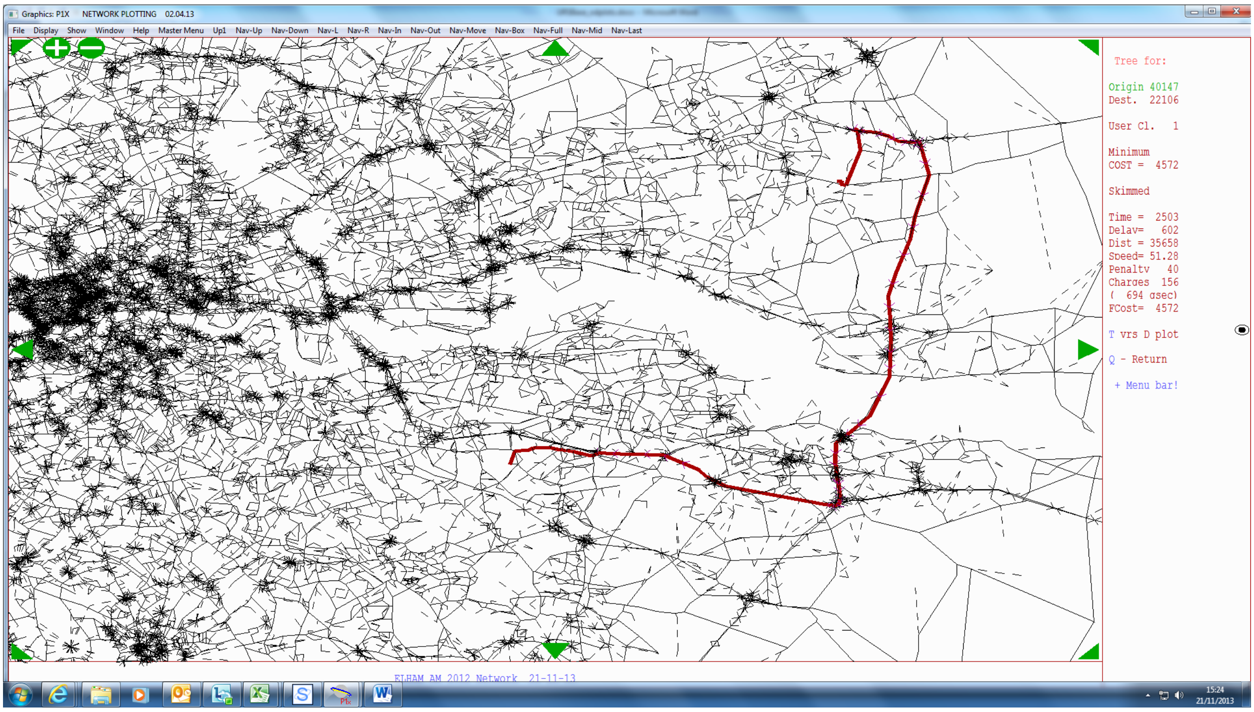
Knockholt to Chadwell Heath – cars



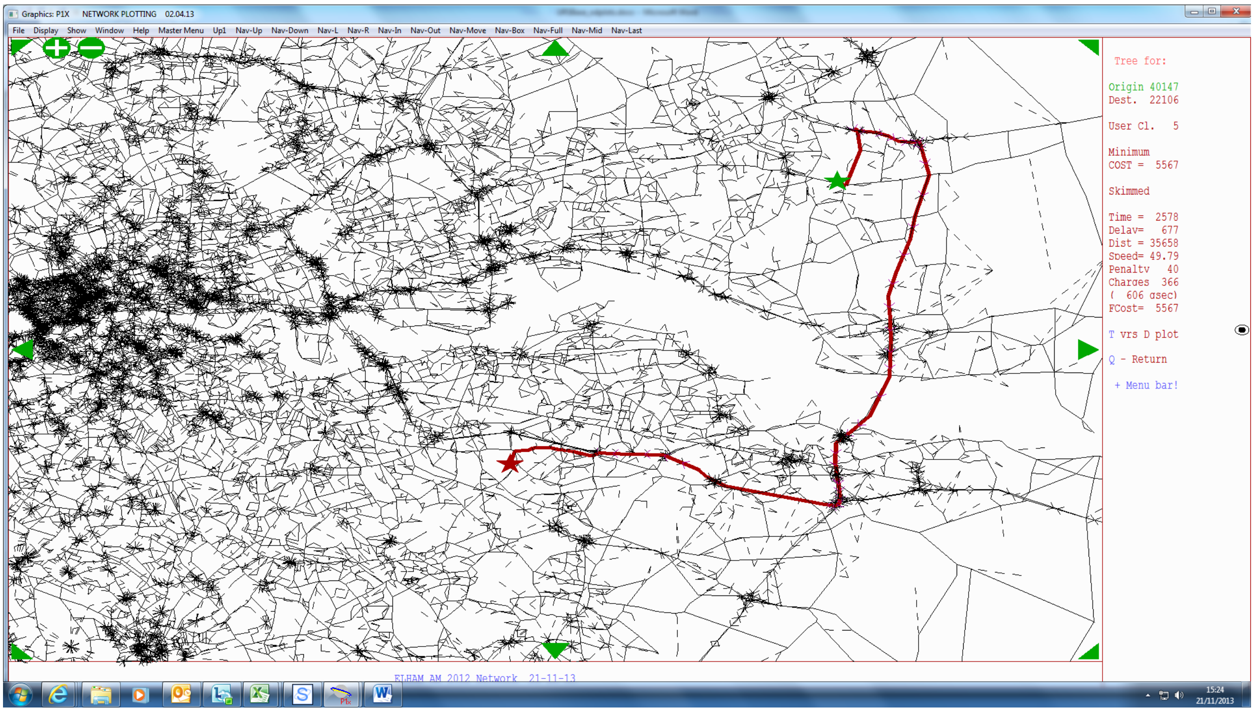
Knockholt to Chadwell Heath – OGVs



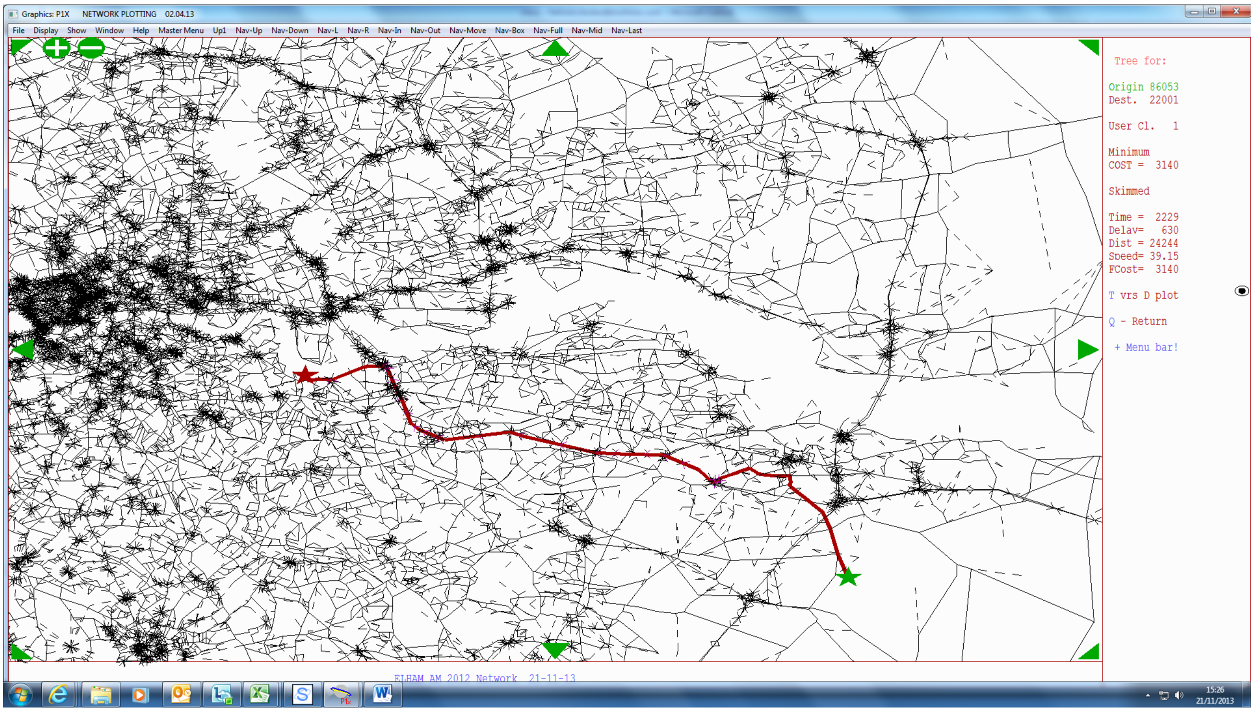
Upminster to Avery Heath – cars



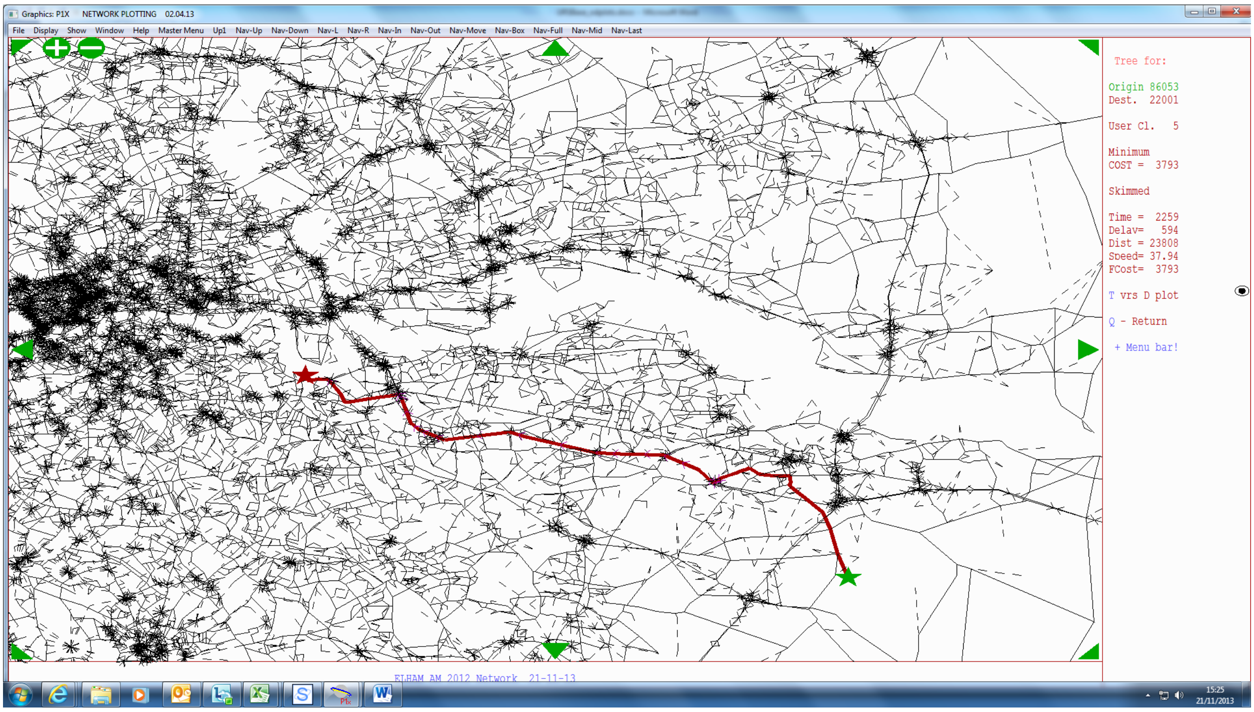
Upminster to Avery Heath – OGVs



South Darenth to Deptford – cars



South Darenth to Deptford – OGVs



Appendix G. Matrix Estimation changes at zonal cell level

User class definitions for following tables:

UC1 – Cars out-of-work time

UC2 – Cars in-work-time

UC3 – Taxi

UC4 – LGV

UC5 – HGV

Table G.1: Test Criteria

Criteria	Min	Max
Slope	0.980	1.020
Intercept	-0.100	0.100
R^2	0.950	1.000

Source: Table 5 TAG Unit 3.19 http://www.dft.gov.uk/webtag/documents/expert/u3_19-highway-assignemnt-modelling-020807.pdf

G.1 Matrix Estimation with River Thames screenline as validation

Table G.2: Regression Statistics for AM peak Matrix Estimation

AM	Slope	Intercept	R^2
UC1	**0.842**	0.025	**0.771**
UC2	**0.901**	0.004	**0.794**
UC3	**0.619**	0.001	**0.630**
UC4	**0.808**	0.004	**0.768**
UC5	**0.764**	0.003	**0.628**

Note: Values in bold indicate that change is significant

Table G.3: Regression Statistics for IP Matrix Estimation

IP	Slope	Intercept	R^2
UC1	**0.950**	0.014	**0.832**
UC2	**0.951**	0.004	**0.824**
UC3	**0.894**	0.000	**0.747**
UC4	**0.786**	0.004	**0.794**
UC5	**0.676**	0.004	**0.642**

Note: Values in bold indicate that change is significant

Table G.4: Regression Statistics for PM Matrix Estimation

PM	Slope	Intercept	R^2
UC1	**1.419**	0.011	**0.716**
UC2	**0.786**	0.002	**0.619**
UC3	**0.432**	0.002	**0.176**
UC4	**0.607**	0.006	**0.607**
UC5	**0.299**	0.002	**0.428**

Note: Values in bold indicate that change is significant

G.2 Matrix Estimation with all counts

Table G.5: Regression Statistics for AM peak Matrix Estimation

AM	Slope	Intercept	R^2
UC1	**0.843**	0.025	**0.769**
UC2	**0.909**	0.003	**0.790**
UC3	**0.632**	0.001	**0.626**
UC4	**0.811**	0.004	**0.770**
UC5	**0.767**	0.003	**0.633**

Note: Values in bold indicate that change is significant

Table G.6: Regression Statistics for IP Matrix Estimation

IP	Slope	Intercept	R^2
UC1	**0.951**	0.014	**0.836**
UC2	**0.953**	0.004	**0.826**
UC3	**0.939**	0.000	**0.747**
UC4	**0.793**	0.004	**0.791**
UC5	**0.672**	0.004	**0.639**

Note: Values in bold indicate that change is significant

Table G.7: Regression Statistics for PM Matrix Estimation

PM	Slope	Intercept	R^2
UC1	**1.094**	0.021	**0.611**
UC2	**0.767**	0.004	**0.534**
UC3	**0.575**	0.000	**0.378**
UC4	**0.751**	0.004	**0.719**
UC5	**0.588**	0.005	**0.429**

Note: Values in bold indicate that change is significant

Appendix H. Matrix Estimation changes of destination trips (zonal level)

User class definitions for following figures:

UC1 – Cars out-of-work time

UC2 – Cars in-work-time

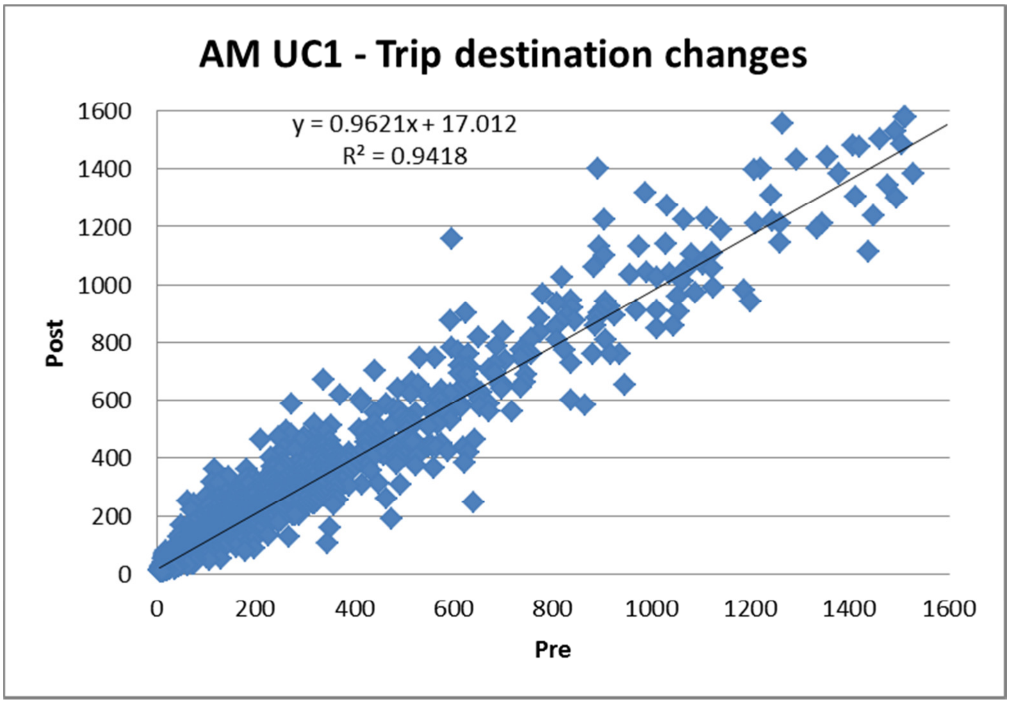
UC3 – Taxi

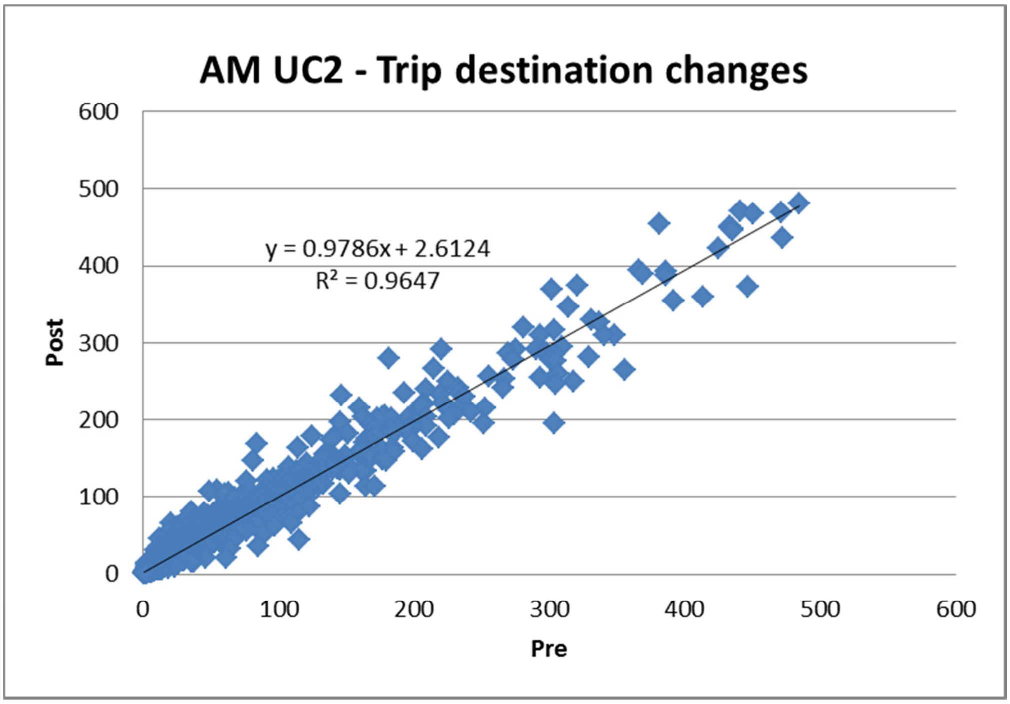
UC4 – LGV

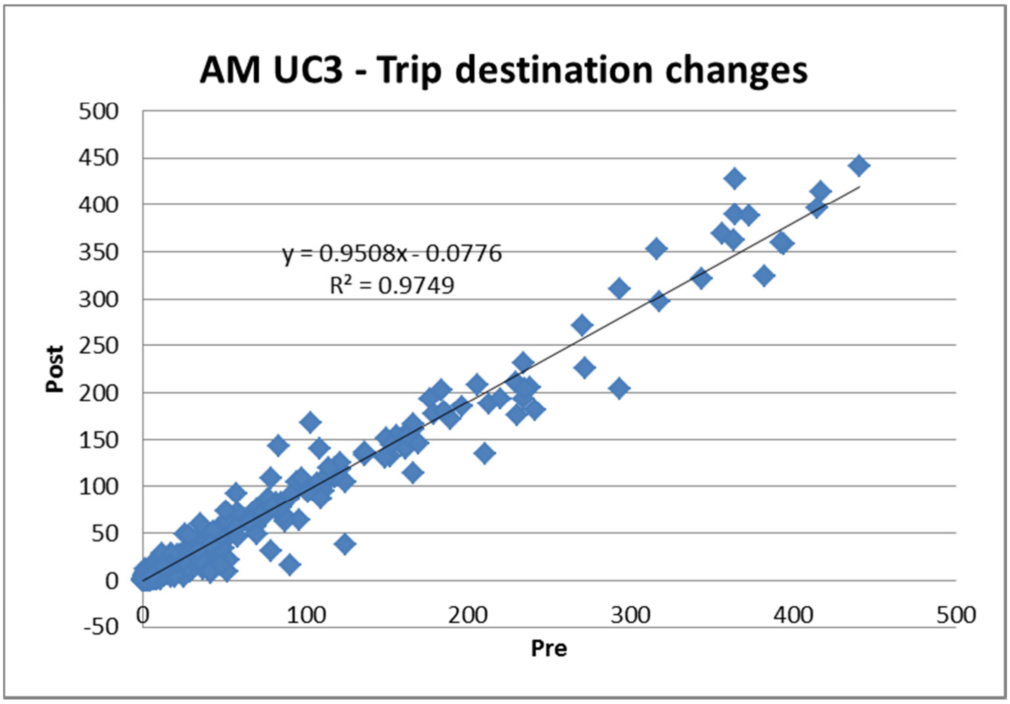
UC5 – HGV

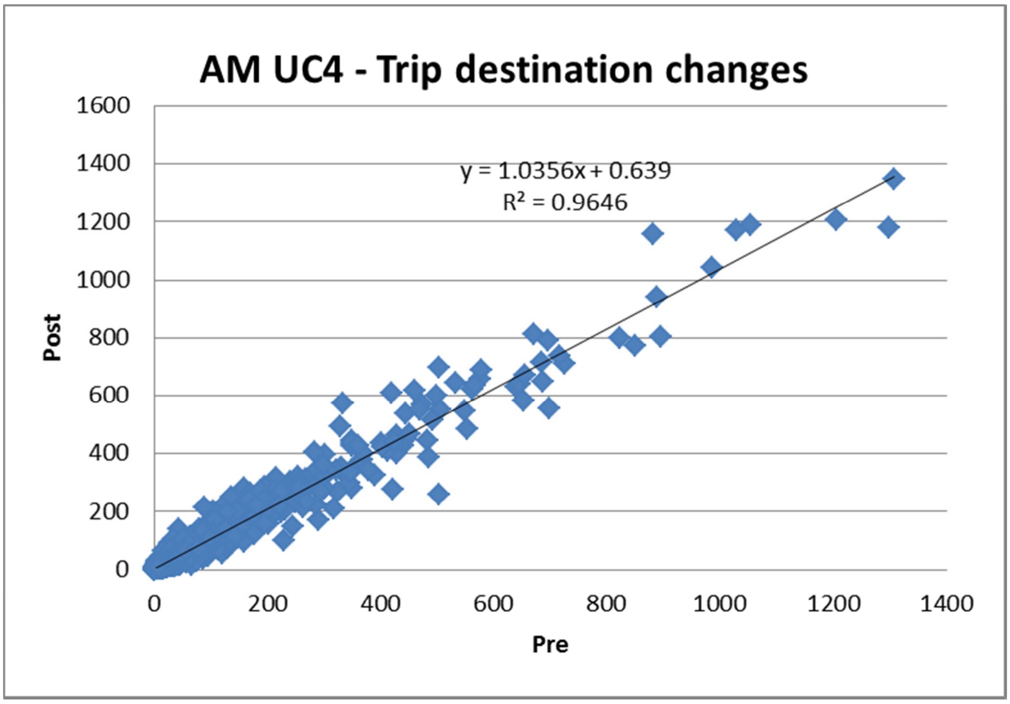
H.1 Matrix Estimation with River Thames screenline as validation

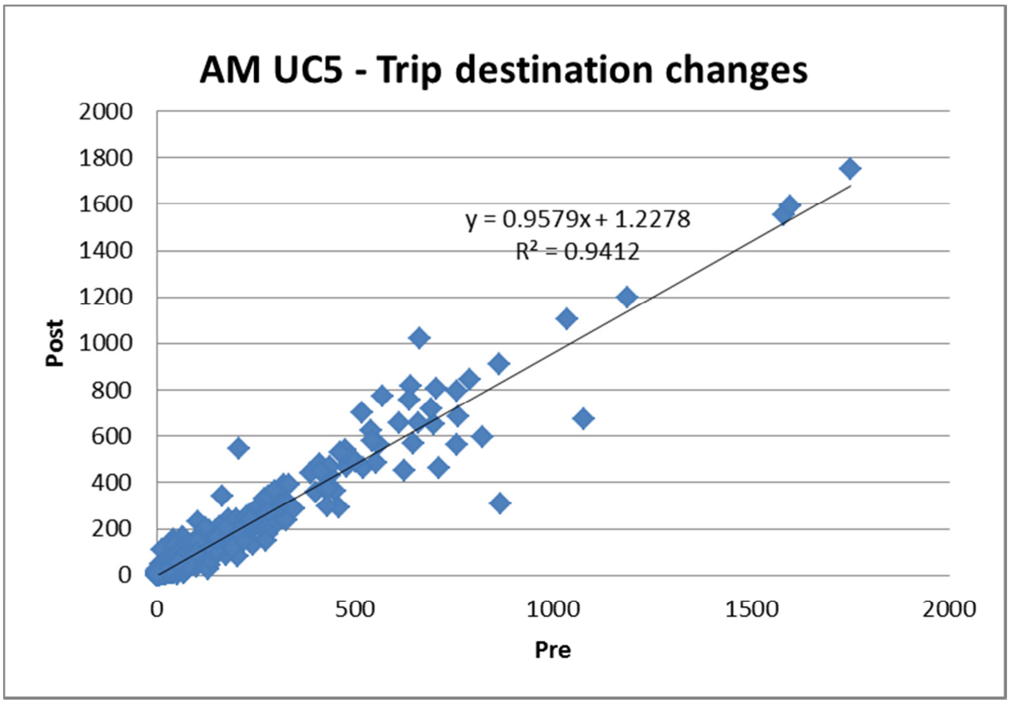
H.1.1 AM trip destination changes



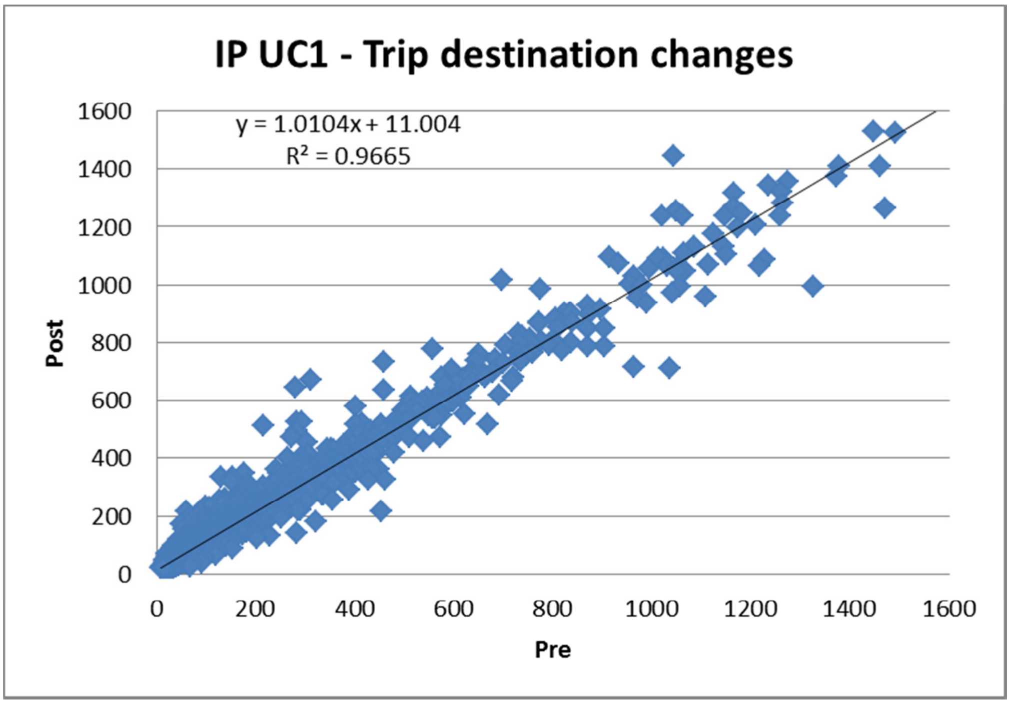

AM UC2 - Trip destination changes
600
500
400
300
200
100
0
0
100
200
300
400
500
600
Post
Pre
y = 0.9786x + 2.6124
R² = 0.9647

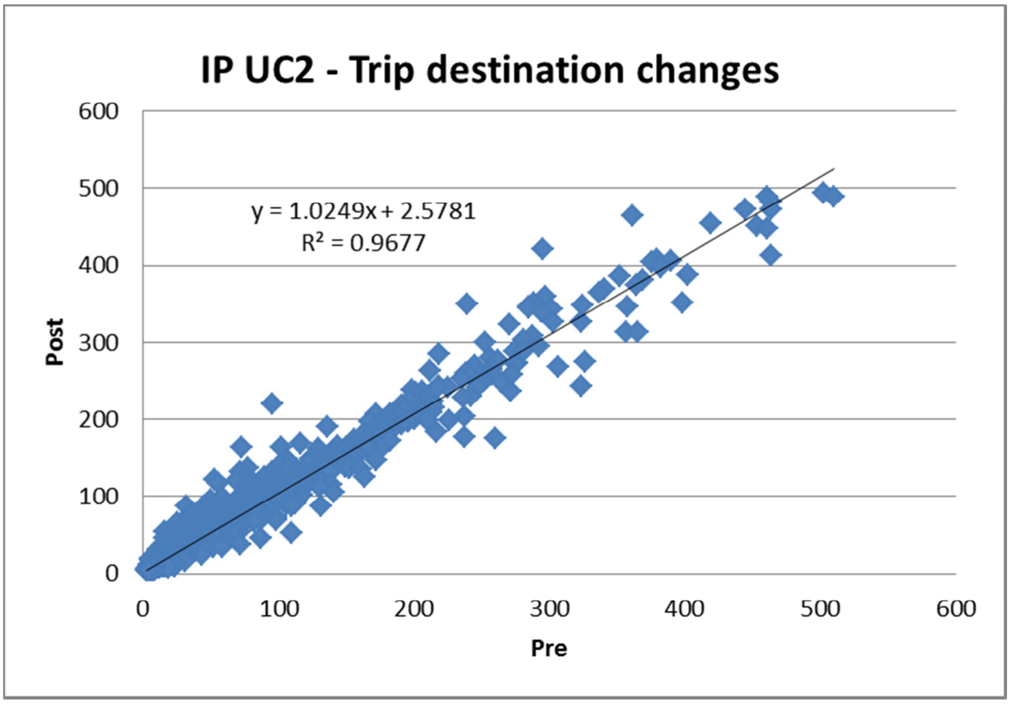

AM UC3 - Trip destination changes
500
450
400
350
300
250
200
150
100
50
0
-50
0
100
200
300
400
500
Post
Pre
y = 0.9508x - 0.0776
R² = 0.9749

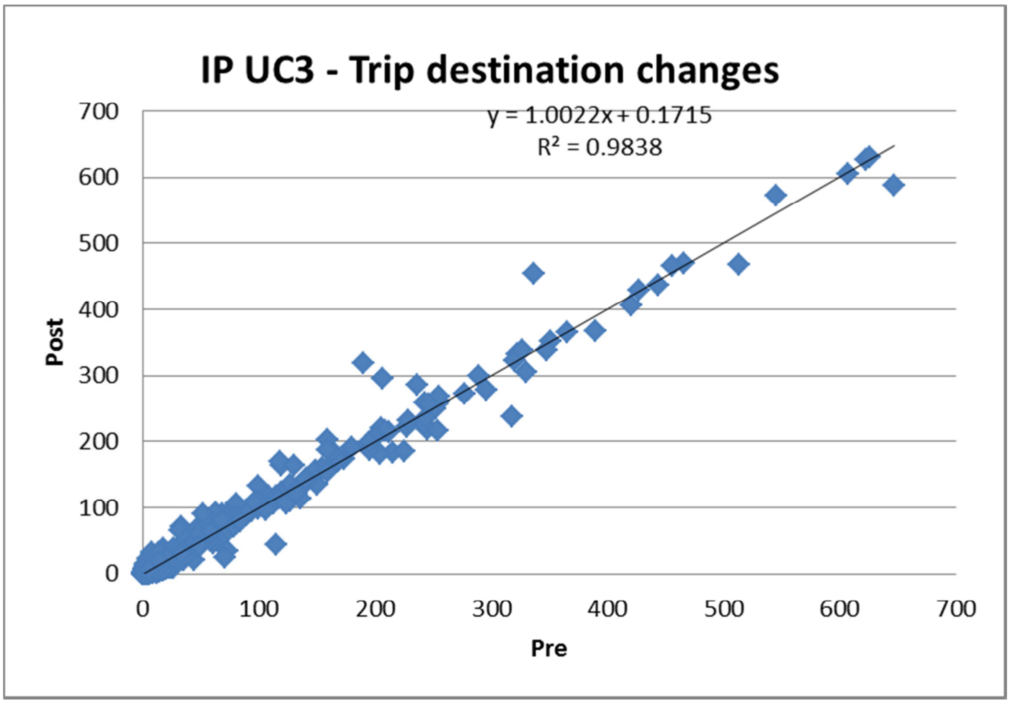

AM UC4 - Trip destination changes
y = 1.0356x + 0.639
R² = 0.9646
Post
Pre
0
200
400
600
800
1000
1200
1400
1600

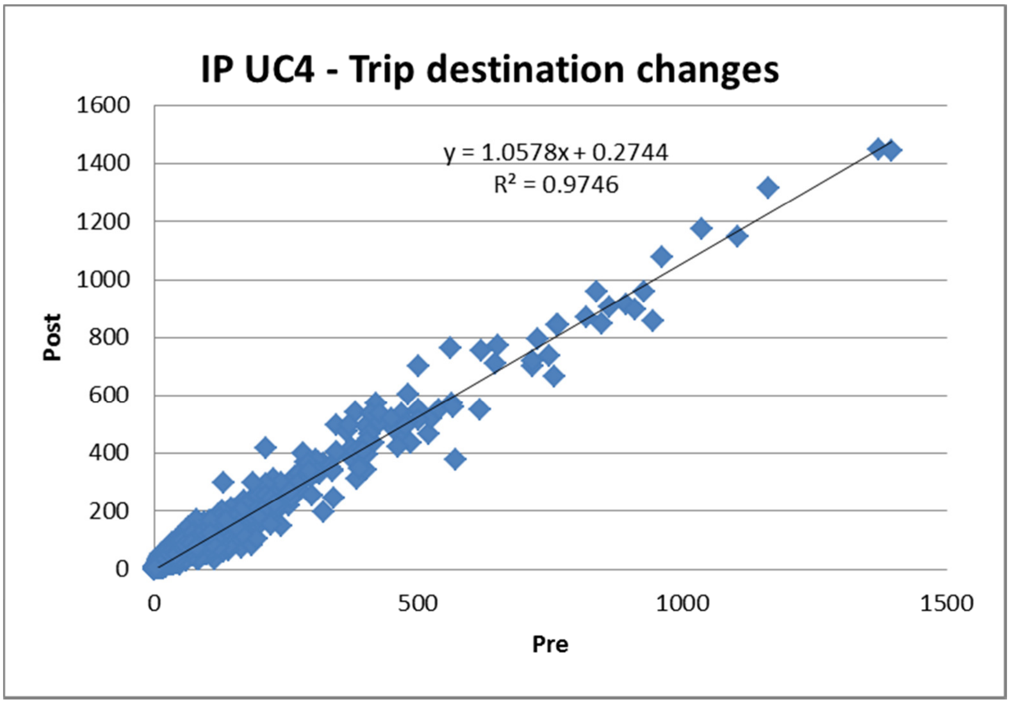

AM UC5 - Trip destination changes
y = 0.9579x + 1.2278
R² = 0.9412
Post
Pre
0
200
400
600
800
1000
1200
1400
1600
1800
2000
500
1500

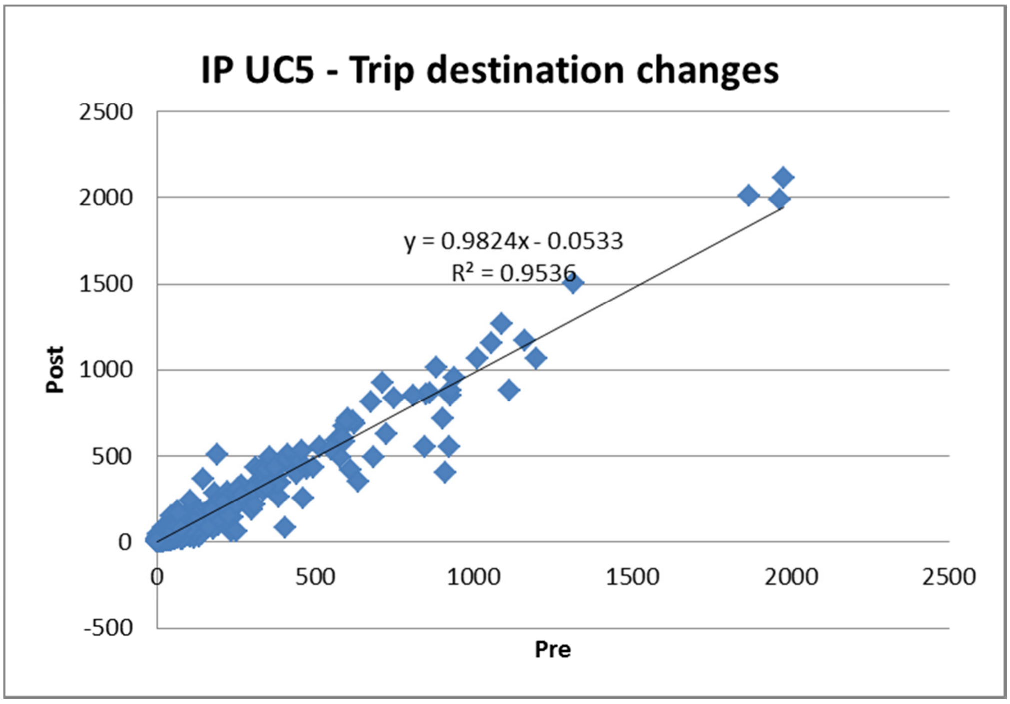
H.1.2 IP trip destination changes



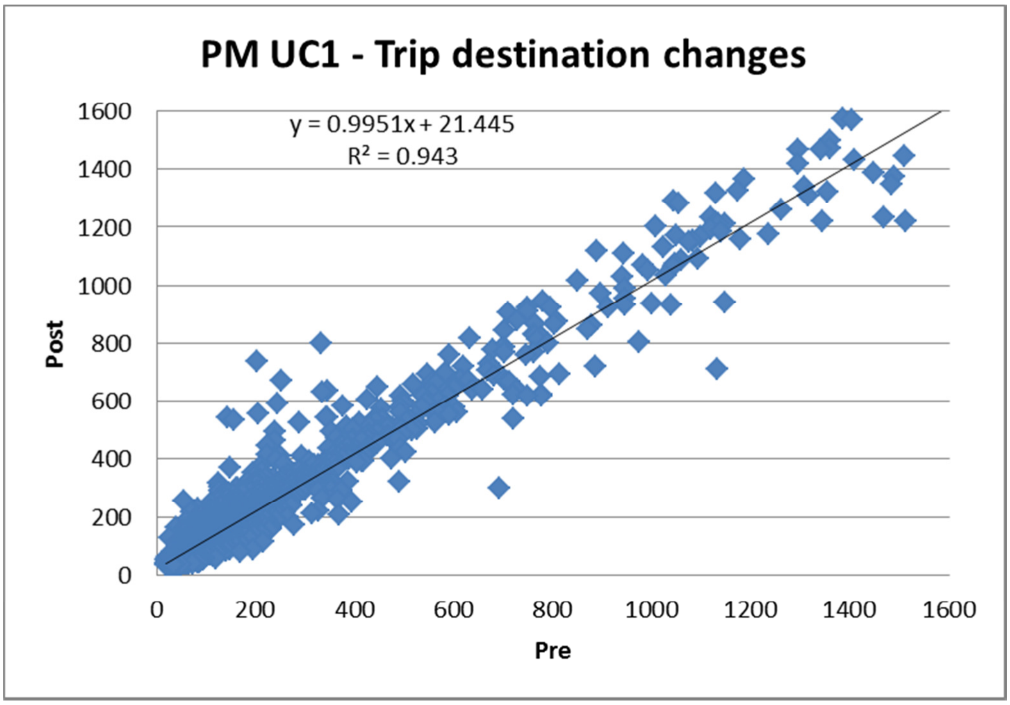


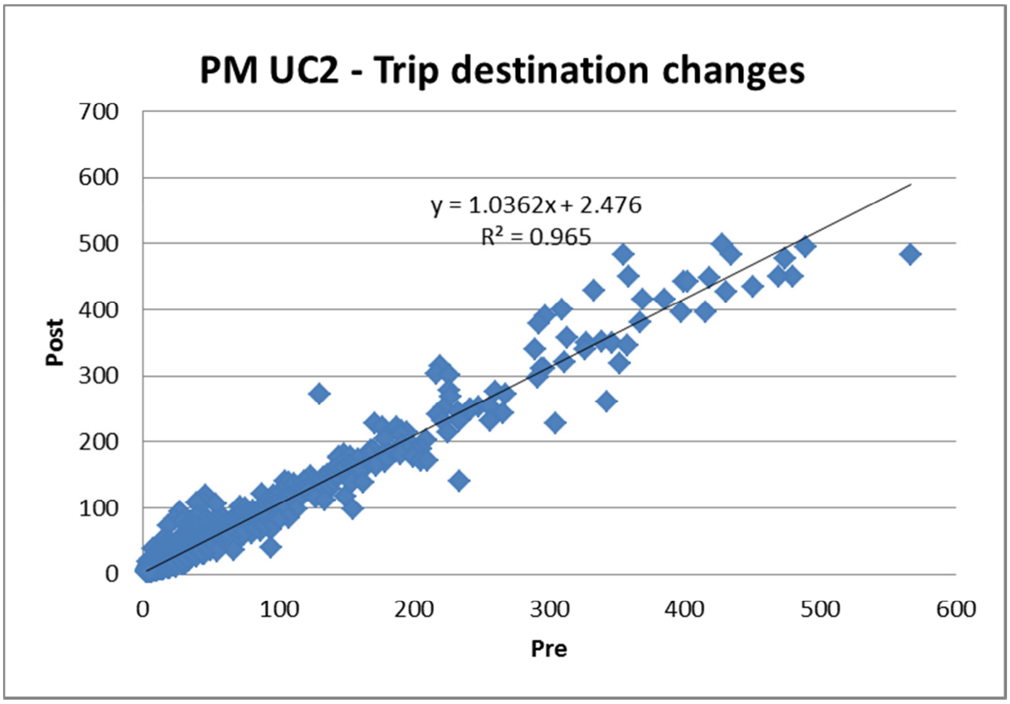

IP UC3 - Trip destination changes
y = 1.0022x + 0.1715
R² = 0.9838
Post
Pre
0
100
200
300
400
500
600
700

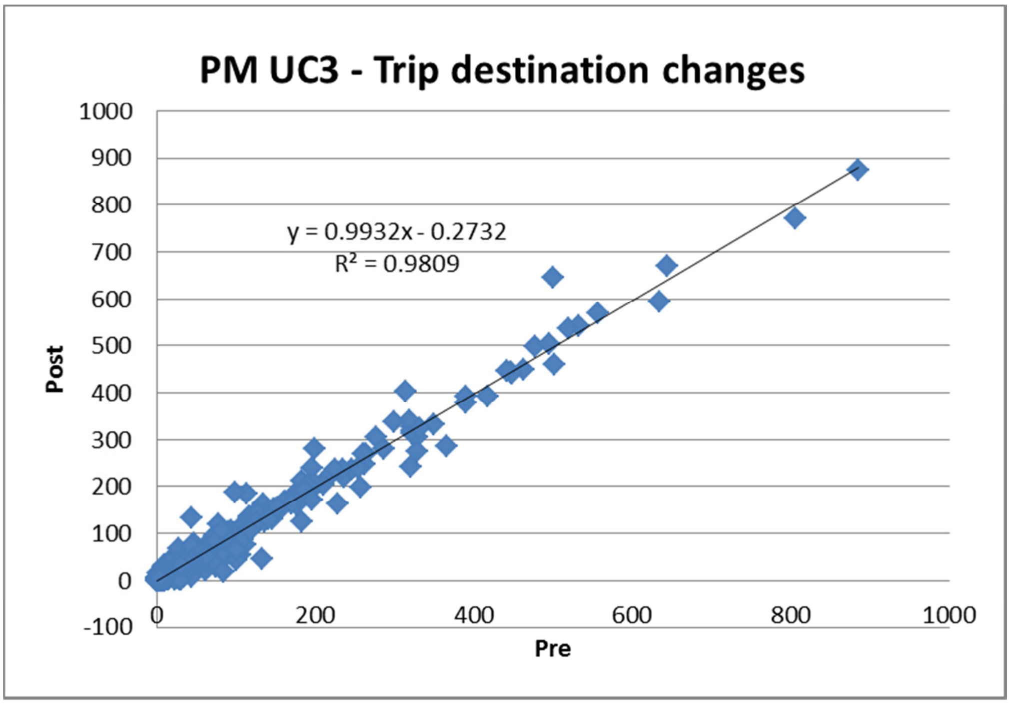

IP UC4 - Trip destination changes
y = 1.0578x + 0.2744
R² = 0.9746
Post
Pre
0
200
400
600
800
1000
1200
1400
1600
500
1500

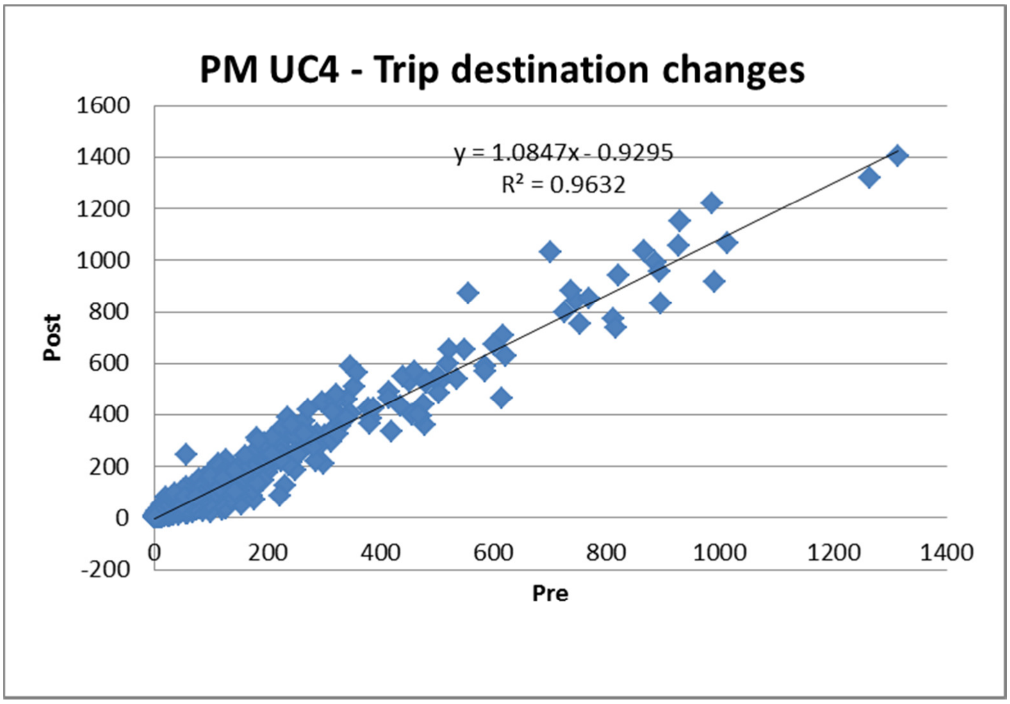


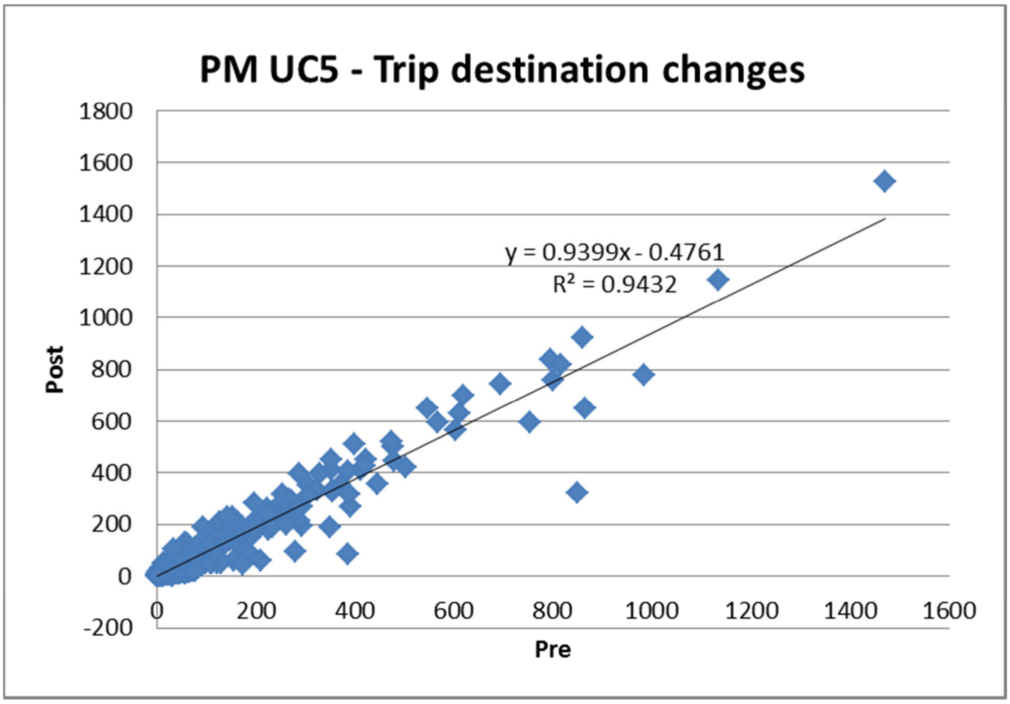
H.1.3 PM trip destination changes




PM UC2 - Trip destination changes
700
600
500
400
300
200
100
0
Post
0
100
200
300
400
500
600
Pre
y = 1.0362x + 2.476
R² = 0.965

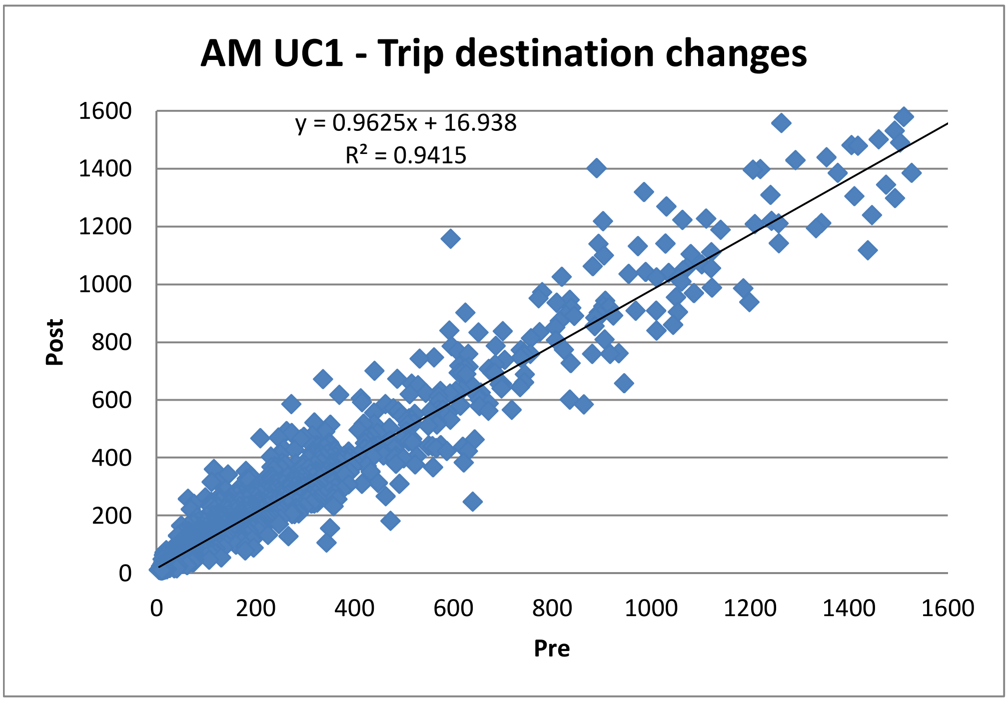

PM UC3 - Trip destination changes
1000
900
800
700
600
500
400
300
200
100
0
-100
Post
0
200
400
600
800
1000
Pre
y = 0.9932x - 0.2732
R² = 0.9809

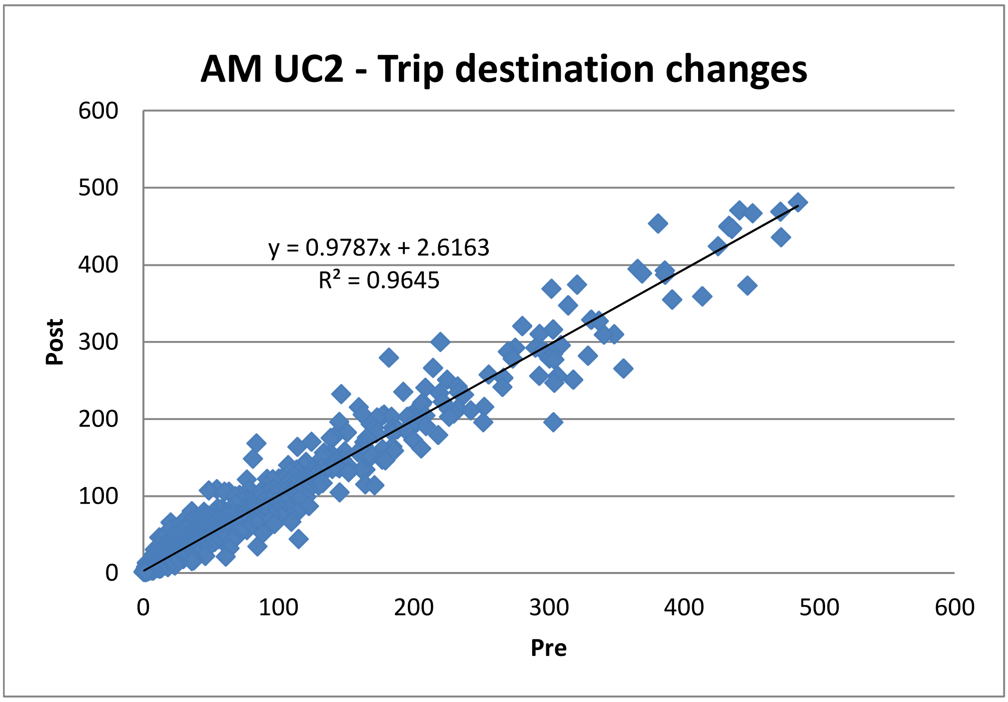

PM UC4 - Trip destination changes
y = 1.0847x - 0.9295
R² = 0.9632
Post
Pre
1600
1400
1200
1000
800
600
400
200
0
-200
0
200
400
600
800
1000
1200
1400

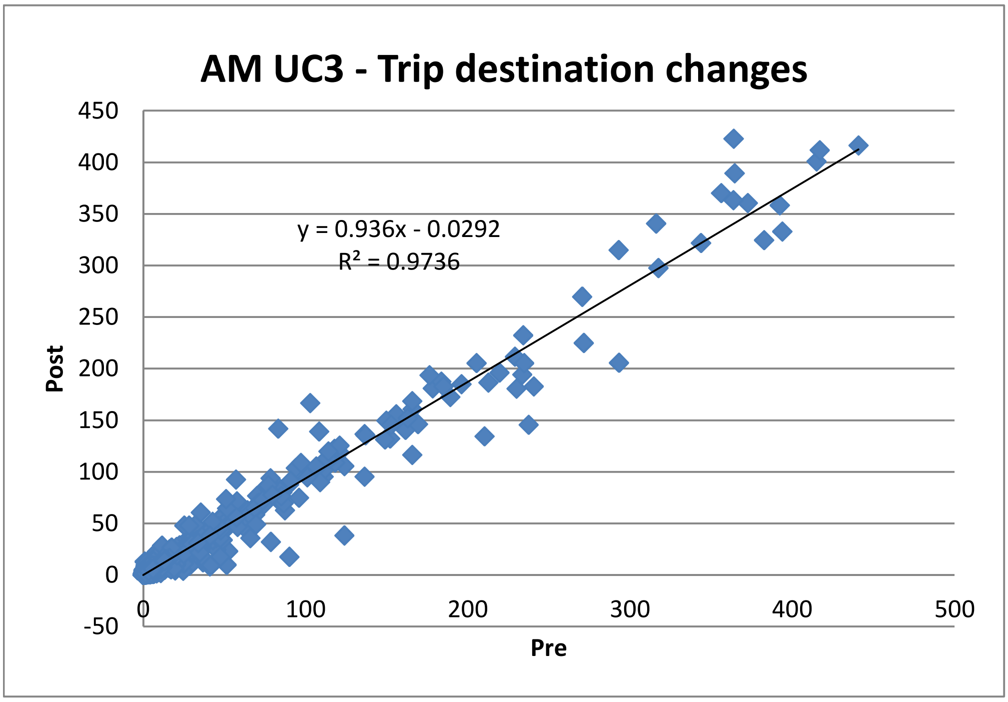

PM UC5 - Trip destination changes
y = 0.9399x - 0.4761
R² = 0.9432
Post
Pre
1800
1600
1400
1200
1000
800
600
400
200
0
-200
0
200
400
600
800
1000
1200
1400
1600

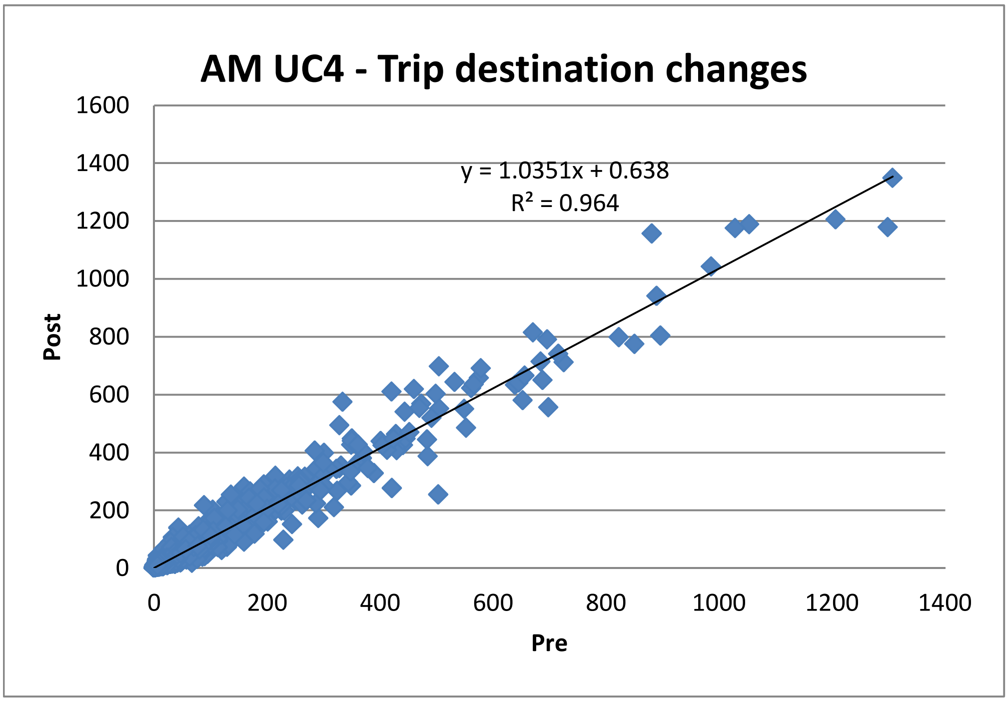
H.2 Matrix Estimation with all counts

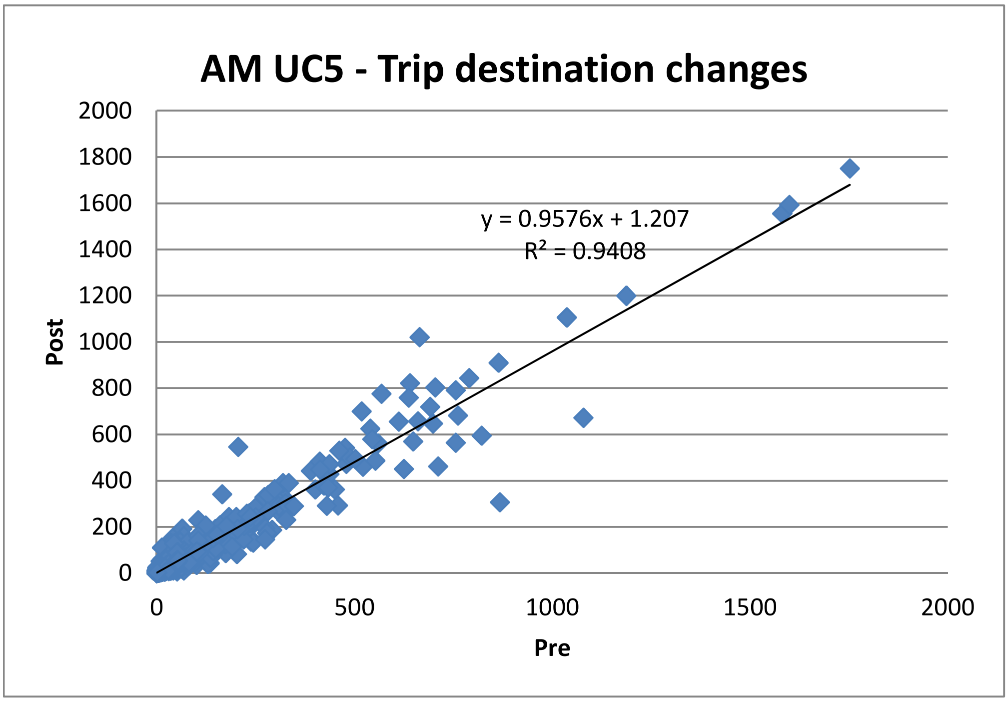
H.2.1 AM trip destination changes



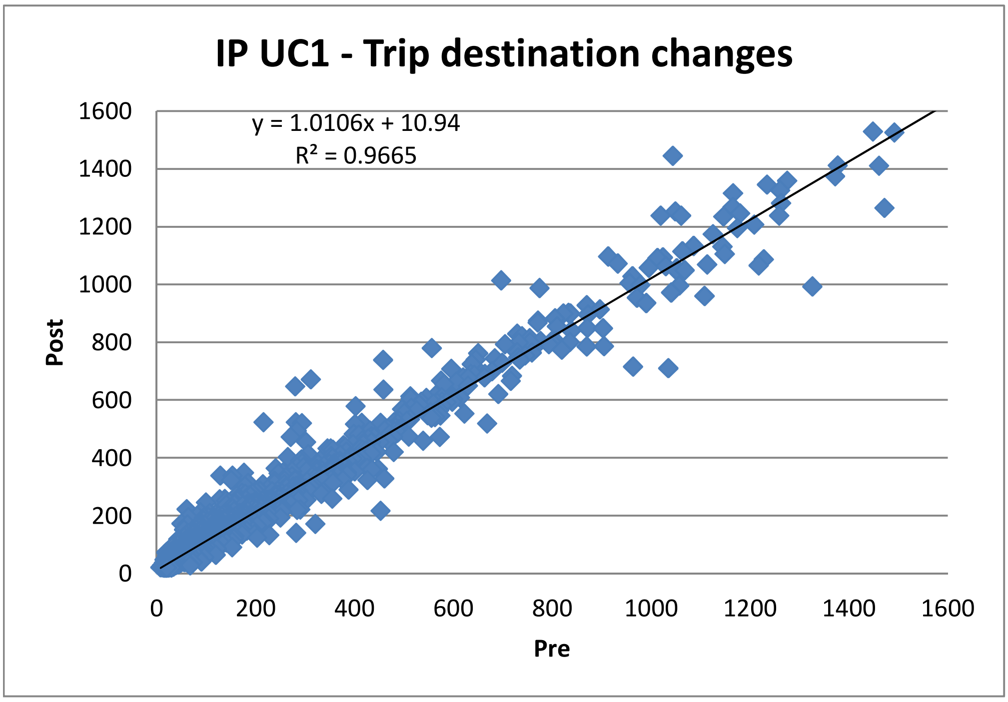

AM UC2 - Trip destination changes
600
500
400
300
200
100
0
Post
y = 0.9787x + 2.6163
R² = 0.9645
0
100
200
300
400
500
600
Pre

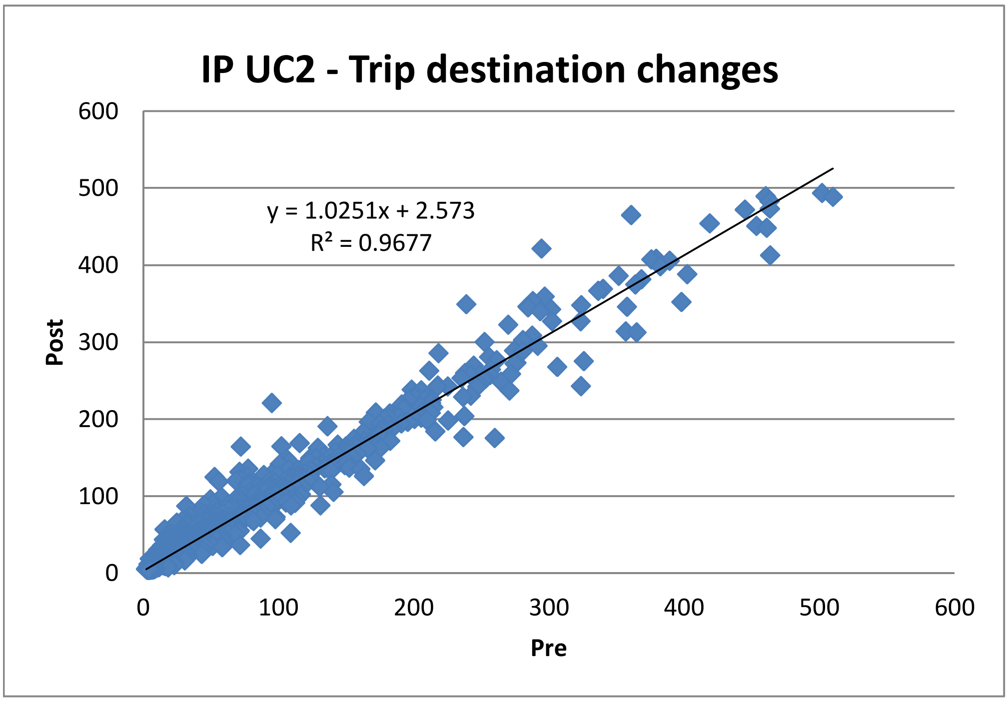

AM UC3 - Trip destination changes
450
400
350
300
250
200
150
100
50
0
-50
Post
y = 0.936x - 0.0292
R² = 0.9736
0
100
200
300
400
500
Pre

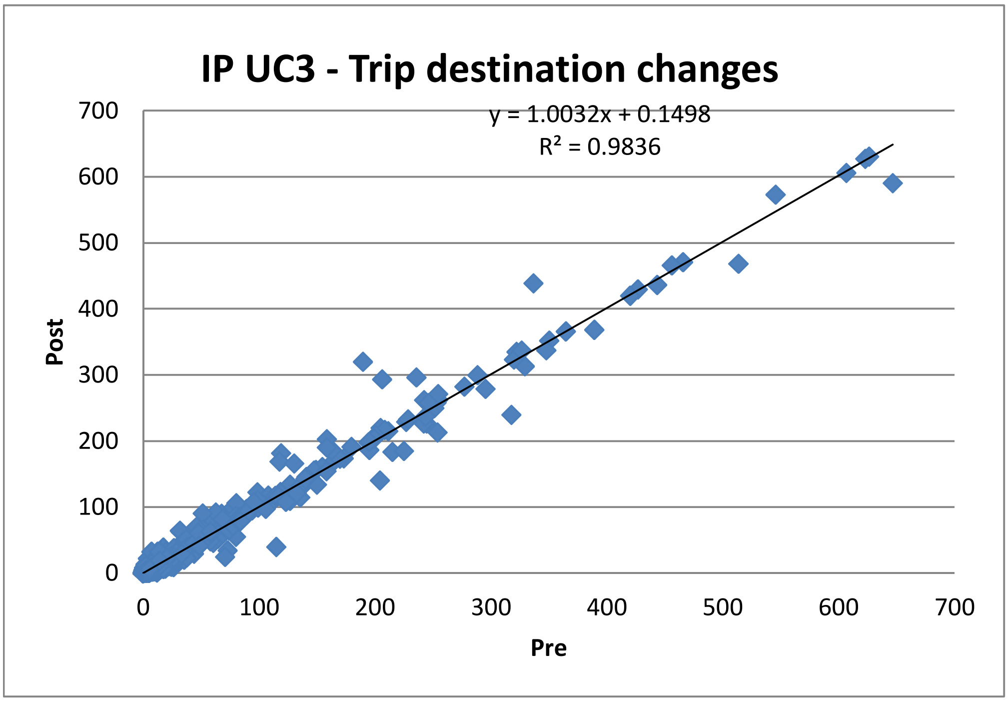

AM UC4 - Trip destination changes
y = 1.0351x + 0.638
R² = 0.964
Post
Pre
0
200
400
600
800
1000
1200
1400
1600

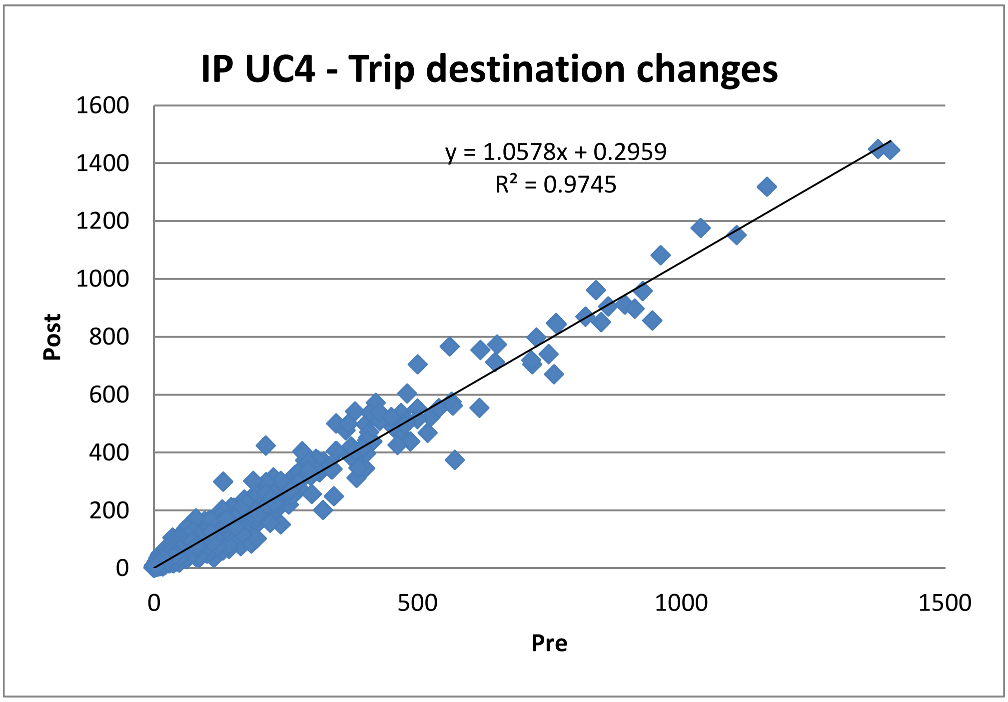

AM UC5 - Trip destination changes
y = 0.9576x + 1.207
R² = 0.9408
Post
Pre
0
500
1000
1500
2000

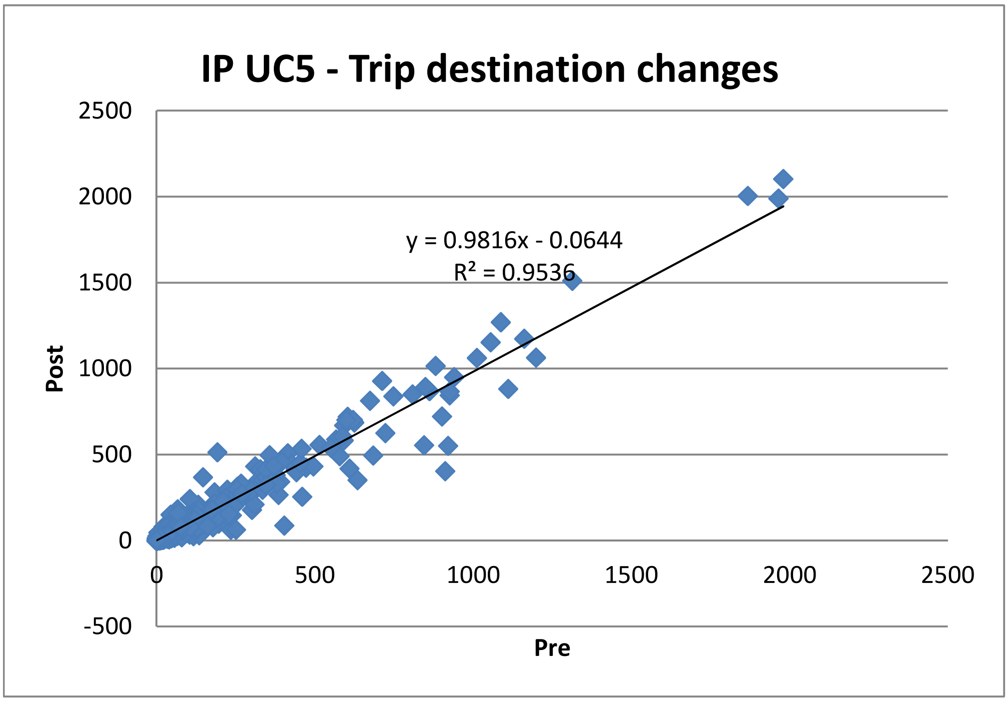
H.2.2 IP trip destination changes



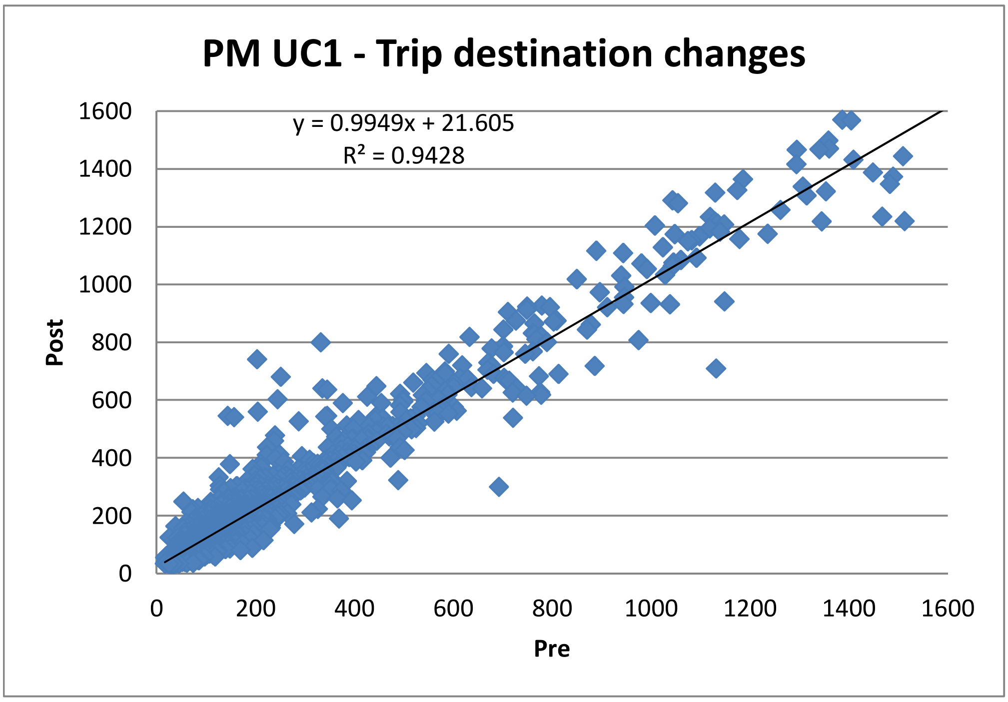


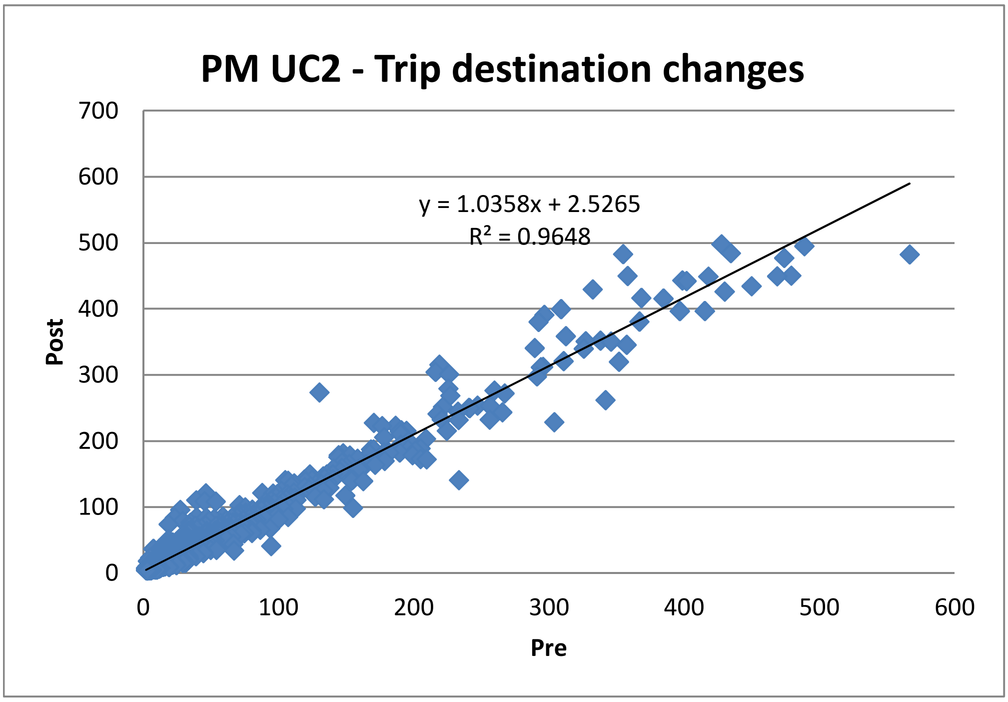

IP UC3 - Trip destination changes
y = 1.0032x + 0.1498
R² = 0.9836
Post
700
600
500
400
300
200
100
0
0
100
200
300
400
500
600
700
Pre

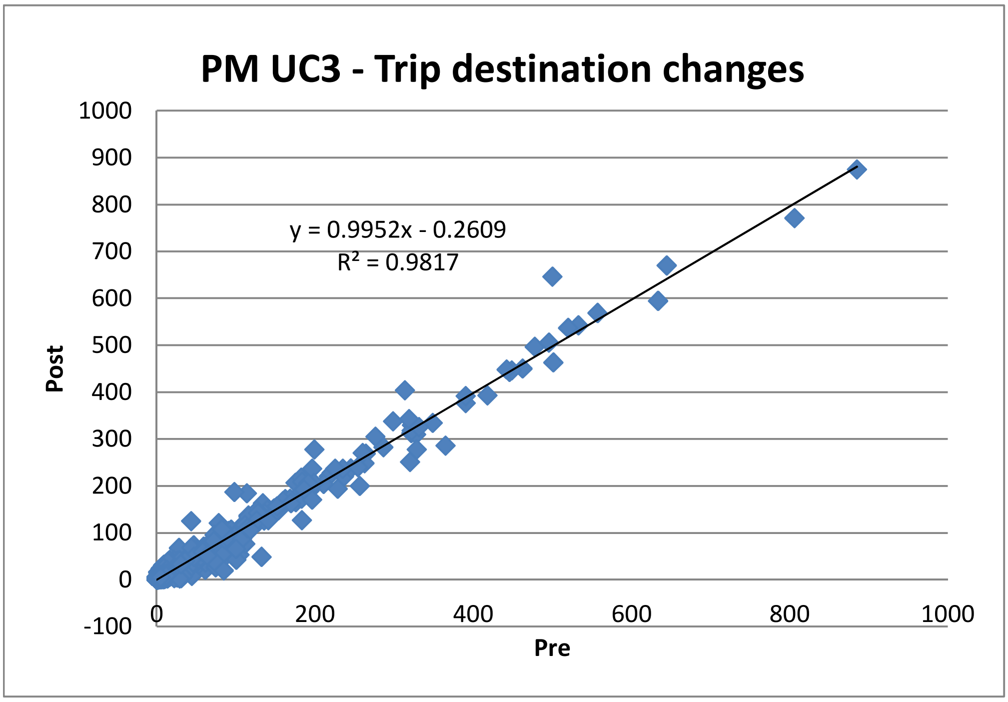

IP UC4 - Trip destination changes
y = 1.0578x + 0.2959
R² = 0.9745
Post
1600
1400
1200
1000
800
600
400
200
0
0
500
1000
1500
Pre

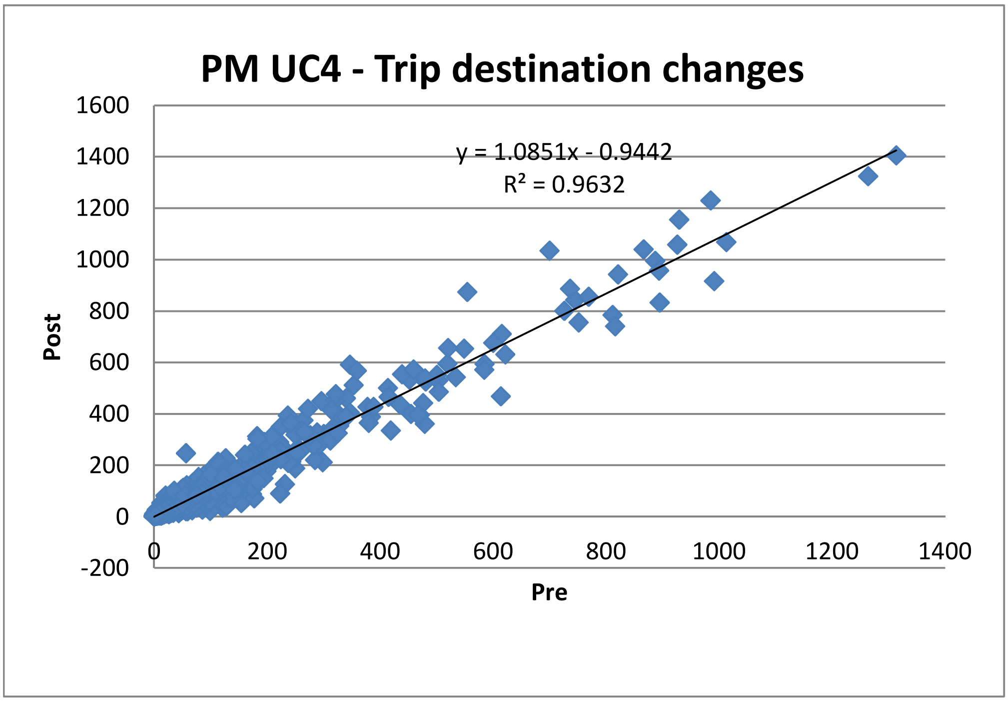


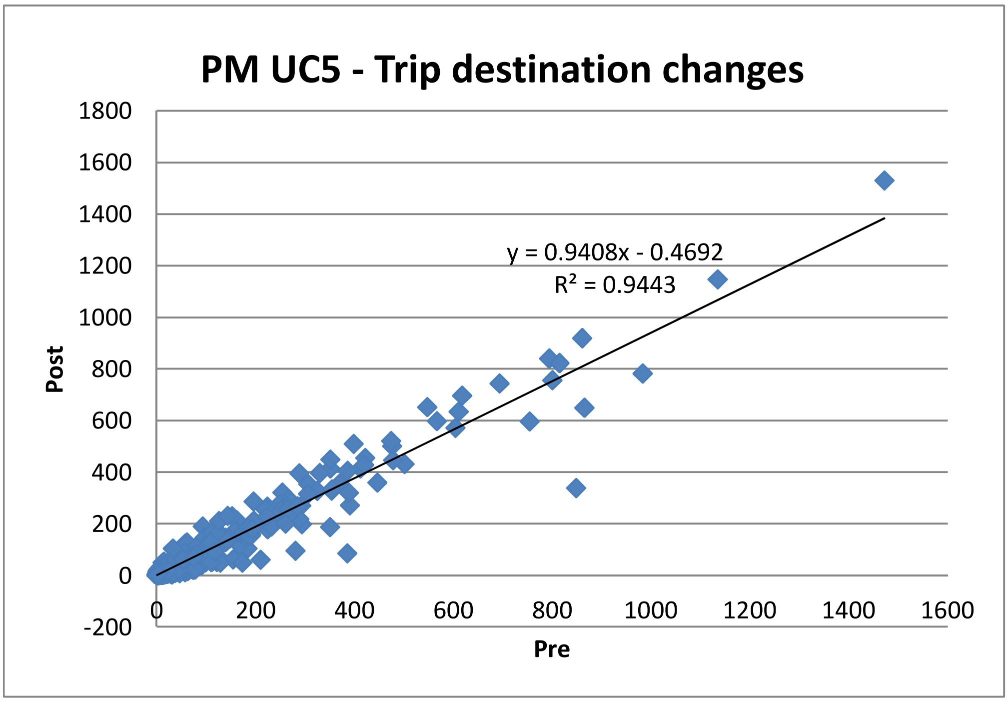
H.2.3 PM trip destination changes




PM UC2 - Trip destination changes
y = 1.0358x + 2.5265
R² = 0.9648
Post
Pre
0
100
200
300
400
500
600
700


PM UC3 - Trip destination changes
y = 0.9952x - 0.2609
R² = 0.9817
Post
Pre
-100
0
100
200
300
400
500
600
700
800
900
1000


PM UC4 - Trip destination changes
y = 1.0851x - 0.9442
R² = 0.9632
Post
Pre
1600
1400
1200
1000
800
600
400
200
0
-200
0
200
400
600
800
1000
1200
1400


PM UC5 - Trip destination changes
y = 0.9408x - 0.4692
R² = 0.9443
Post
Pre
1800
1600
1400
1200
1000
800
600
400
200
0
-200
0
200
400
600
800
1000
1200
1400
1600

Appendix I. Matrix Estimation changes to trip length distributions

I.1 Matrix Estimation with River Thames screenline as validation

I.1.1 AM peak comparison of trip length distributions

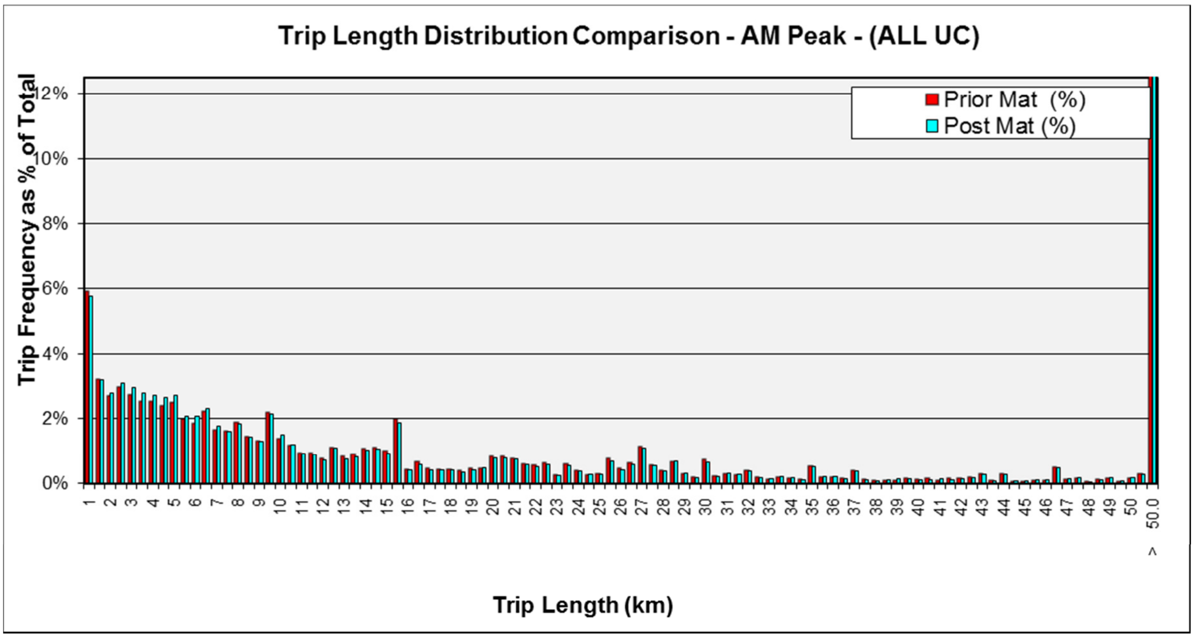


Table I.1: AM peak comparison of trip length distributions

Prior Matrix	UC1	UC2	UC3	UC4	UC5	Total
Mean	9.80	9.98	4.86	10.28	10.52	9.82
Std deviation	3.13	3.16	2.21	3.21	3.24	3.13
Post-ME	UC1	UC2	UC3	UC4	UC5	Total
Mean	9.52	9.69	4.35	10.16	10.32	9.55
Std deviation	3.09	3.11	2.09	3.19	3.21	3.09
% diff	UC1	UC2	UC3	UC4	UC5	Total
Mean	-2.9%	-2.9%	-10.6%	-1.1%	-2.0%	-2.7%
Std deviation	-1.5%	-1.5%	-5.5%	-0.6%	-1.0%	-1.4%

I.1.2 Interpeak comparison of trip length distributions

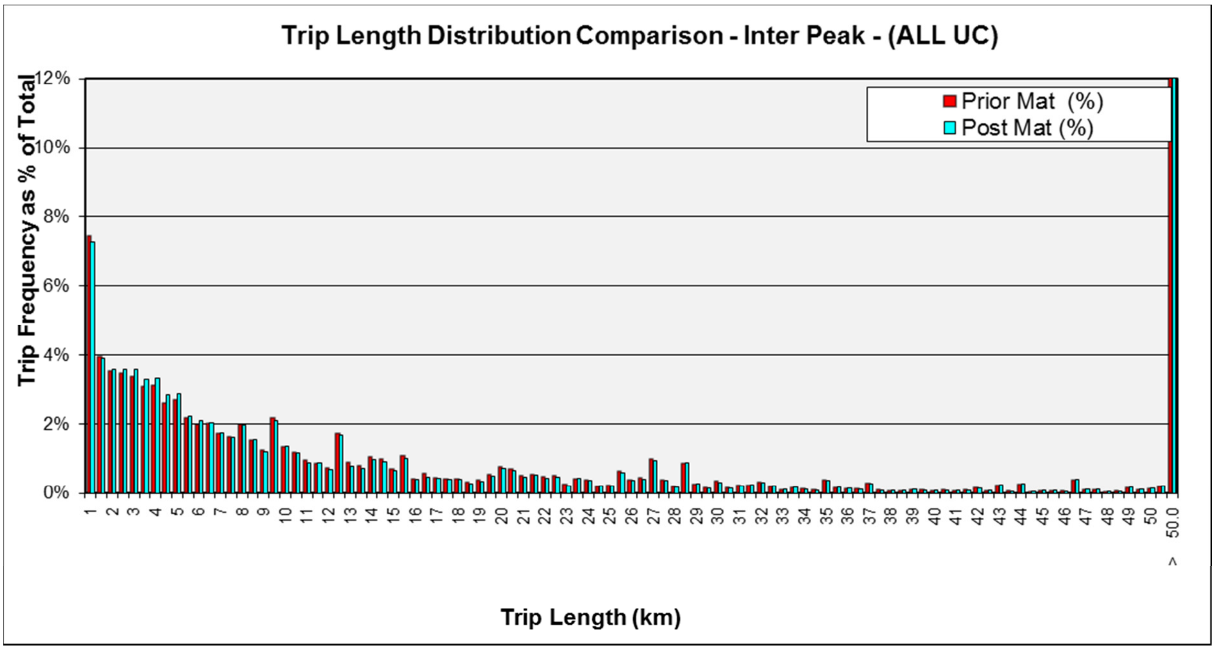


Table I.2: Interpeak comparison of trip length distributions

Prior Matrix	UC1	UC2	UC3	UC4	UC5	Total
Mean	8.55	8.47	4.27	9.55	10.05	8.63
Std deviation	2.92	2.91	2.07	3.09	3.17	2.94
Post-ME	UC1	UC2	UC3	UC4	UC5	Total
Mean	8.29	8.29	4.09	9.52	9.78	8.41
Std deviation	2.88	2.88	2.02	3.09	3.13	2.90
% diff	UC1	UC2	UC3	UC4	UC5	Total
Mean	-3.0%	-2.1%	-4.2%	-0.3%	-2.7%	-2.6%
Std deviation	-1.5%	-1.1%	-2.1%	-0.2%	-1.3%	-1.3%

I.1.3 PM peak comparison of trip length distributions

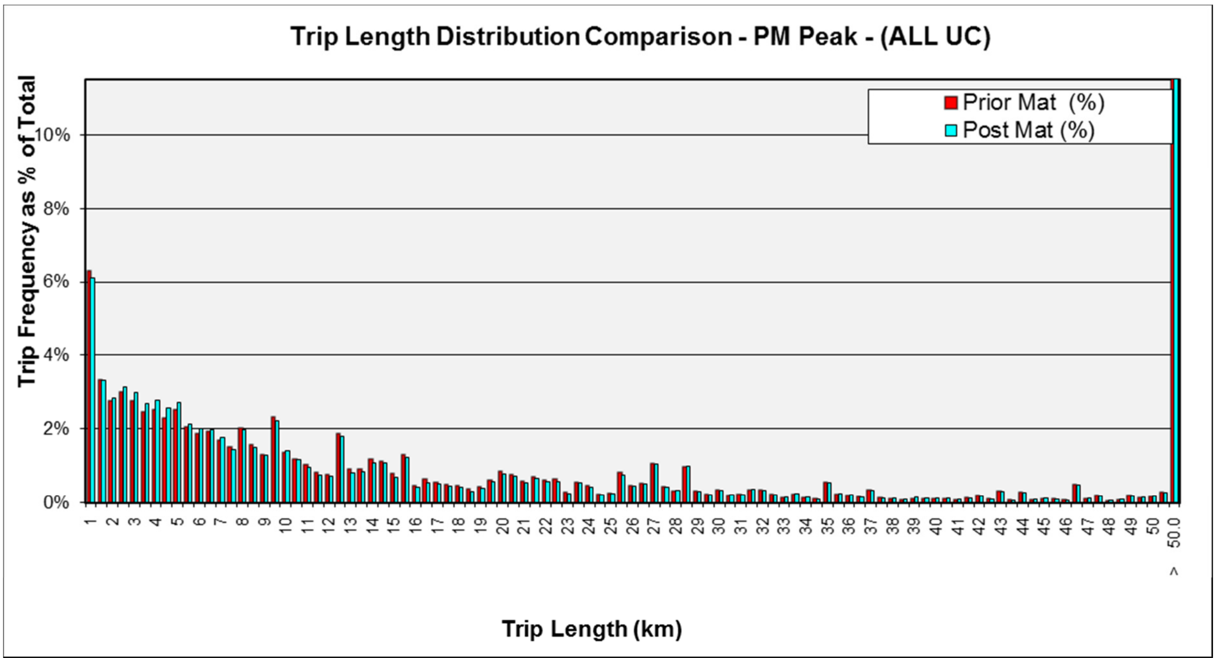


Table I.3: PM peak comparison of trip length distributions

Prior Matrix	UC1	UC2	UC3	UC4	UC5	Total
Mean	9.84	10.02	4.30	10.56	9.30	9.73
Std deviation	3.14	3.17	2.07	3.25	3.05	3.12
Post-ME	UC1	UC2	UC3	UC4	UC5	Total
Mean	9.61	9.77	3.94	10.49	9.37	9.53
Std deviation	3.10	3.13	1.98	3.24	3.06	3.09
% diff	UC1	UC2	UC3	UC4	UC5	Total
Mean	-2.3%	-2.4%	-8.5%	-0.7%	0.7%	-2.0%
Std deviation	-1.2%	-1.2%	-4.4%	-0.3%	0.4%	-1.0%

I.2 Matrix Estimation with all counts

I.2.1 AM peak comparison of trip length distributions

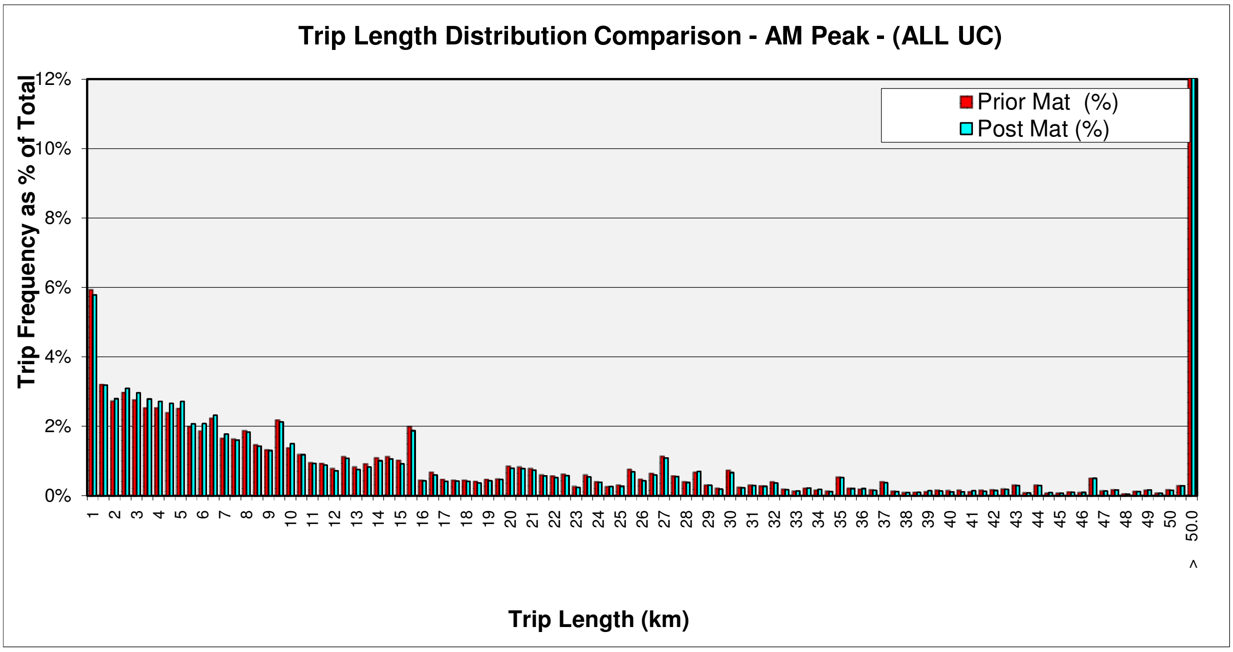


Table I.4: AM peak comparison of trip length distributions

Prior <atrix	UC1	UC2	UC3	UC4	UC5	Total
Mean	9.80	9.98	4.86	10.28	10.52	9.82
Std deviation	3.13	3.16	2.21	3.21	3.24	3.13
Post-ME	UC1	UC2	UC3	UC4	UC5	Total
Mean	9.52	9.69	4.37	10.17	10.32	9.55
Std deviation	3.08	3.11	2.09	3.19	3.21	3.09
% diff	UC1	UC2	UC3	UC4	UC5	Total
Mean	-2.9%	-2.9%	-10.2%	-1.1%	-1.9%	-2.7%
Std deviation	-1.5%	-1.5%	-5.2%	-0.5%	-1.0%	-1.4%

I.2.2 IP peak comparison of trip length distributions

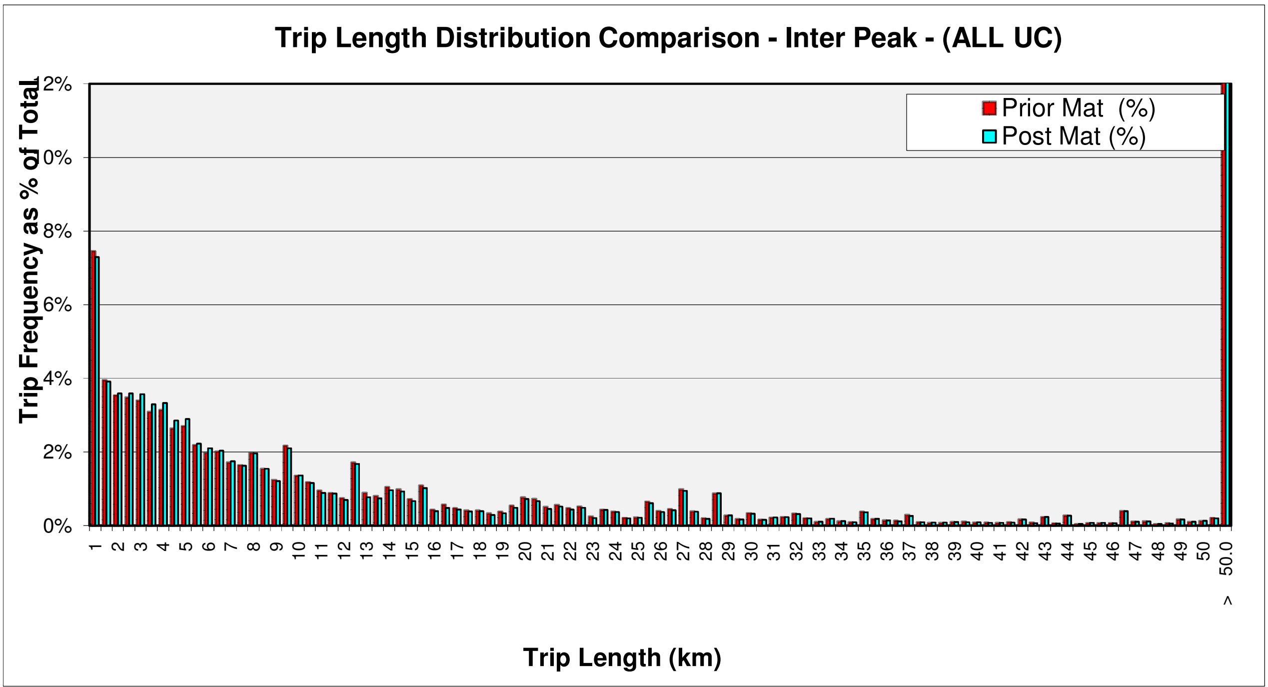


Table I.5: Interpeak comparison of trip length distributions

prior matrix	UC1	UC2	UC3	UC4	UC5	Total
Mean	8.55	8.47	4.27	9.55	10.05	8.63
Std deviation	2.92	2.91	2.07	3.09	3.17	2.94
Post-ME	UC1	UC2	UC3	UC4	UC5	Total
Mean	8.29	8.29	4.09	9.52	9.77	8.41
Std deviation	2.88	2.88	2.02	3.08	3.13	2.90
%diff	UC1	UC2	UC3	UC4	UC5	Total
Mean	-3.0%	-2.1%	-4.2%	-0.4%	-2.8%	-2.6%
Std deviation	-1.5%	-1.1%	-2.1%	-0.2%	-1.4%	-1.3%

I.2.3 PM peak comparison of trip length distributions

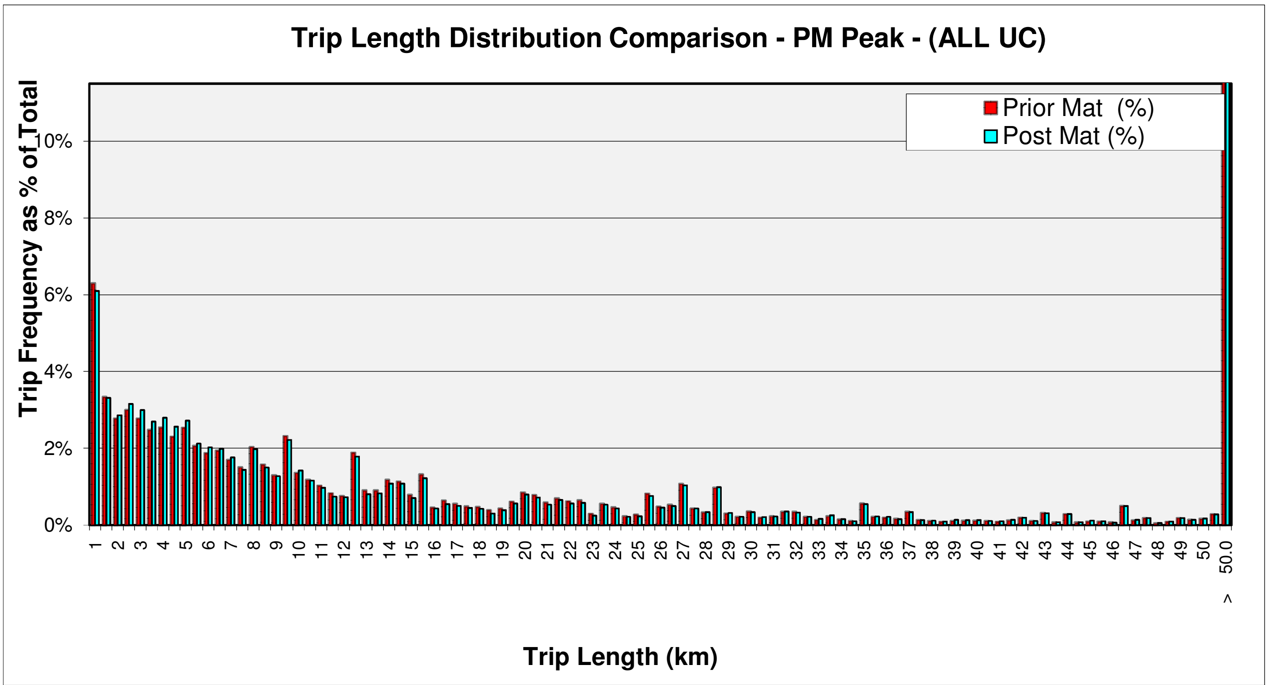


Table I.6: PM peak comparison of trip length distributions

prior matrix	UC1	UC2	UC3	UC4	UC5	Total
Mean	9.84	10.02	4.30	10.56	9.30	9.73
Std deviation	3.14	3.17	2.07	3.25	3.05	3.12
Post-ME	UC1	UC2	UC3	UC4	UC5	Total
Mean	9.61	9.77	3.93	10.48	9.37	9.53
Std deviation	3.10	3.13	1.98	3.24	3.06	3.09
% diff	UC1	UC2	UC3	UC4	UC5	Total
Mean	-2.3%	-2.4%	-8.7%	-0.7%	0.7%	-2.0%
Std deviation	-1.2%	-1.2%	-4.4%	-0.4%	0.3%	-1.0%

Appendix J. Matrix Estimation changes at sector cells

User class definitions for following figures

UC1 – Cars out-of-work time

UC2 – Cars in-work-time

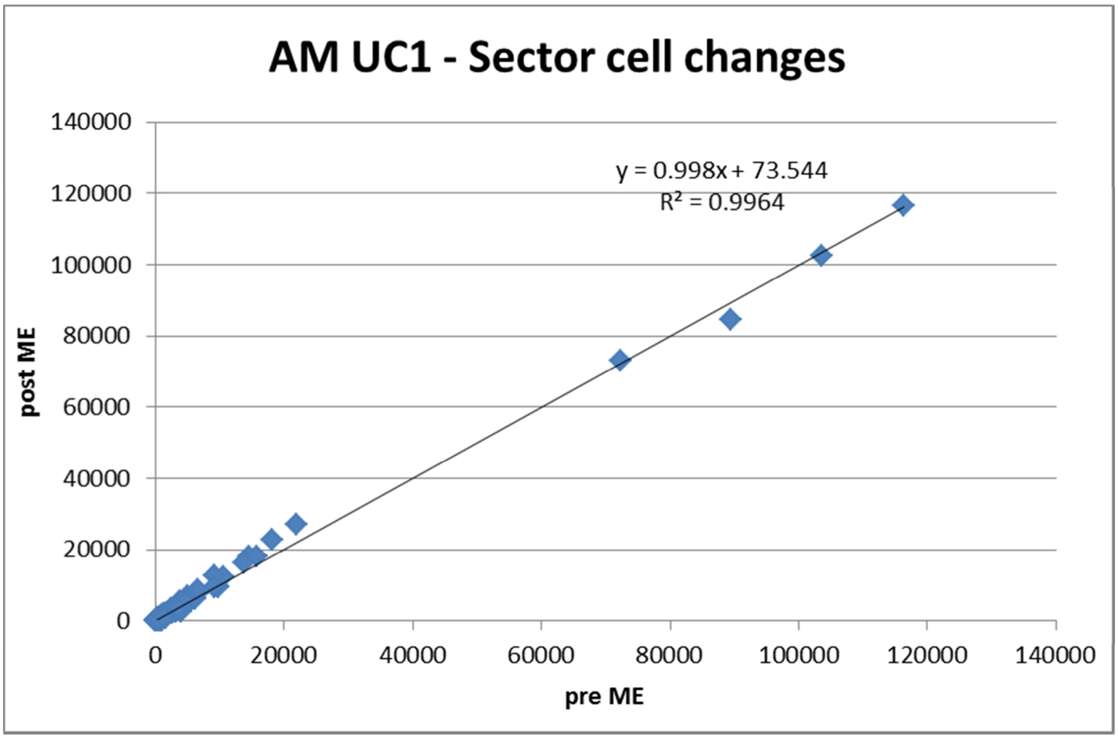
UC3 – Taxi

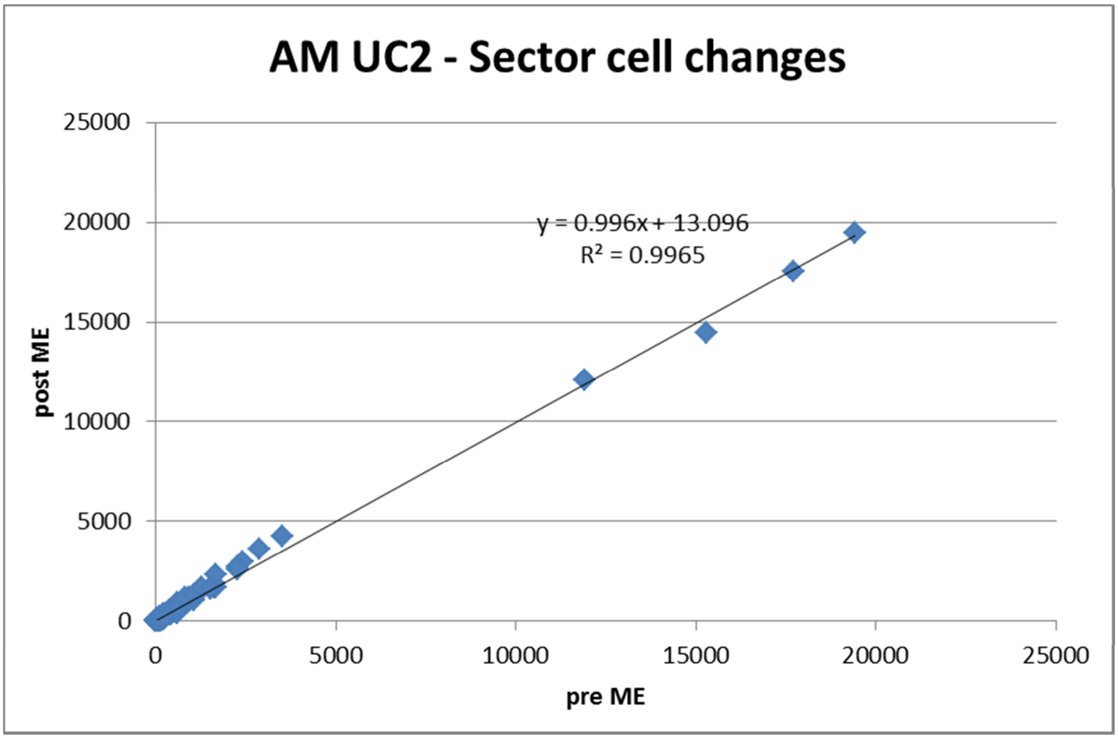
UC4 – LGV

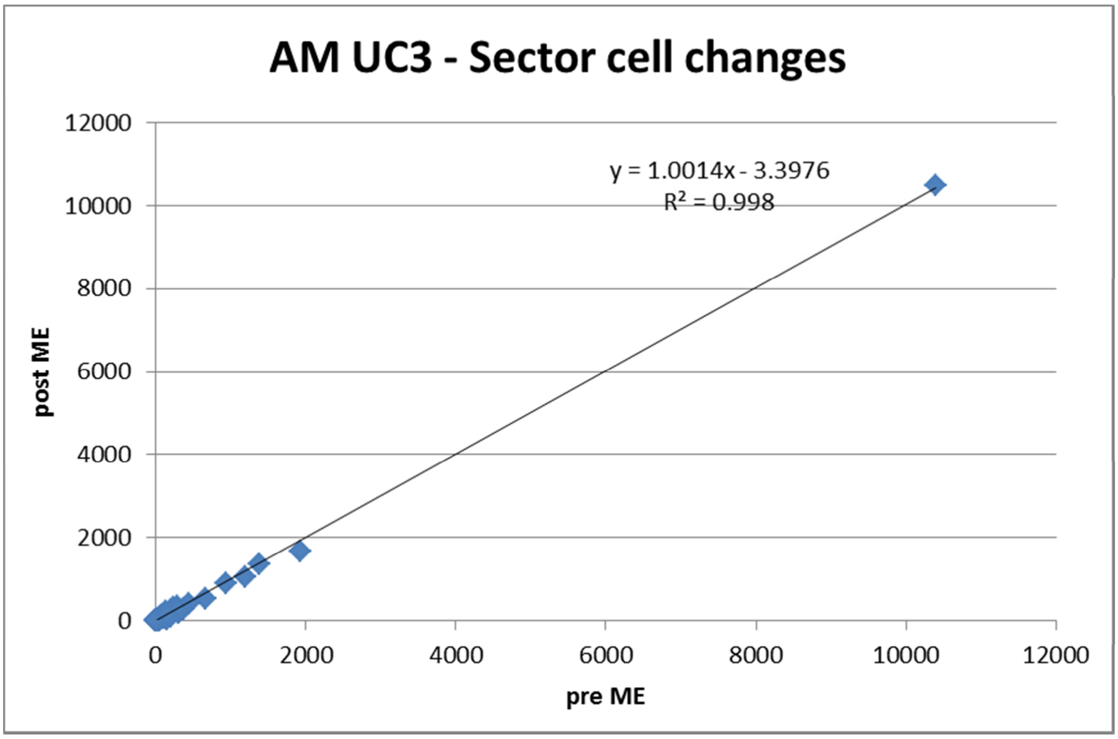
UC5 – HGV

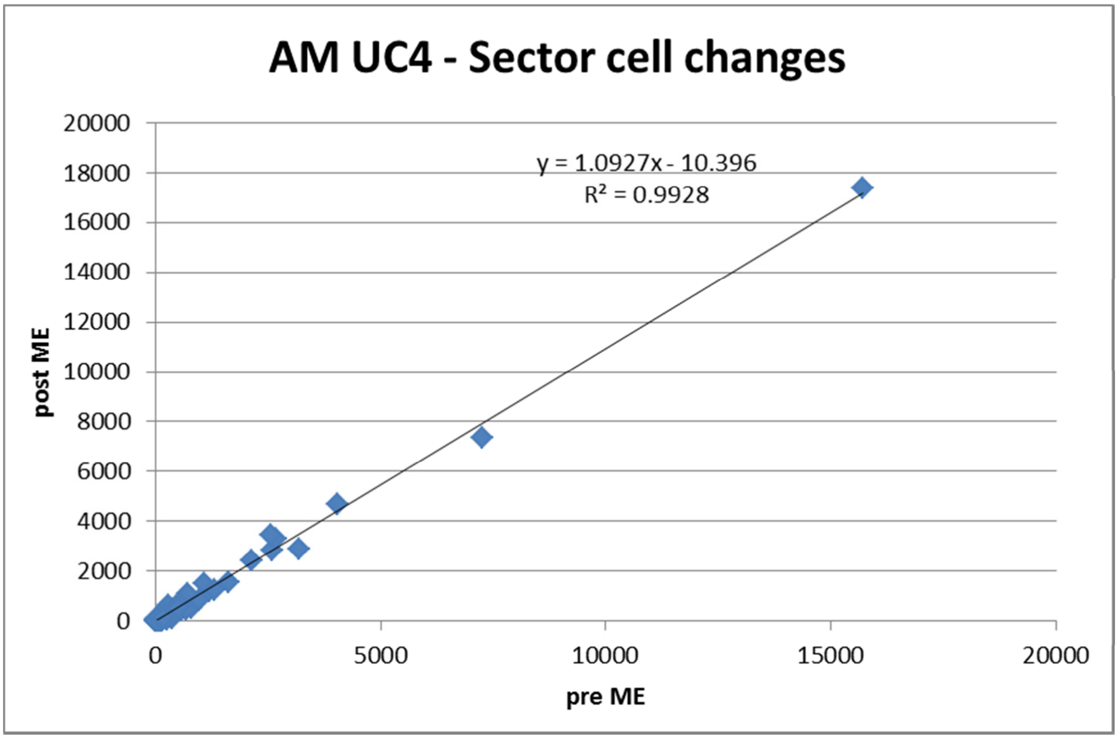
J.1 Matrix Estimation with River Thames screenline as validation

J.1.1 AM cell changes




AM UC2 - Sector cell changes
y = 0.996x + 13.096
R² = 0.9965
post ME
pre ME
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000


AM UC3 - Sector cell changes
y = 1.0014x - 3.3976
R² = 0.998
post ME
pre ME
12000
10000
8000
6000
4000
2000
0
0
2000
4000
6000
8000
10000
12000


AM UC4 - Sector cell changes
y = 1.0927x - 10.396
R² = 0.9928
post ME
pre ME
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
5000
10000
15000
20000

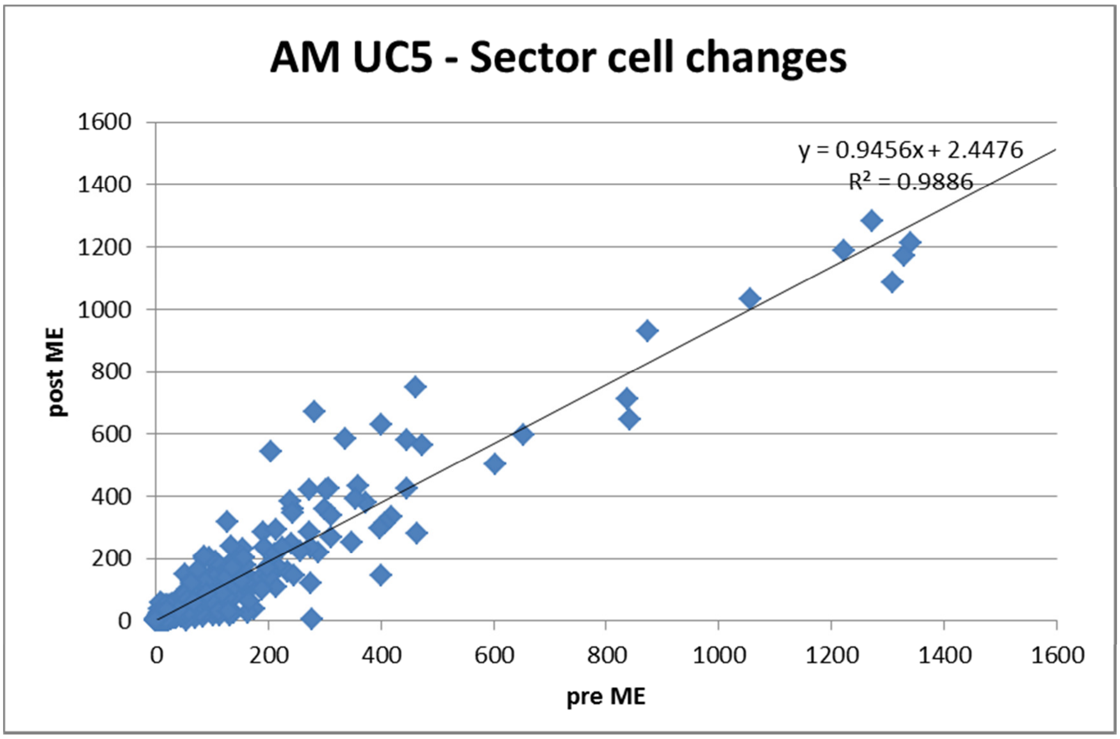
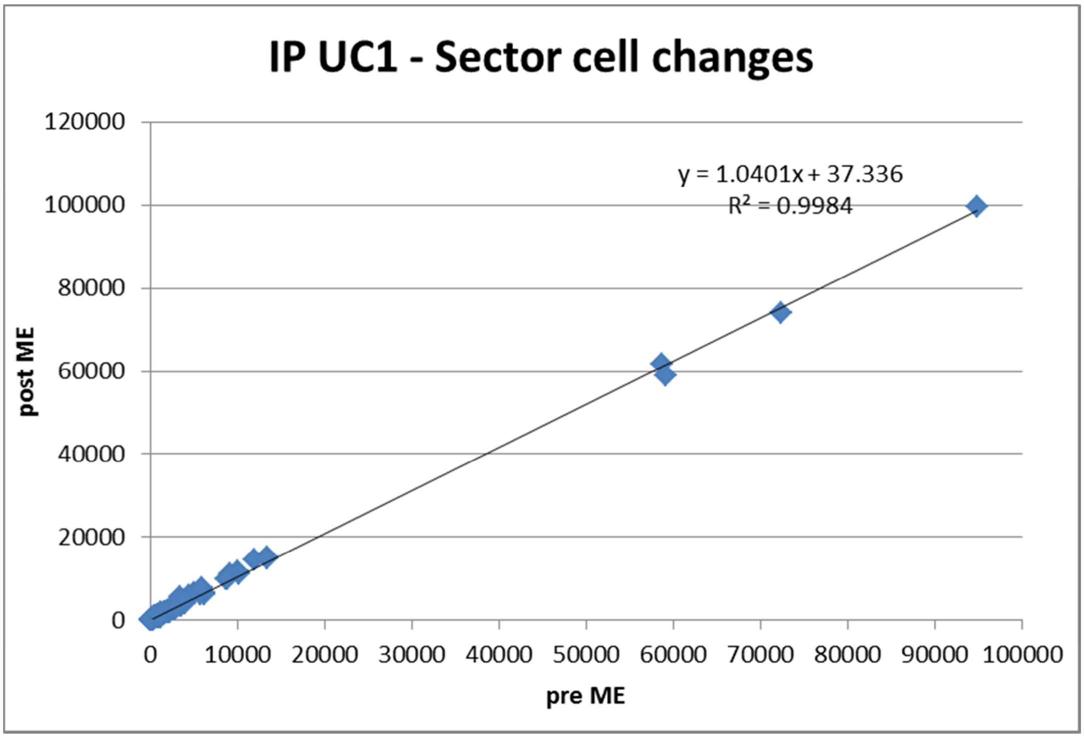
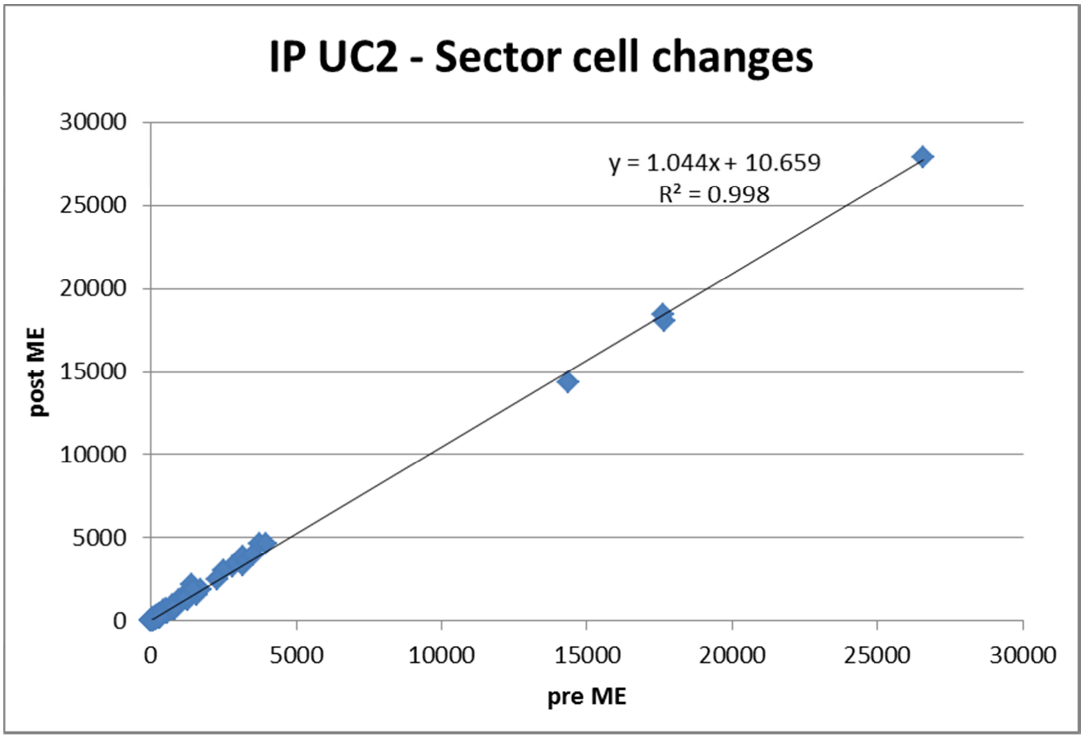

AM UC5 - Sector cell changes
y = 0.9456x + 2.4476
R² = 0.9886
post ME
pre ME
1600
1400
1200
1000
800
600
400
200
0
0
200
400
600
800
1000
1200
1400
1600

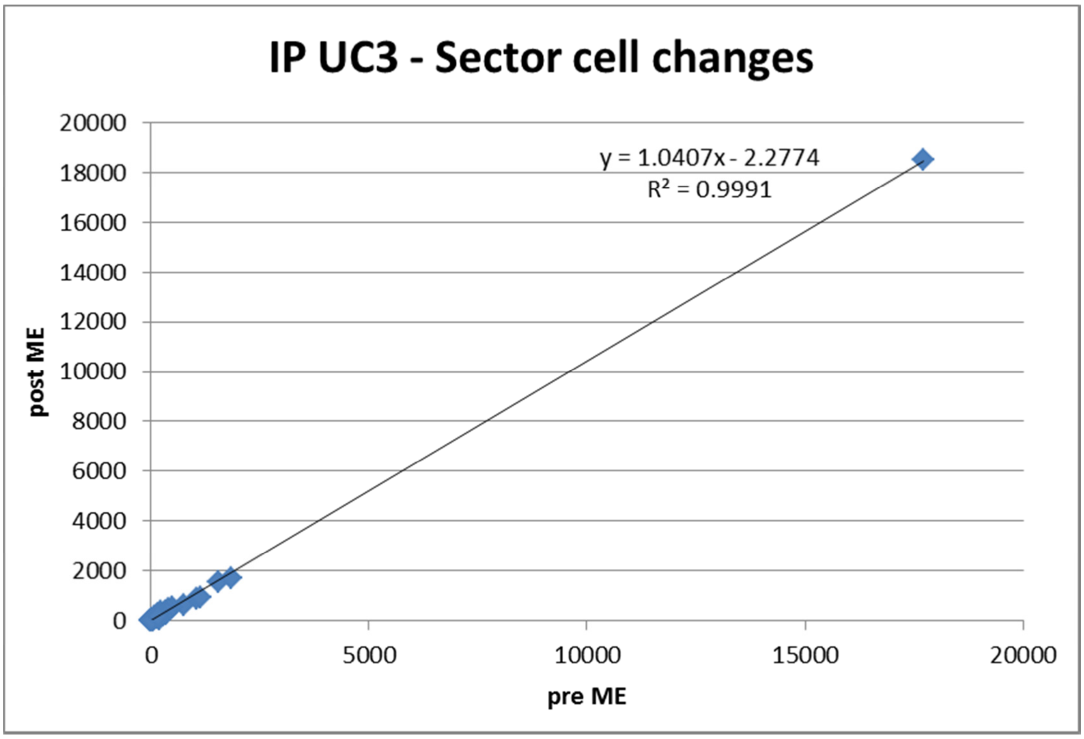
Table J.1: Differences in sector to sector level matrices prior to and post matrix estimation for AM peak

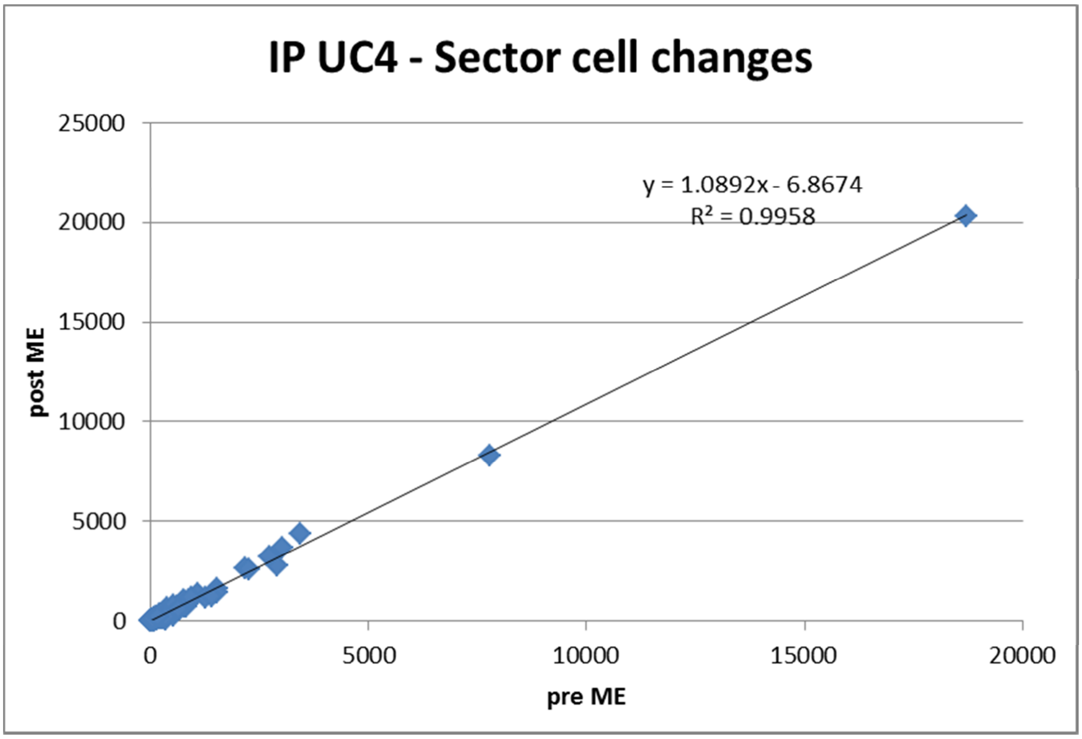
AM		UC1	UC2	UC3	UC4	UC5
diff <=5%		264	265	343	258	260
diff >5%	abs diff <=20	59	112	85	99	109
diff >5%	abs diff >20	118	64	13	84	72
total		441	441	441	441	441
diff <=5%		60%	60%	78%	59%	59%

J.1.2 IP cell changes




IP UC2 - Sector cell changes
y = 1.044x + 10.659
R² = 0.998
post ME
pre ME
30000
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000
30000


IP UC3 - Sector cell changes
y = 1.0407x - 2.2774
R² = 0.9991
post ME
pre ME
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
5000
10000
15000
20000


IP UC4 - Sector cell changes
y = 1.0892x - 6.8674
R² = 0.9958
post ME
pre ME
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000

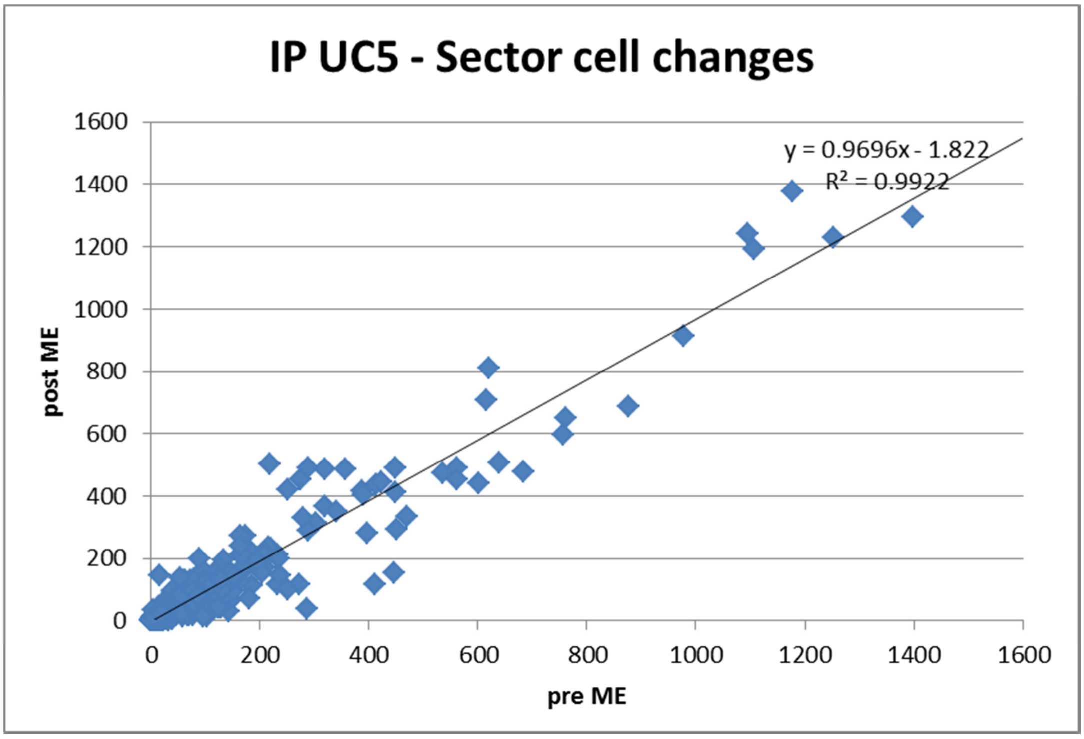
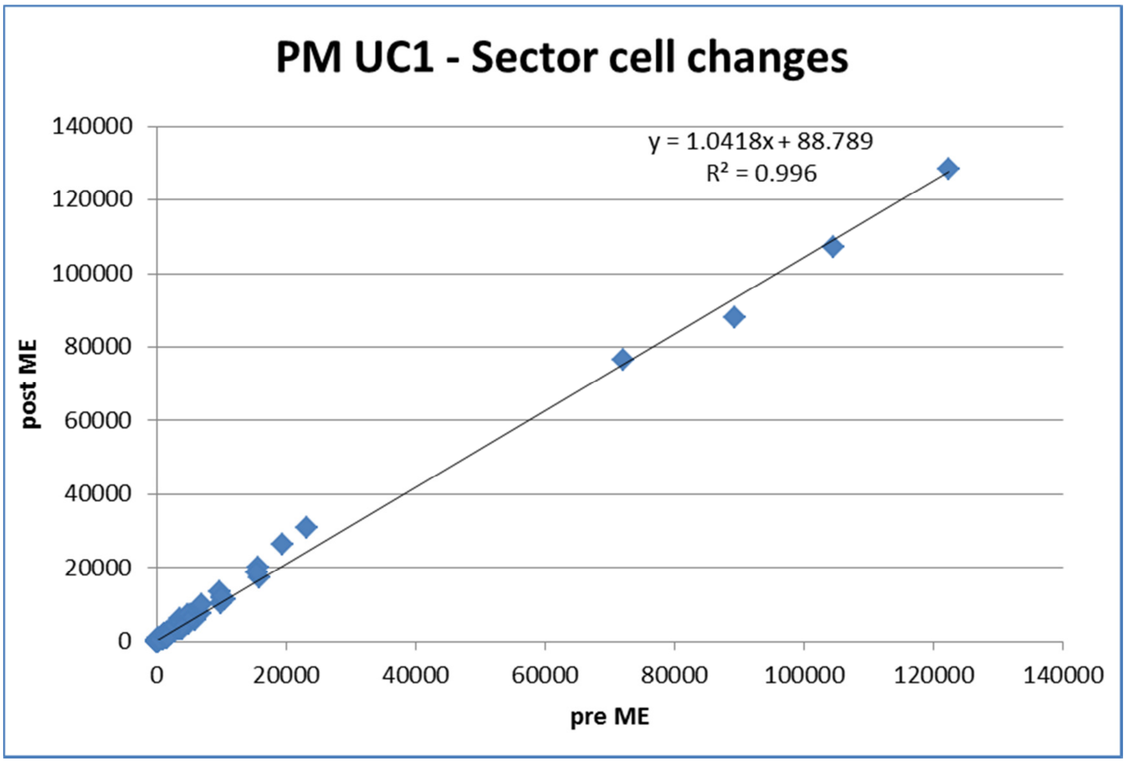
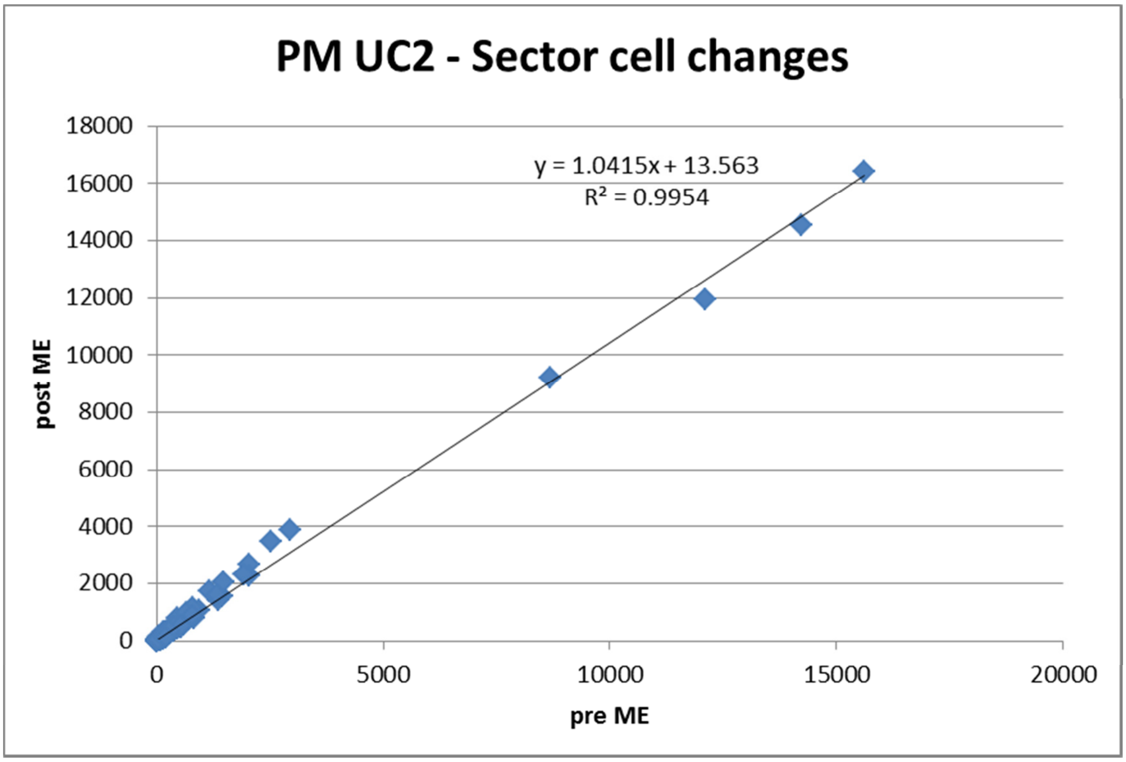

IP UC5 - Sector cell changes
y = 0.9696x - 1.822
R² = 0.9922
post ME
pre ME
1600
1400
1200
1000
800
600
400
200
0
0
200
400
600
800
1000
1200
1400
1600

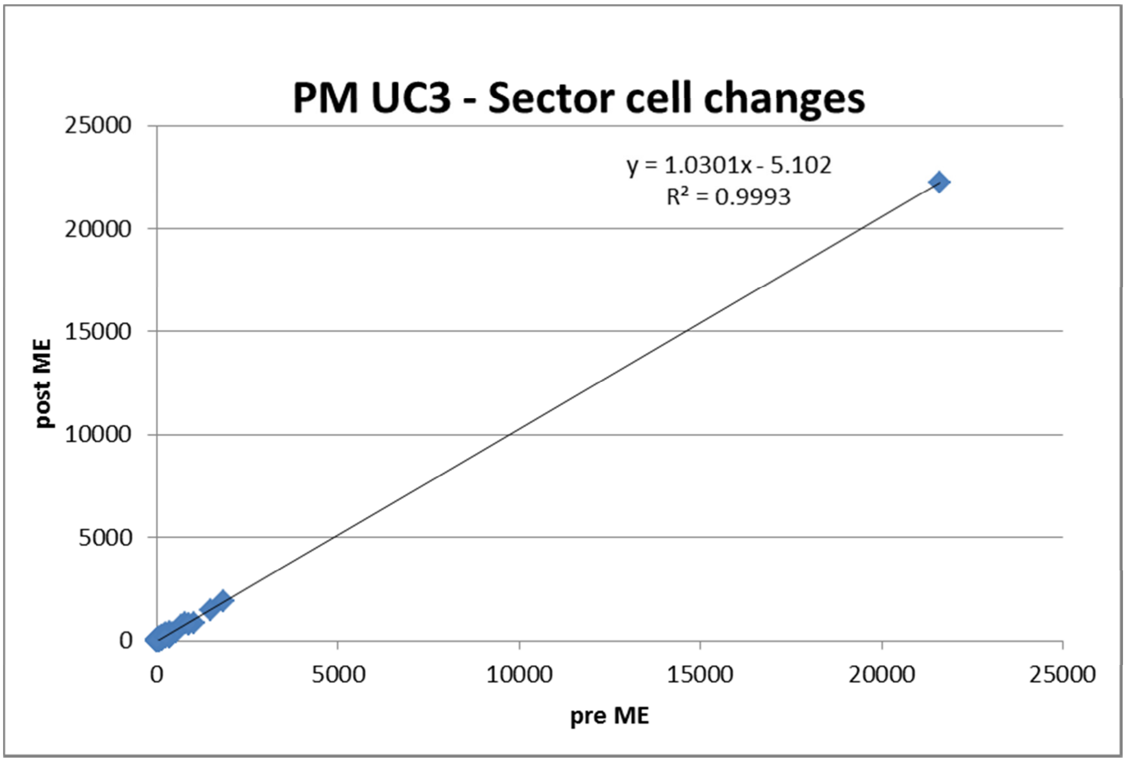
Table J.2: Differences in sector to sector level matrices prior to and post matrix estimation for Interpeak

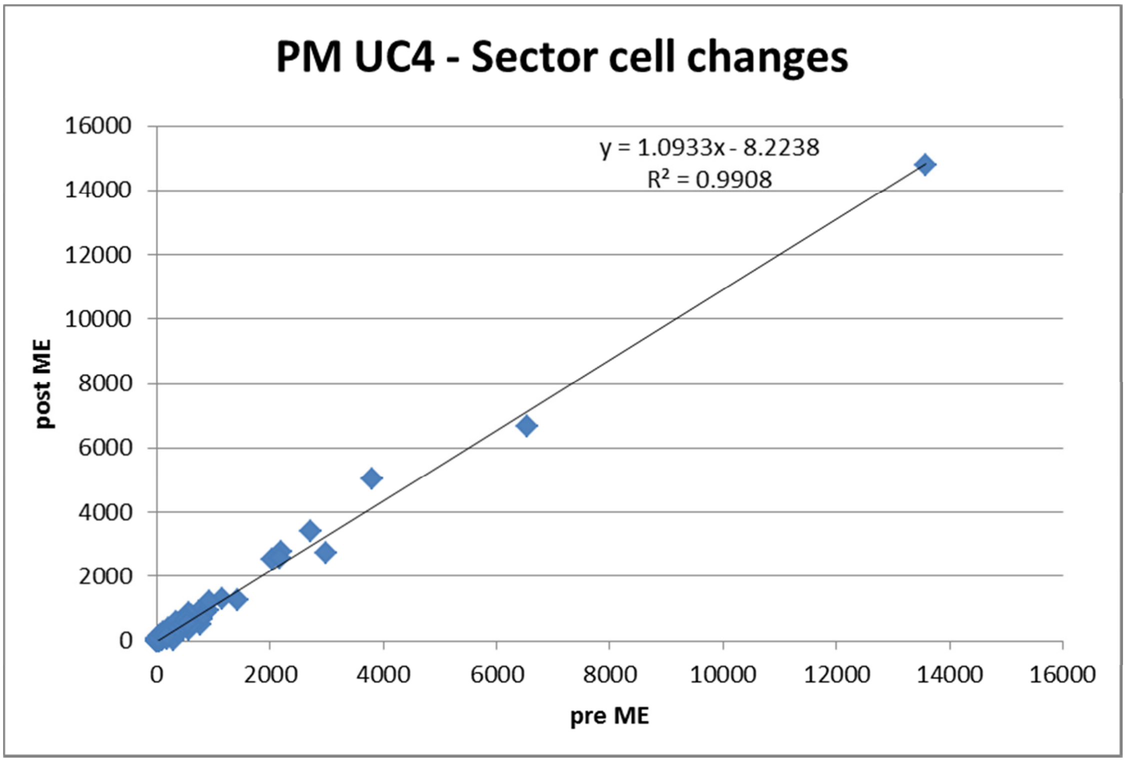
AM		UC1	UC2	UC3	UC4	UC5
diff <=5%		280	285	322	250	286
diff >5%	abs diff <=20	45	80	97	113	92
diff >5%	abs diff >20	116	76	22	78	63
total		441	441	441	441	441
diff <=5%		63%	65%	73%	57%	65%

J.1.3 PM cell changes




PM UC2 - Sector cell changes
y = 1.0415x + 13.563
R² = 0.9954
post ME
pre ME
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
5000
10000
15000
20000


PM UC3 - Sector cell changes
y = 1.0301x - 5.102
R² = 0.9993
post ME
pre ME
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000


PM UC4 - Sector cell changes
y = 1.0933x - 8.2238
R² = 0.9908
post ME
pre ME
0
2000
4000
6000
8000
10000
12000
14000
16000

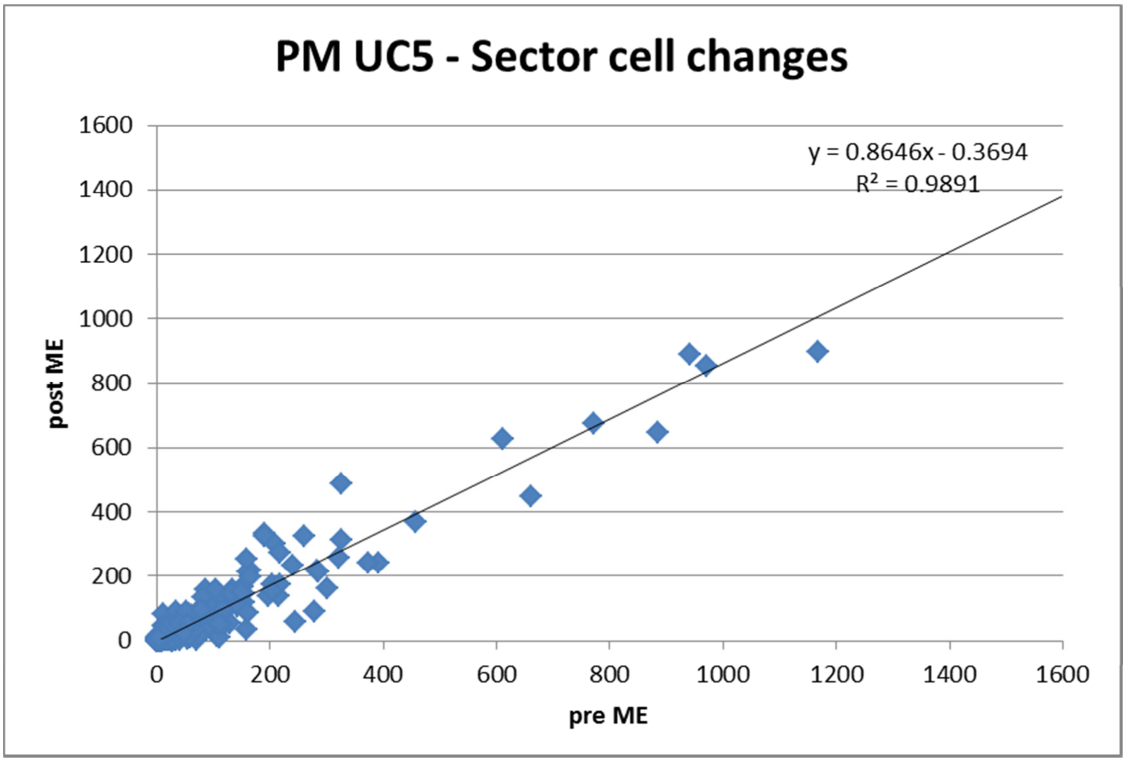
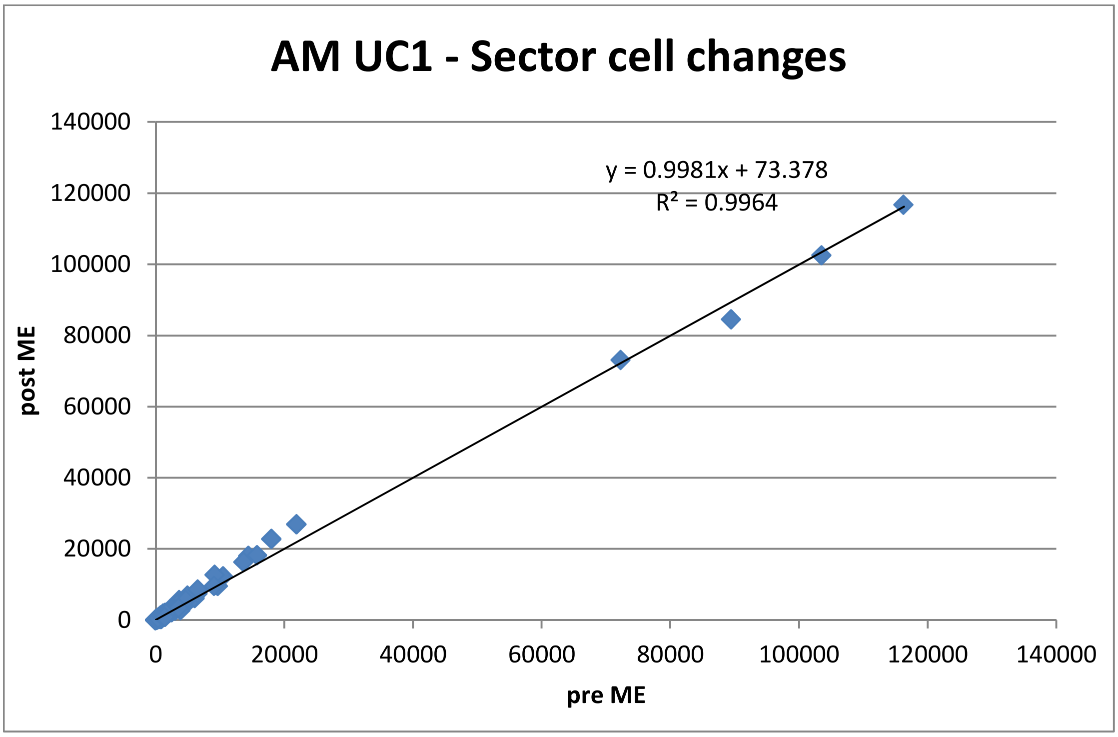

PM UC5 - Sector cell changes
y = 0.8646x - 0.3694
R² = 0.9891
post ME
pre ME
0
200
400
600
800
1000
1200
1400
1600

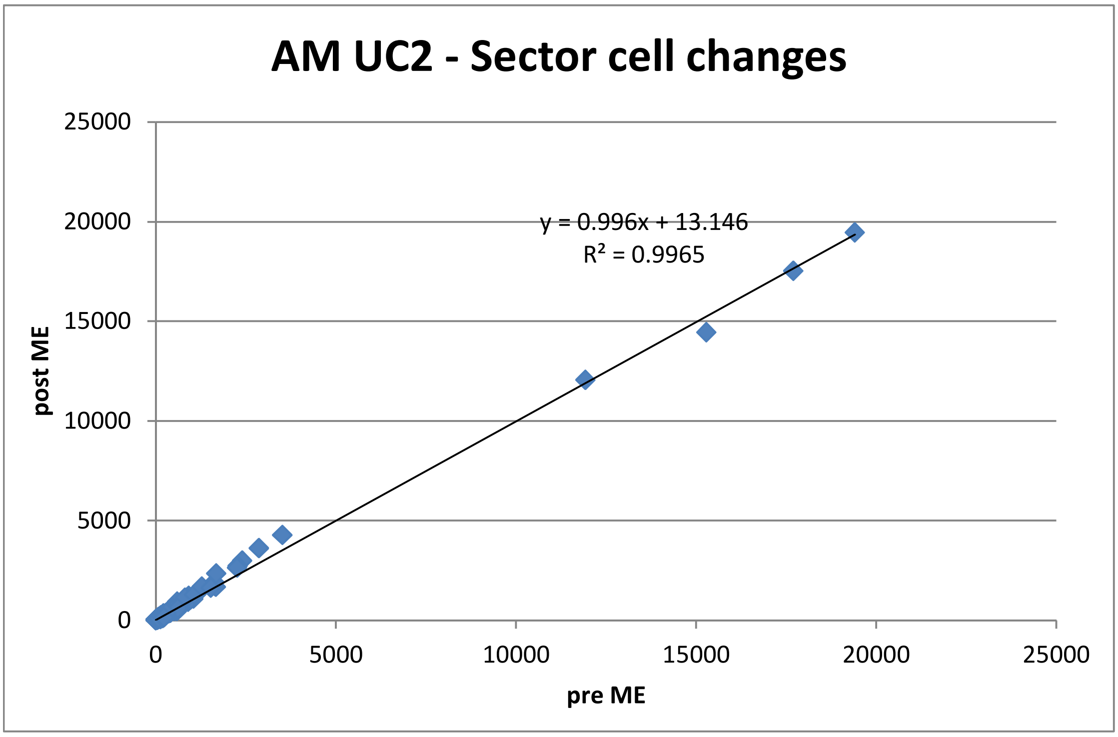
Table J.3: Differences in sector to sector level matrices prior to and post matrix estimation for PM Peak

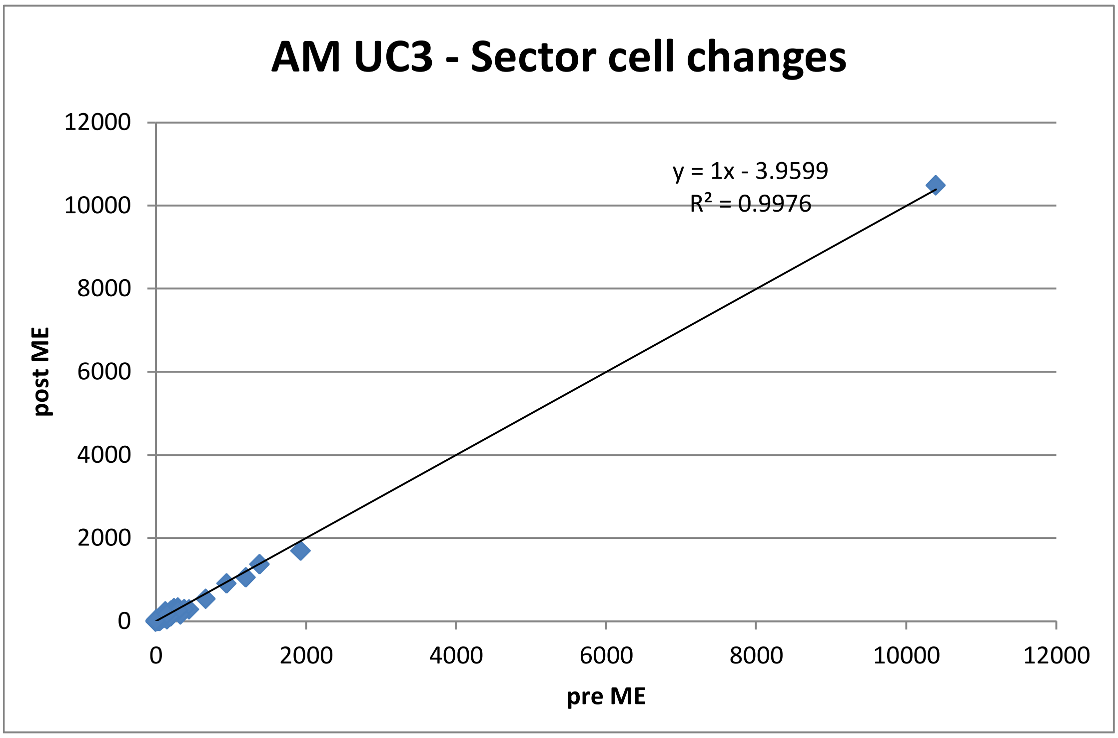
AM		UC1	UC2	UC3	UC4	UC5
diff <=5%		250	246	324	276	283
diff >5%	abs diff <=20	39	115	100	88	129
diff >5%	abs diff >20	152	80	17	77	29
total		441	441	441	441	441
diff <=5%		57%	56%	73%	63%	64%

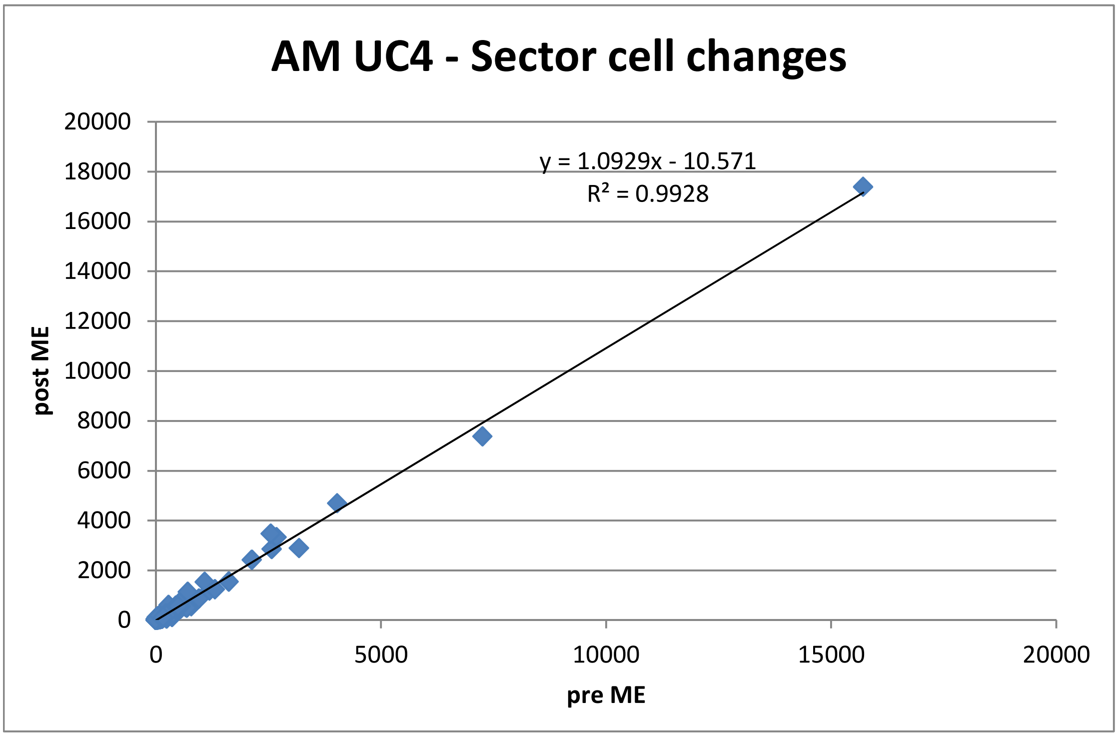
J.2 Matrix Estimation with all counts

J.2.1 AM cell changes




AM UC2 - Sector cell changes
y = 0.996x + 13.146
R² = 0.9965
post ME
pre ME
0
5000
10000
15000
20000
25000


AM UC3 - Sector cell changes
y = 1x - 3.9599
R² = 0.9976
post ME
pre ME
0
2000
4000
6000
8000
10000
12000


AM UC4 - Sector cell changes
y = 1.0929x - 10.571
R² = 0.9928
post ME
pre ME
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
5000
10000
15000
20000

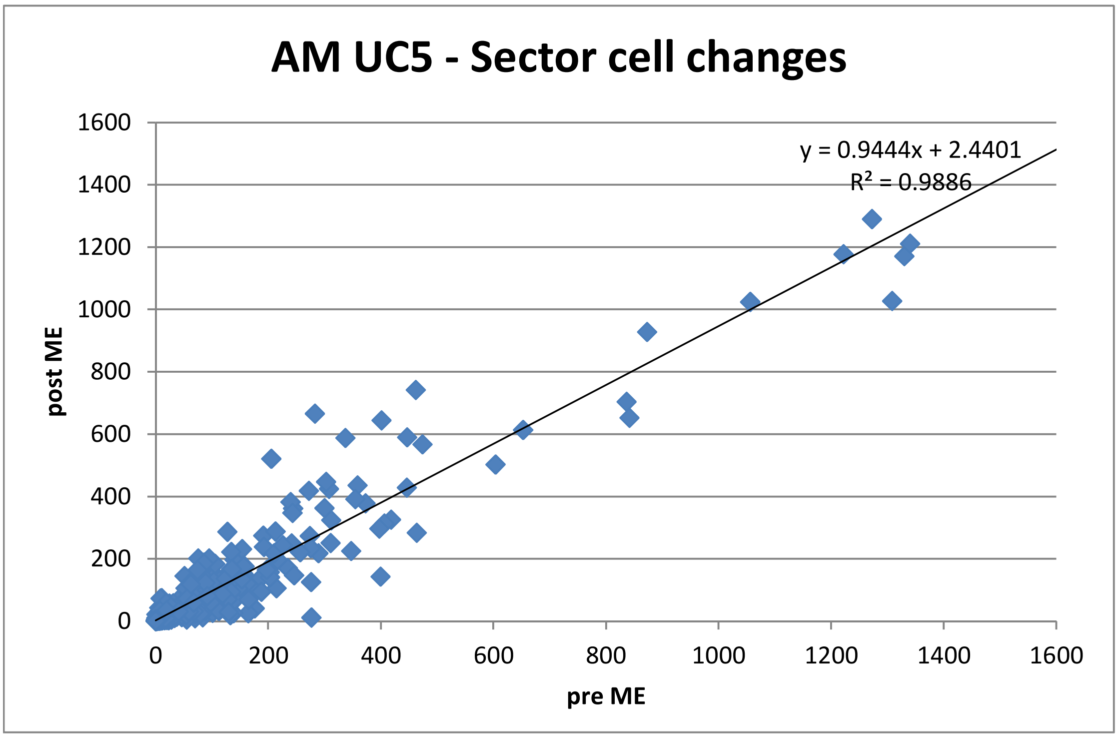
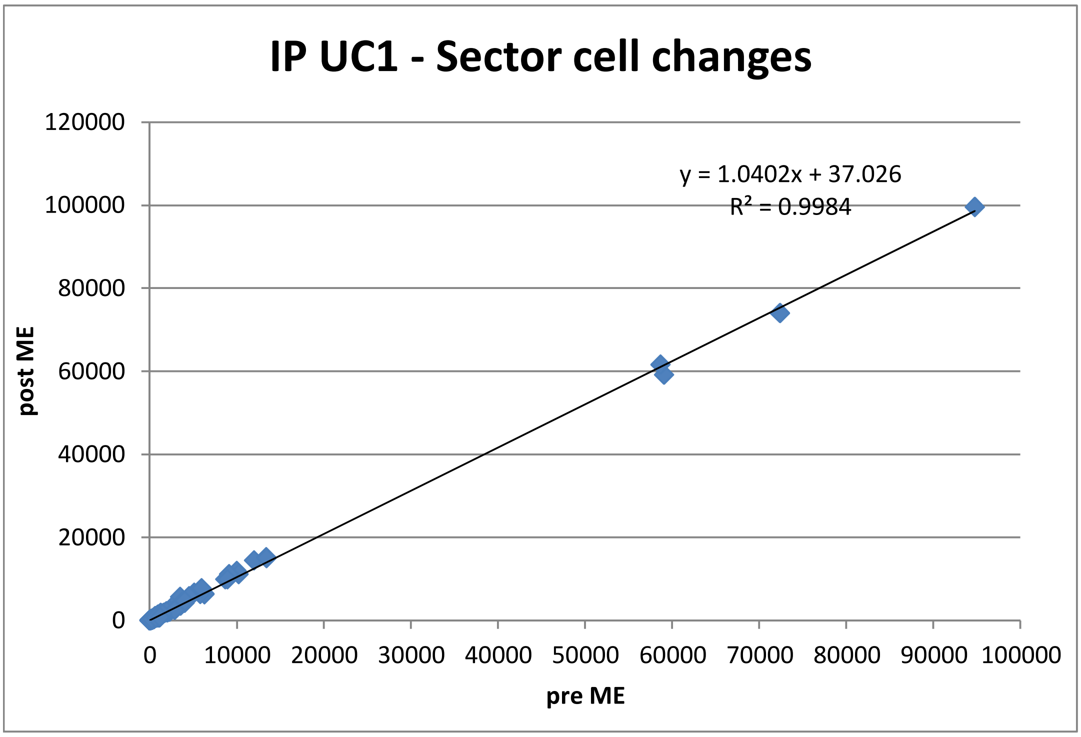
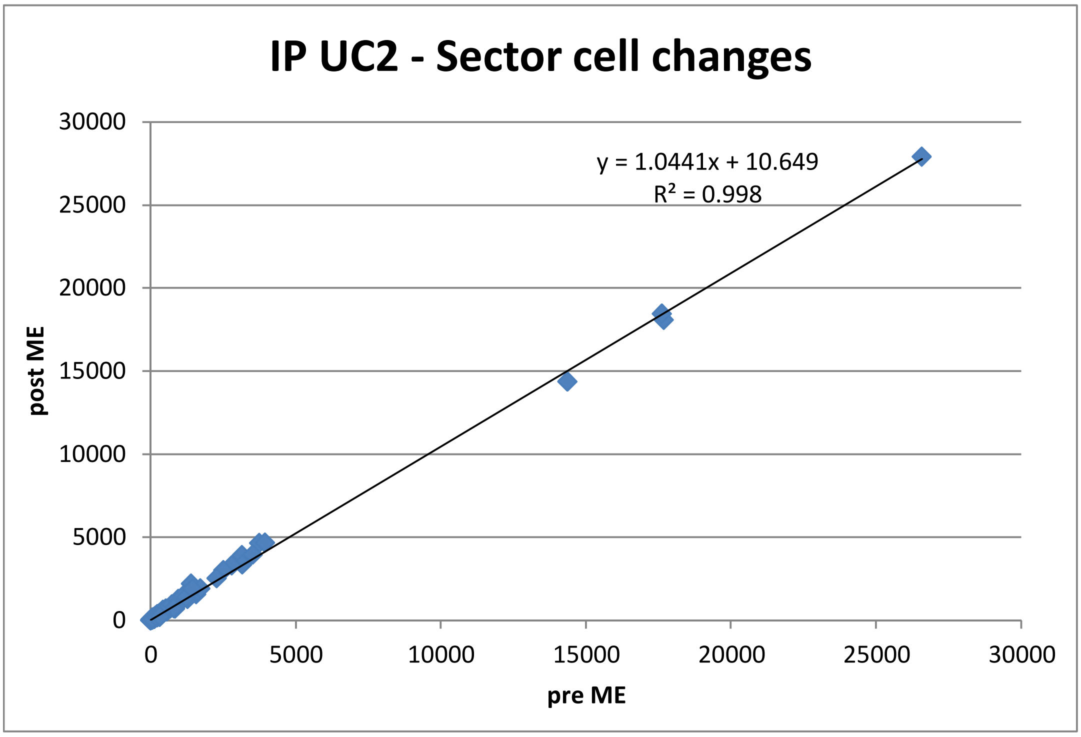

AM UC5 - Sector cell changes
y = 0.9444x + 2.4401
R² = 0.9886
post ME
pre ME
1600
1400
1200
1000
800
600
400
200
0
0
200
400
600
800
1000
1200
1400
1600

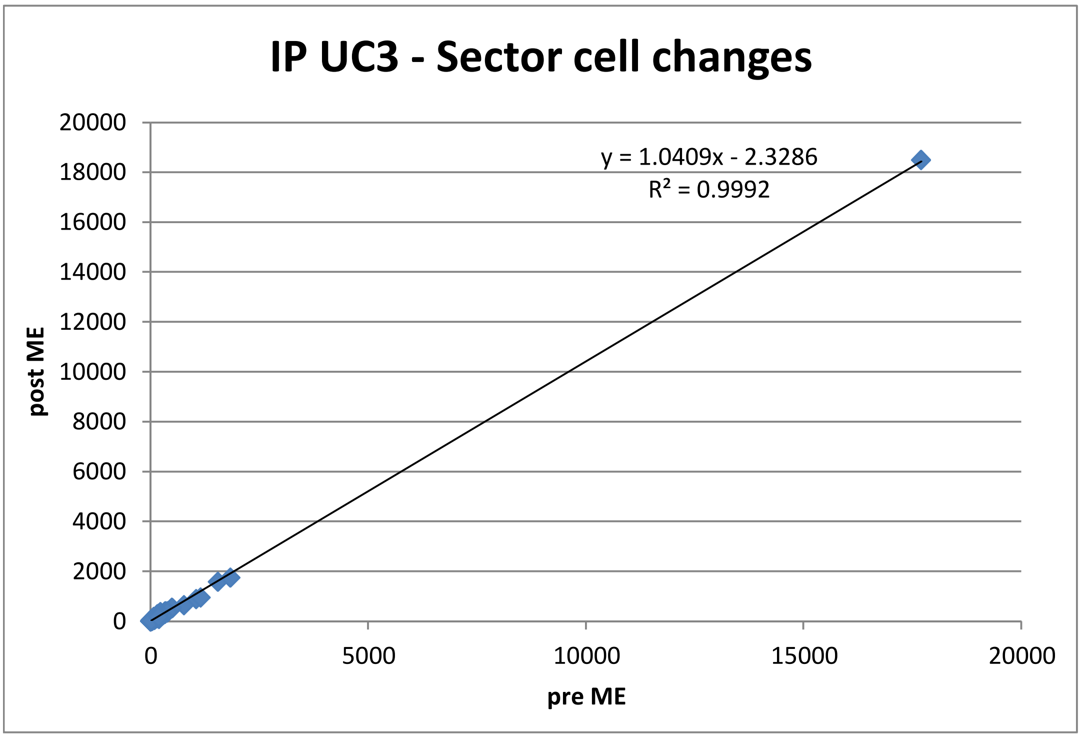
Table J.4: Differences in sector to sector level matrices prior to and post matrix estimation for AM peak

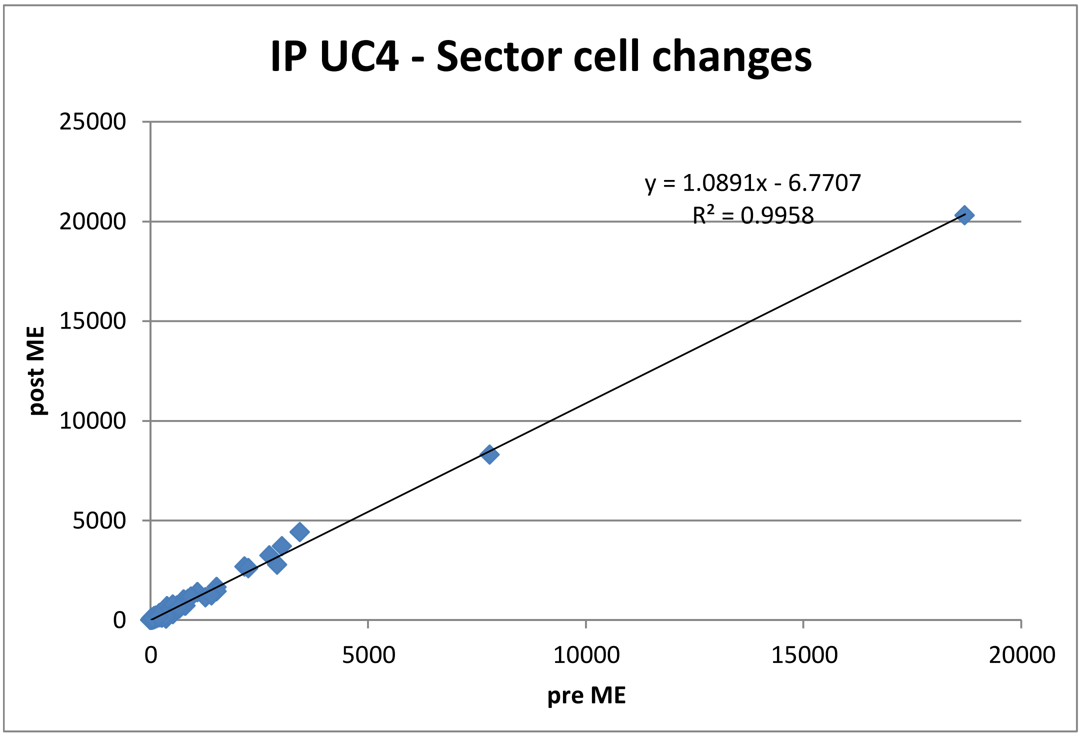
AM		UC1	UC2	UC3	UC4	UC5
diff <=5%		260	268	337	240	254
diff >5%	abs diff <=20	59	109	91	114	117
diff >5%	abs diff >20	122	64	13	87	70
total		441	441	441	441	441
diff <=5%		59%	61%	76%	54%	58%

J.2.2 IP cell changes




IP UC2 - Sector cell changes
y = 1.0441x + 10.649
R² = 0.998
post ME
pre ME
30000
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000
30000


IP UC3 - Sector cell changes
y = 1.0409x - 2.3286
R² = 0.9992
post ME
pre ME
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
5000
10000
15000
20000


IP UC4 - Sector cell changes
y = 1.0891x - 6.7707
R² = 0.9958
post ME
pre ME
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000

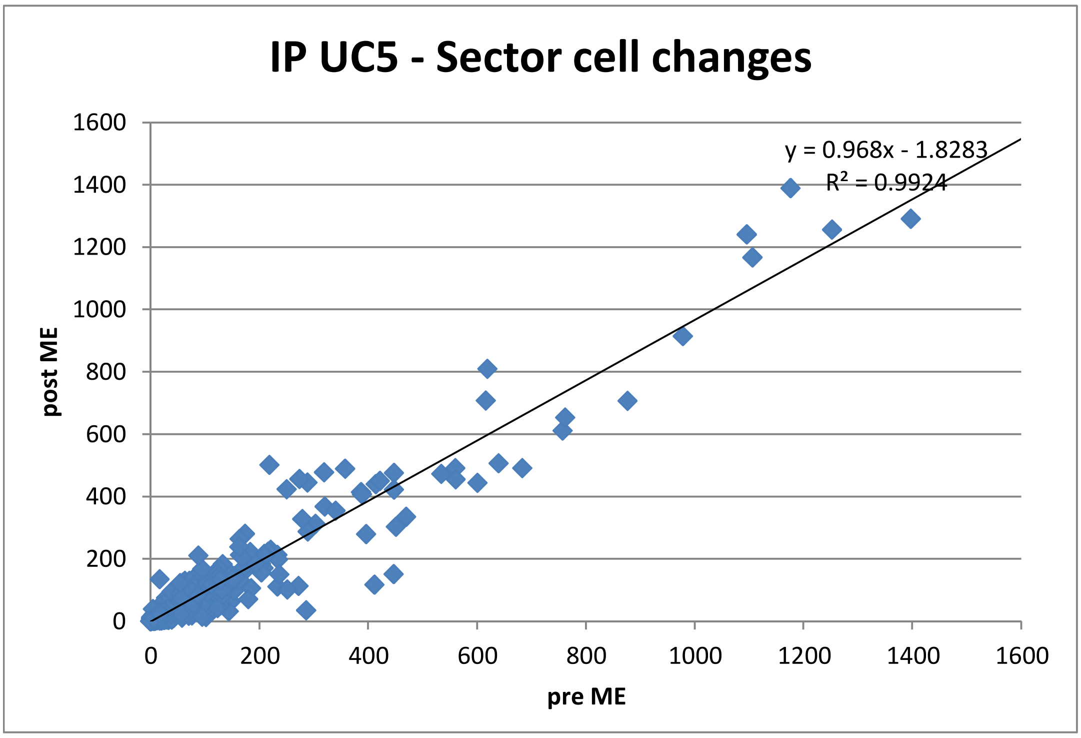
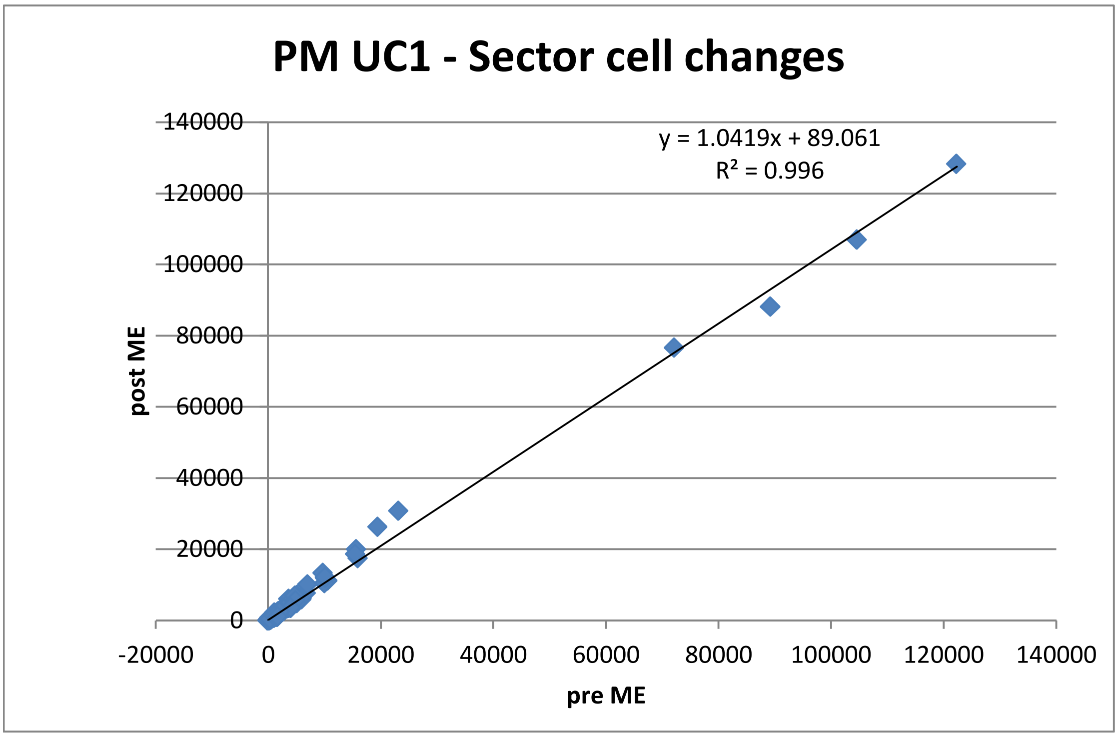
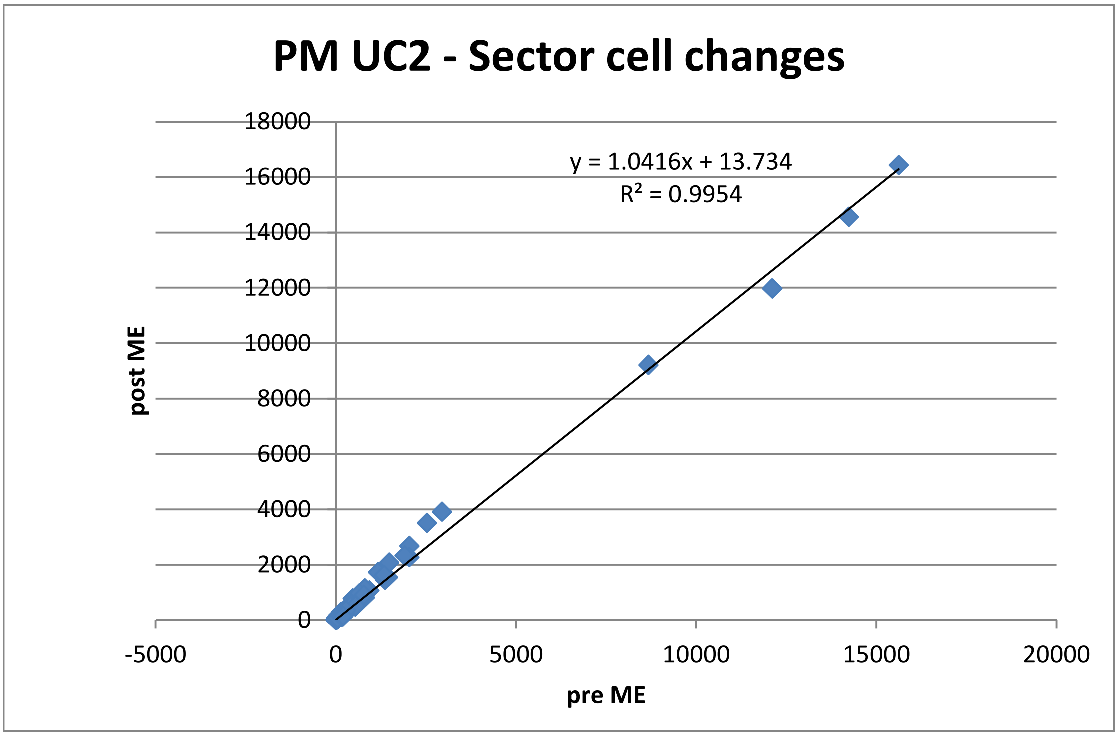

IP UC5 - Sector cell changes
y = 0.968x - 1.8283
R² = 0.9924
post ME
pre ME
1600
1400
1200
1000
800
600
400
200
0
0
200
400
600
800
1000
1200
1400
1600

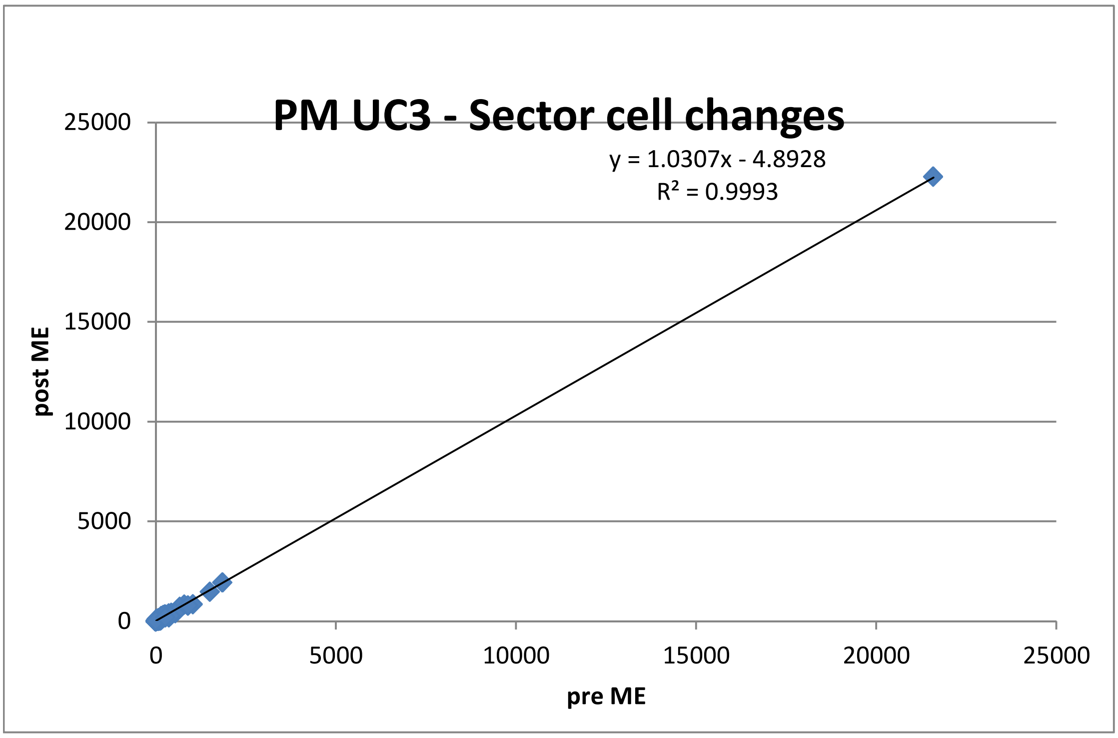
Table J.5: Differences in sector to sector level matrices prior to and post matrix estimation for IP peak

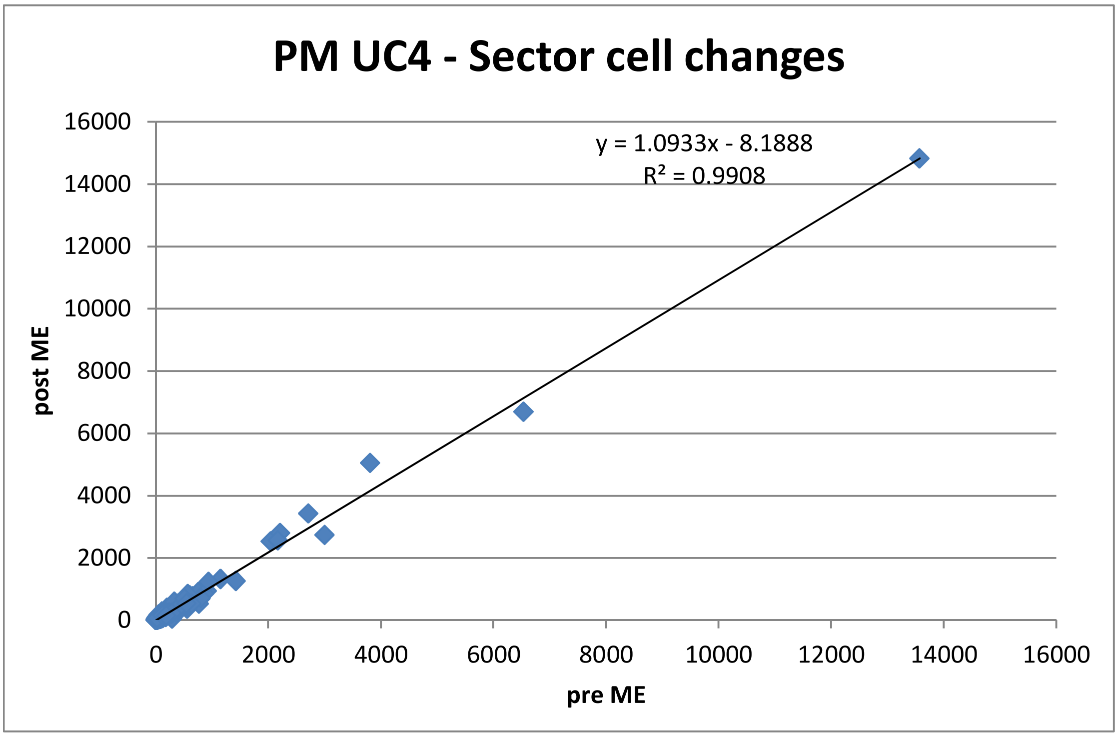
AM		UC1	UC2	UC3	UC4	UC5
diff <=5%		278	280	324	246	284
diff >5%	abs diff <=20	48	85	99	113	95
diff >5%	abs diff >20	115	76	18	82	62
total		441	441	441	441	441
diff <=5%		63%	63%	73%	56%	64%

J.2.3 PM cell changes




PM UC2 - Sector cell changes
y = 1.0416x + 13.734
R² = 0.9954
post ME
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-5000
0
5000
10000
15000
20000
pre ME


PM UC3 - Sector cell changes
y = 1.0307x - 4.8928
R² = 0.9993
post ME
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000
pre ME


PM UC4 - Sector cell changes
y = 1.0933x - 8.1888
R² = 0.9908
post ME
pre ME
16000
14000
12000
10000
8000
6000
4000
2000
0

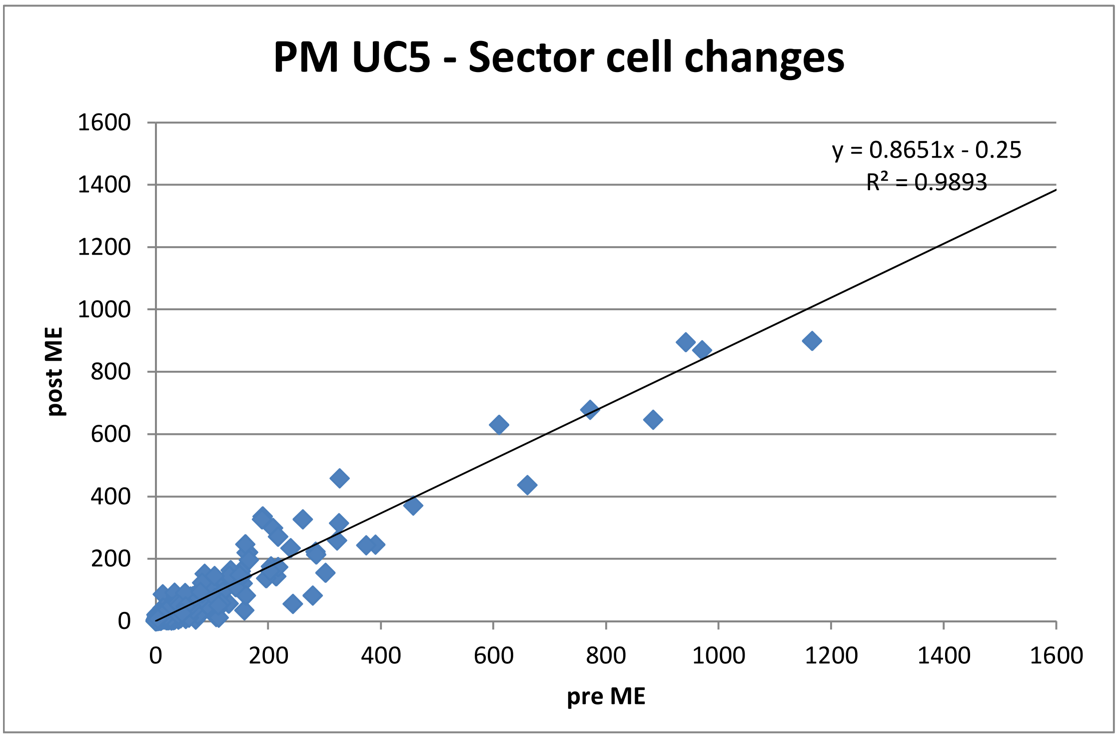

PM UC5 - Sector cell changes
y = 0.8651x - 0.25
R² = 0.9893
post ME
pre ME
1600
1400
1200
1000
800
600
400
200
0

Table J.6: Differences in sector to sector level matrices prior to post matrix estimation for AM Peak

AM		UC1	UC2	UC3	UC4	UC5
diff <=5%		251	241	327	271	273
diff >5%	abs diff <=20	45	116	97	91	138
diff >5%	abs diff >20	145	84	17	79	30
total		441	441	441	441	441
diff <=5%		57%	55%	74%	61%	62%

Appendix K. Matrix Estimation changes of destination cells (sector level)

User class definitions for following figures

UC1 – Cars out-of-work time

UC2 – Cars in-work time

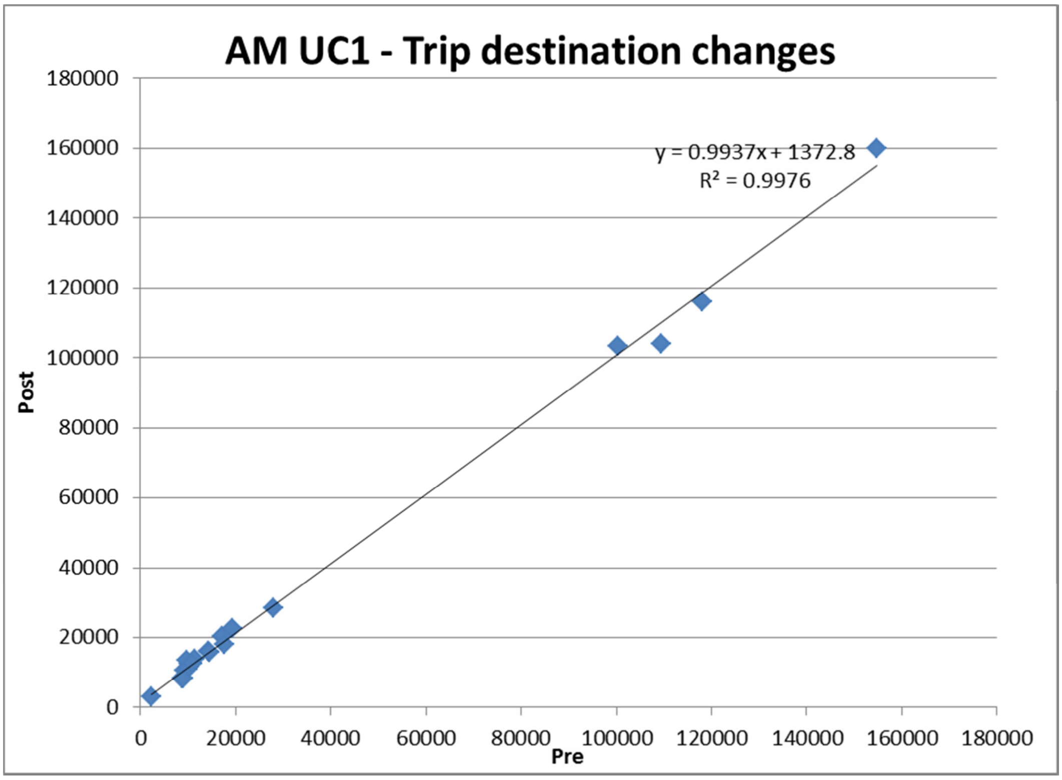
UC3 – Taxi

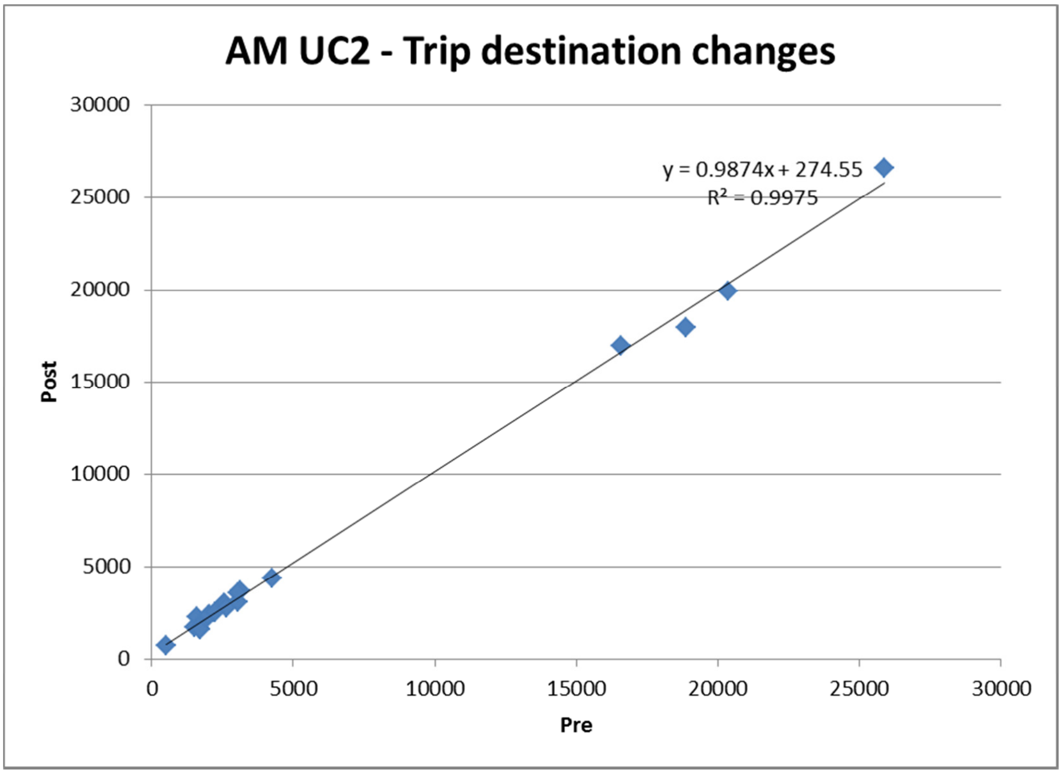
UC4 – LGV

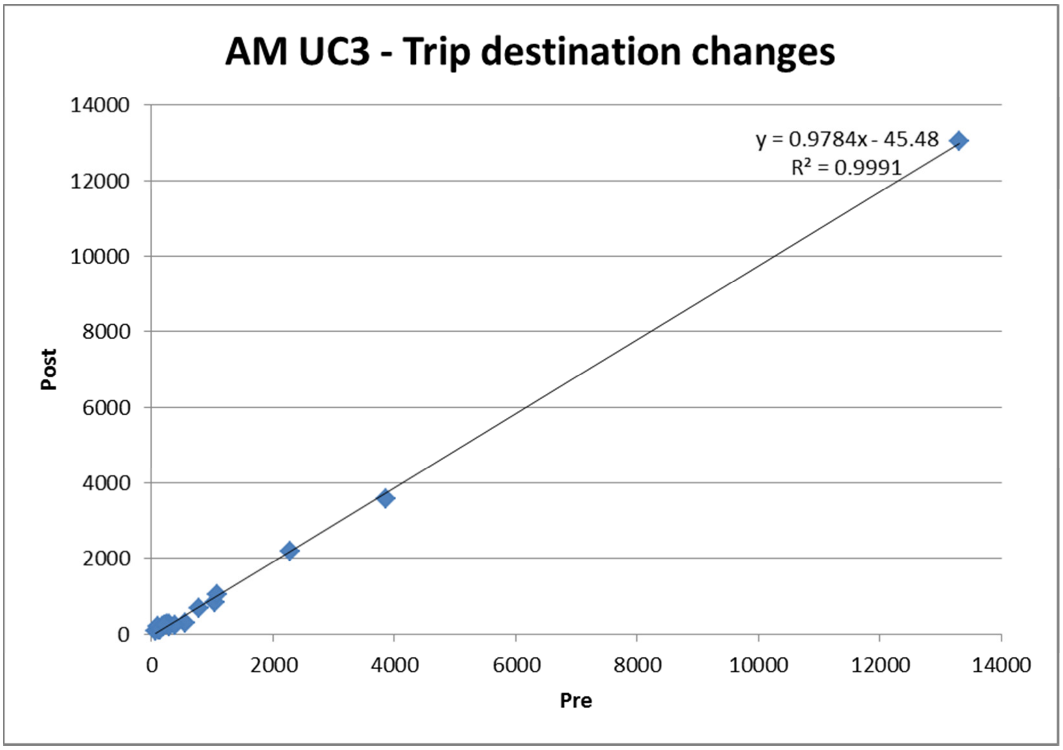
UC5 – HGV

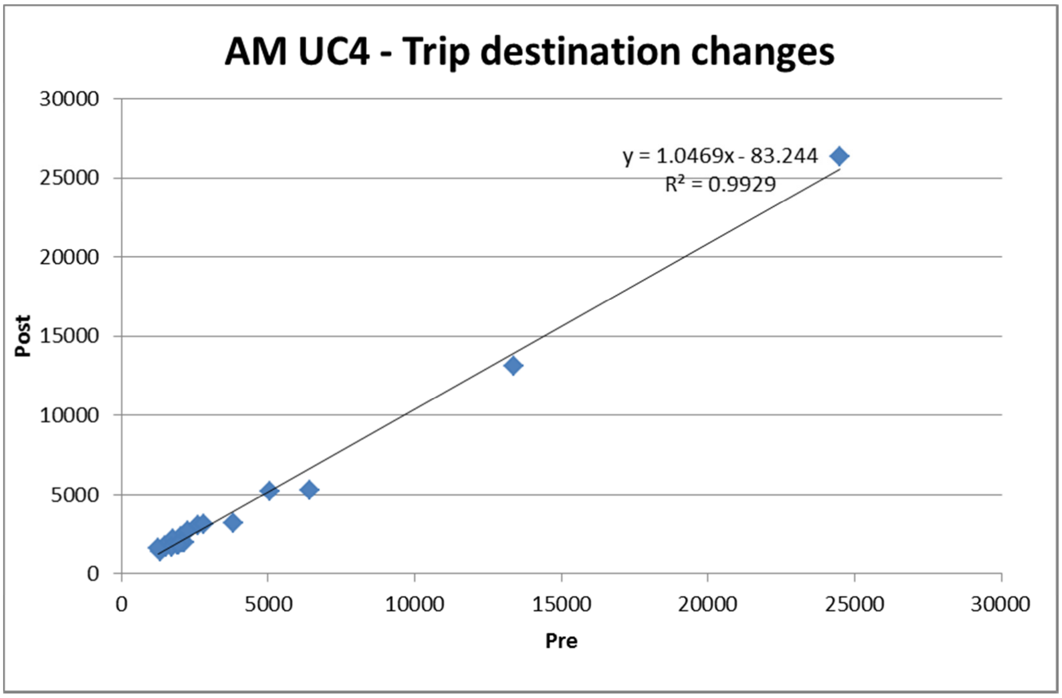
K.1 Matrix Estimation with River Thames screenline as validation

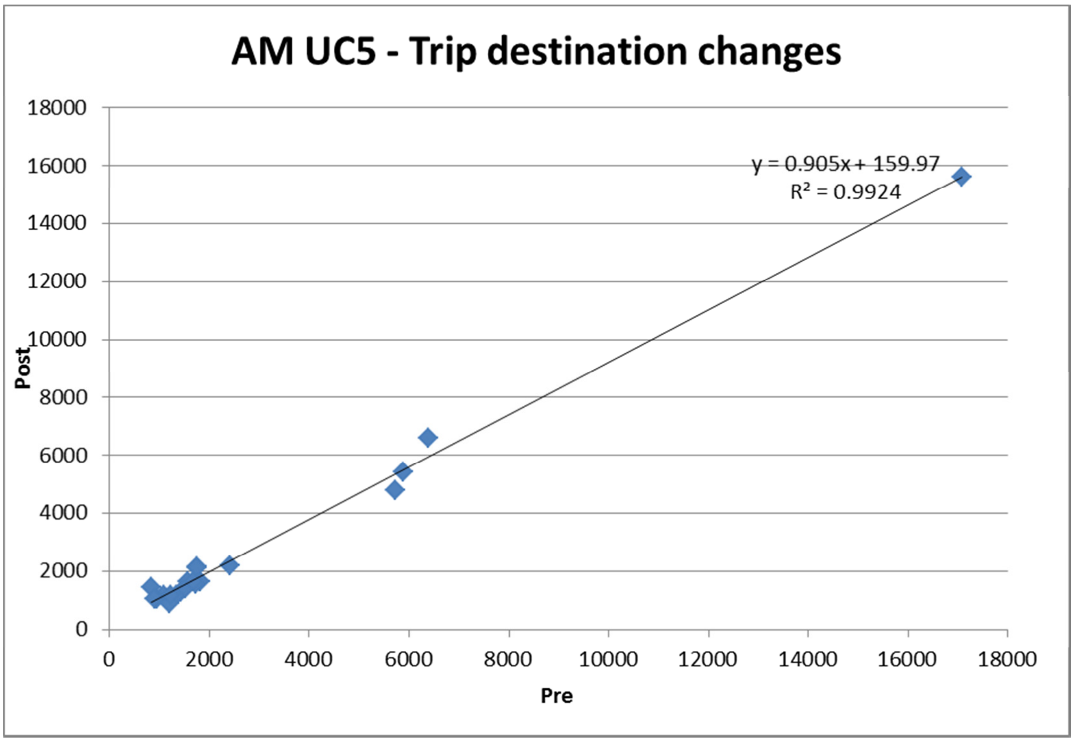
K.1.1 AM trip destination changes



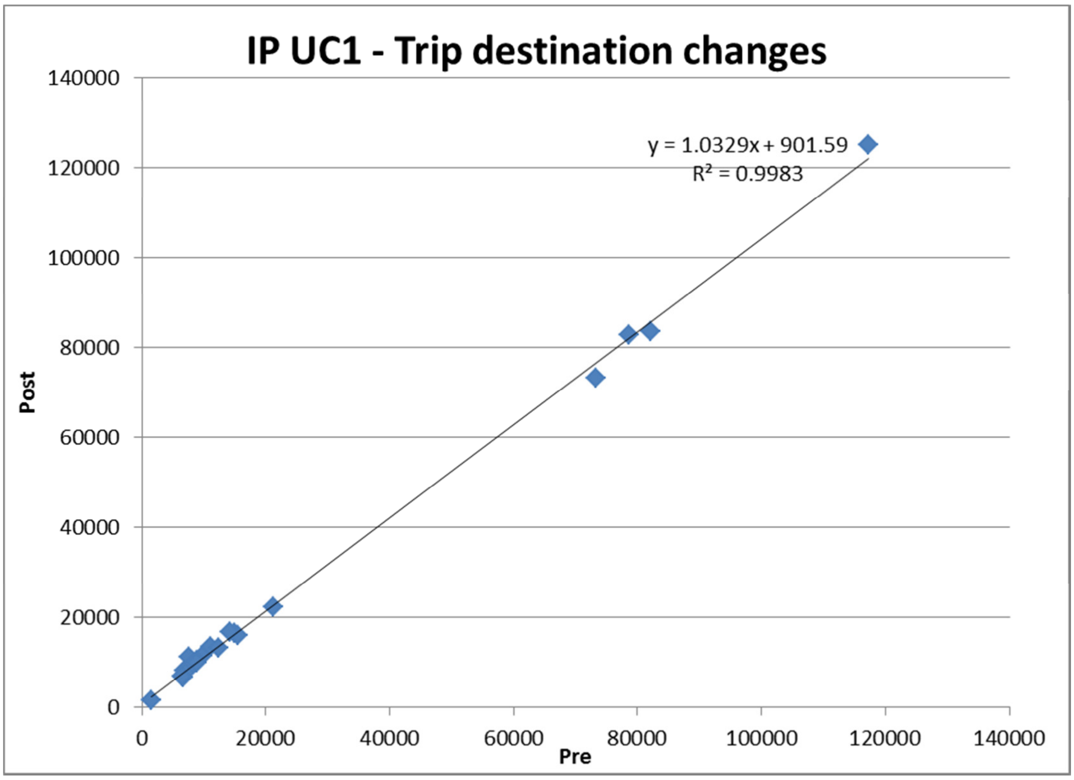

AM UC2 - Trip destination changes
y = 0.9874x + 274.55
R² = 0.9975
Post
Pre
0
5000
10000
15000
20000
25000
30000

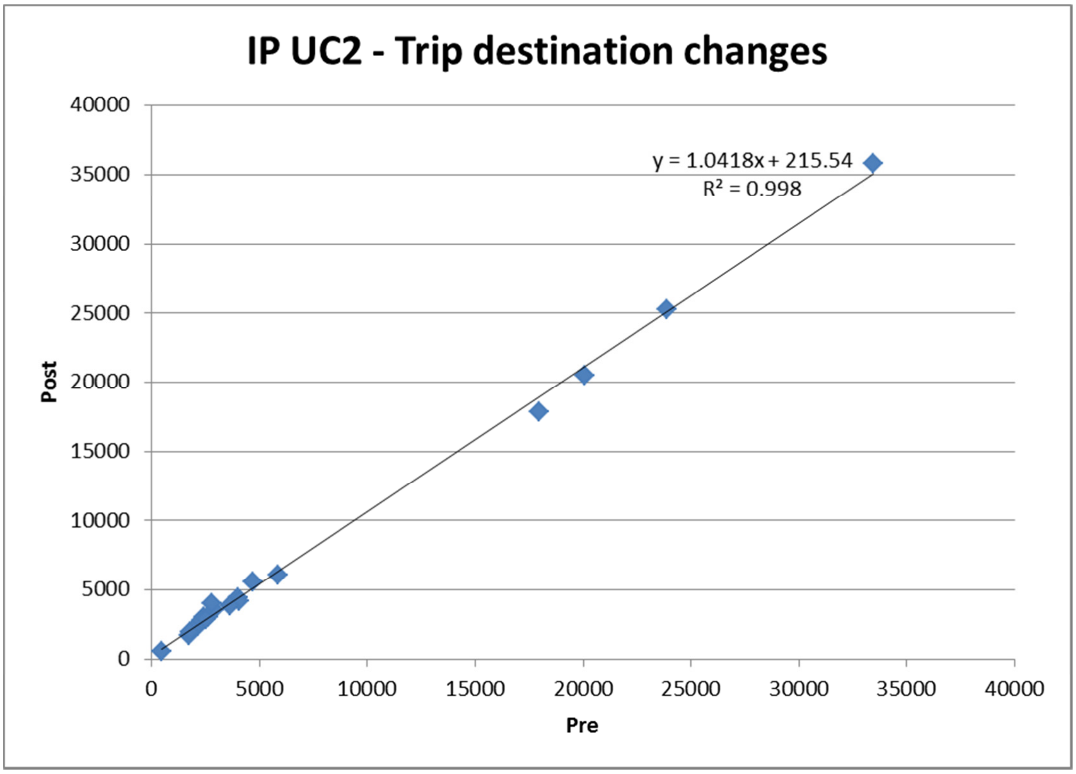

AM UC3 - Trip destination changes
y = 0.9784x - 45.48
R² = 0.9991
Post
Pre
0
2000
4000
6000
8000
10000
12000
14000

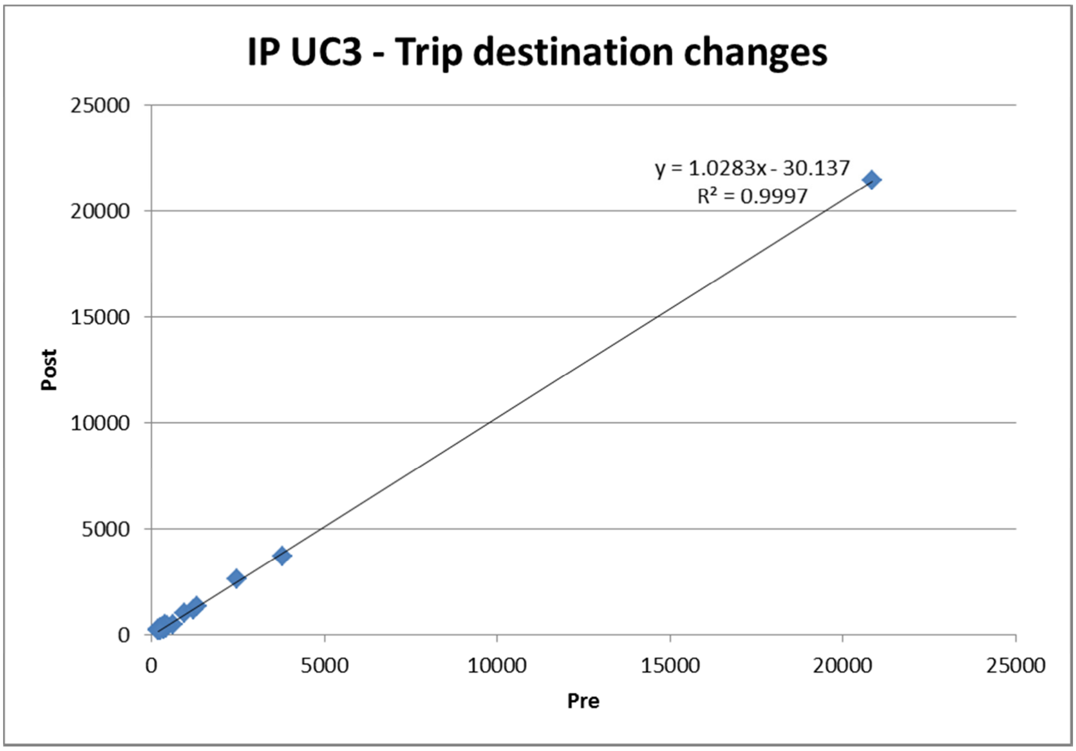

AM UC4 - Trip destination changes
y = 1.0469x - 83.244
R² = 0.9929
Post
Pre
30000
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000
30000

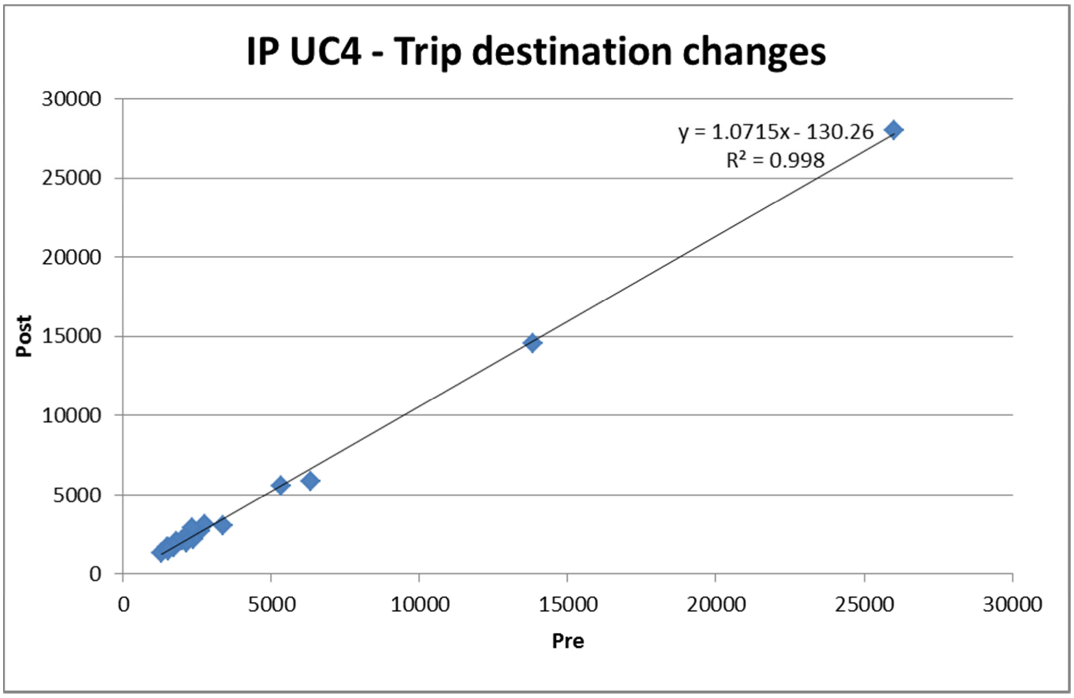

AM UC5 - Trip destination changes
y = 0.905x + 159.97
R² = 0.9924
Post
Pre
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
2000
4000
6000
8000
10000
12000
14000
16000
18000

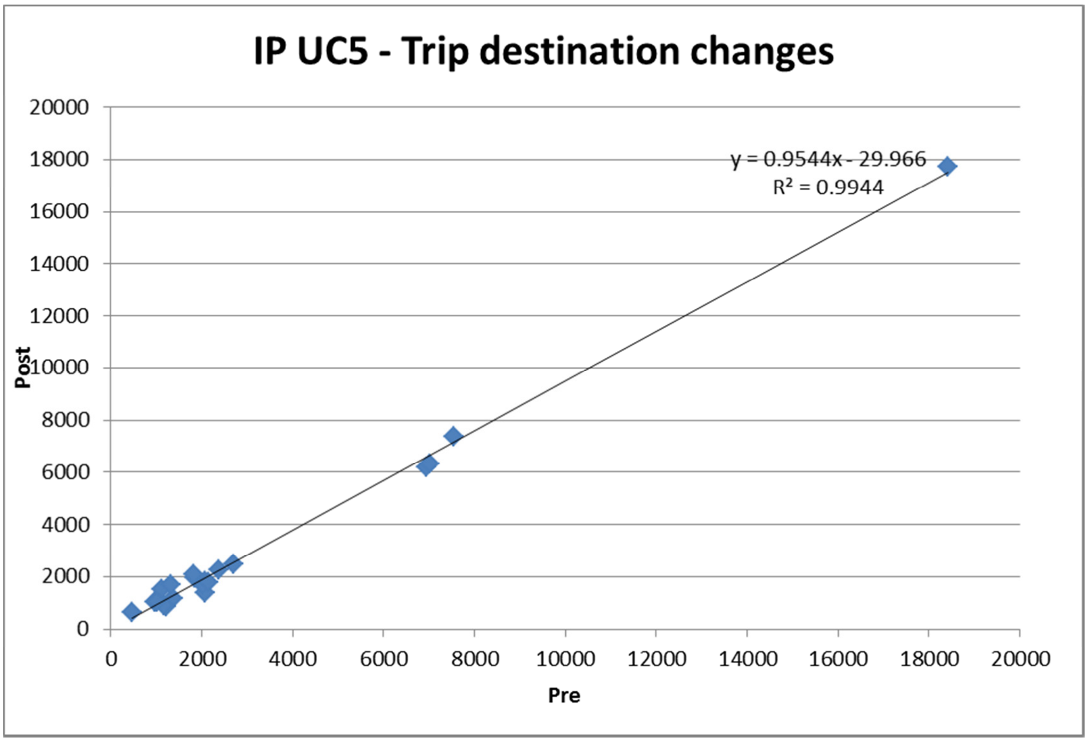
K.1.2 Interpeak trip destination changes



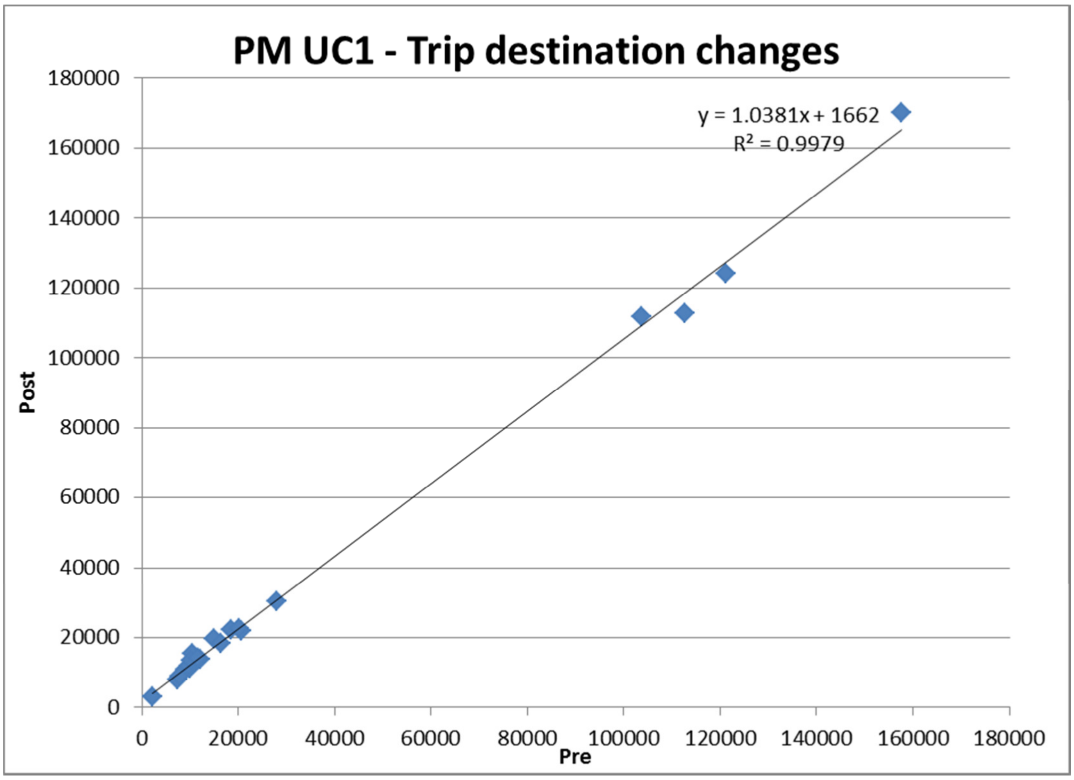

IP UC2 - Trip destination changes
y = 1.0418x + 215.54
R² = 0.998
Post
Pre
40000
35000
30000
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000
30000
35000
40000

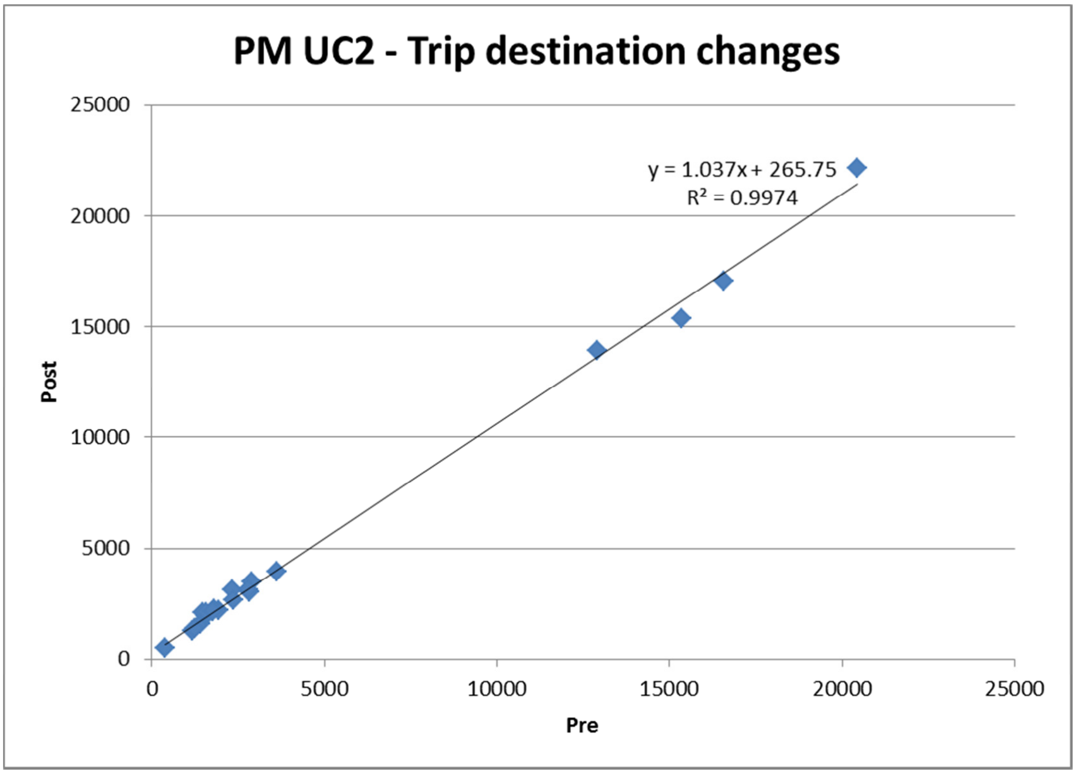

IP UC3 - Trip destination changes
y = 1.0283x - 30.137
R² = 0.9997
Post
Pre
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000

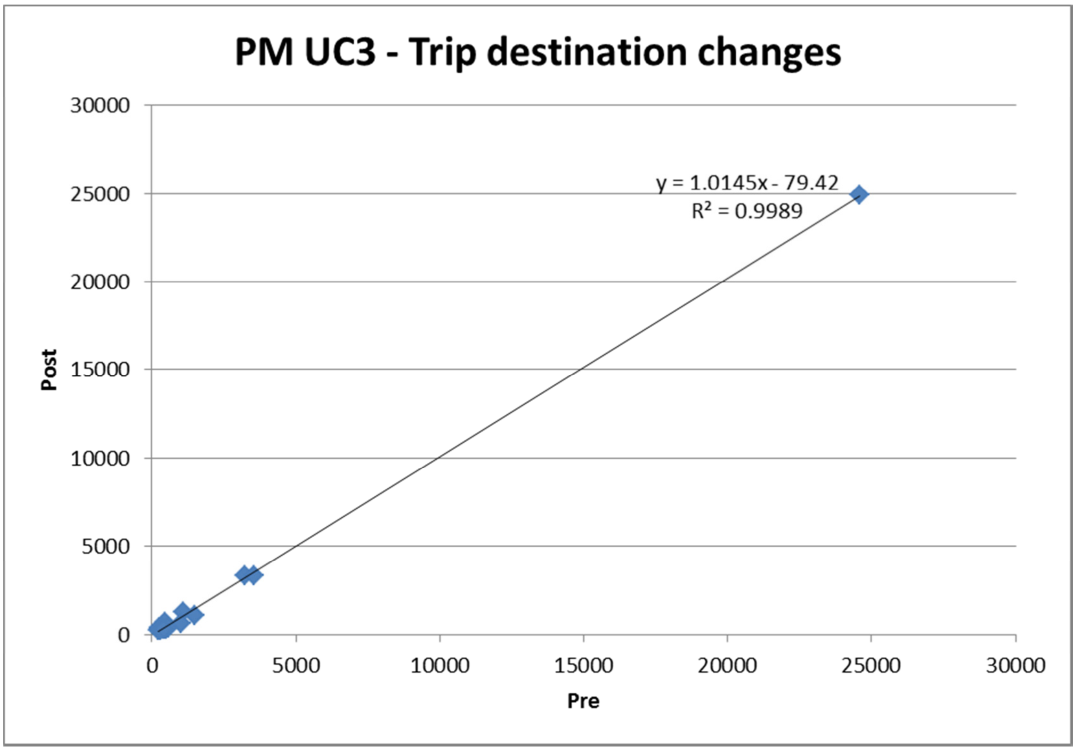

IP UC4 - Trip destination changes
y = 1.0715x - 130.26
R² = 0.998
Post
Pre
30000
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000
30000

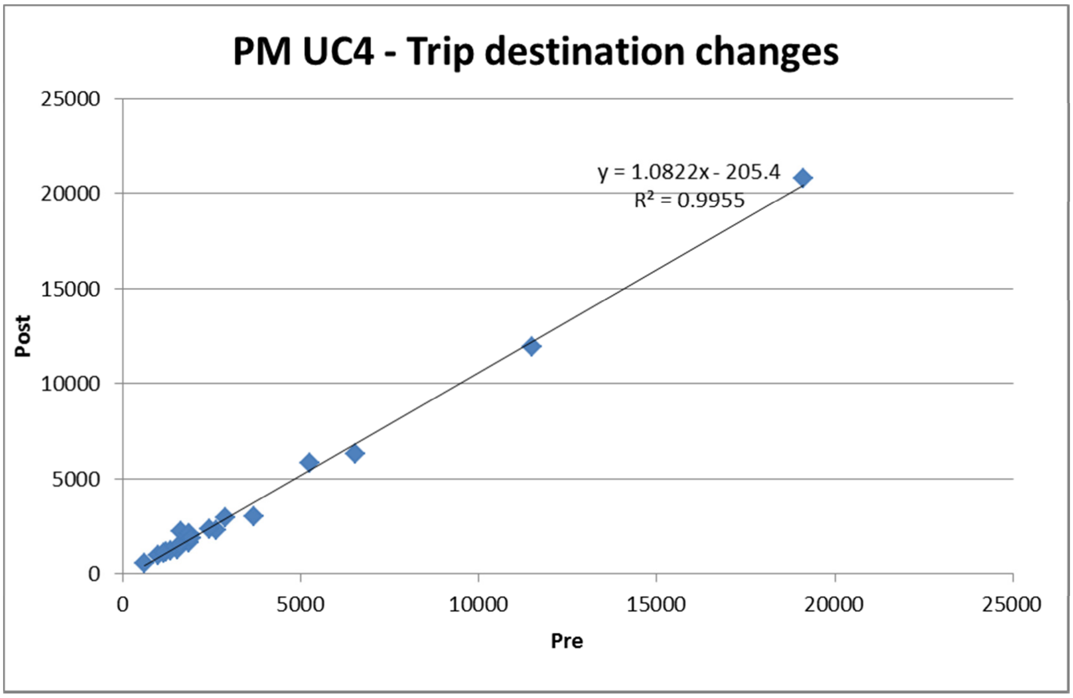

IP UC5 - Trip destination changes
y = 0.9544x - 29.966
R² = 0.9944
Post
Pre
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000

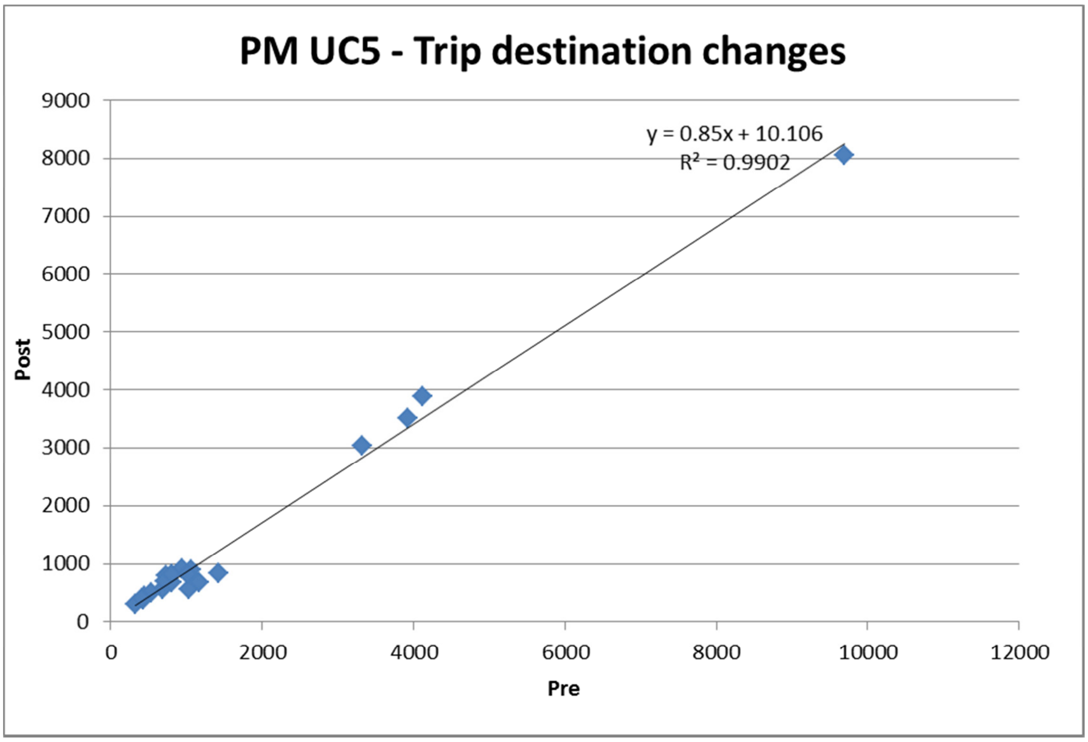
K.1.3 PM trip destination changes




PM UC2 - Trip destination changes
y = 1.037x + 265.75
R² = 0.9974
Post
Pre
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000

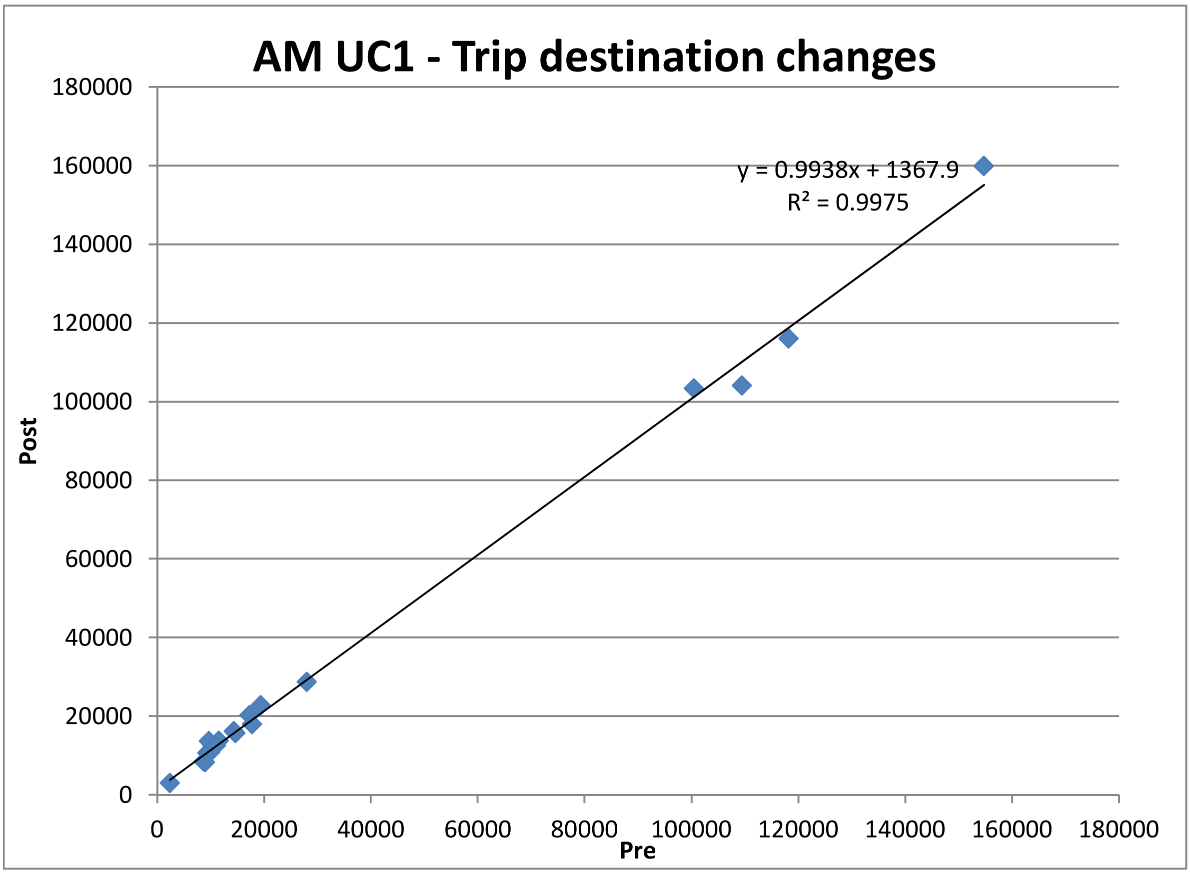

PM UC3 - Trip destination changes
y = 1.0145x - 79.42
R² = 0.9989
Post
Pre
30000
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000
30000

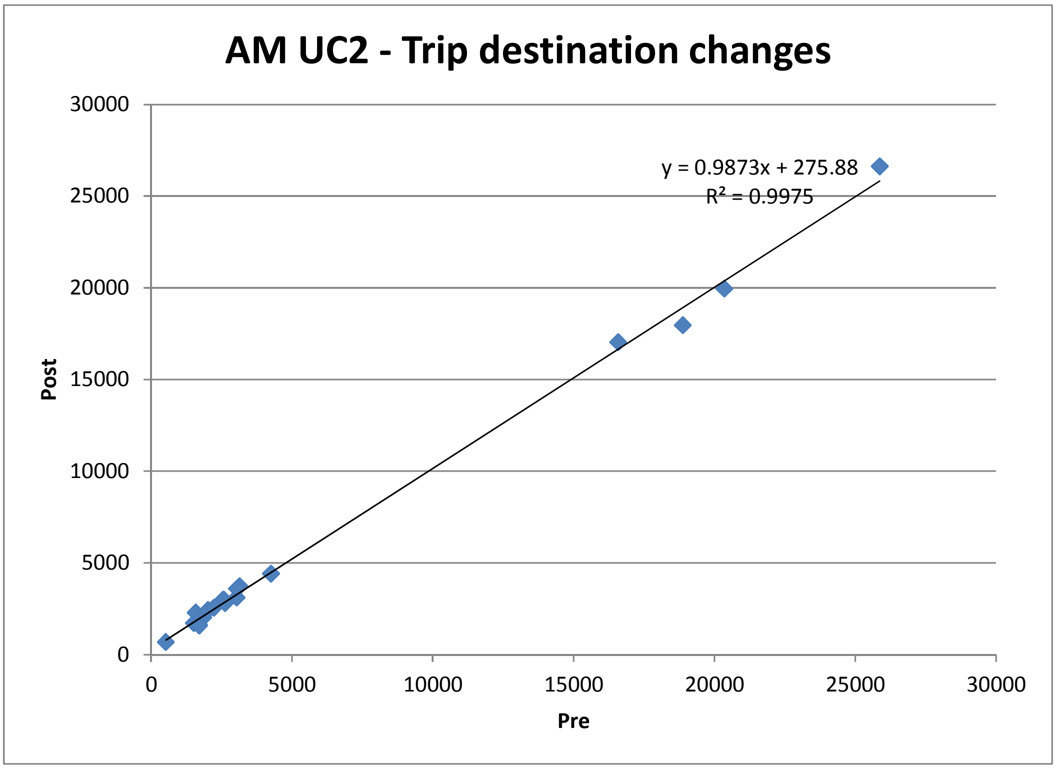

PM UC4 - Trip destination changes
y = 1.0822x - 205.4
R² = 0.9955
Post
Pre
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000

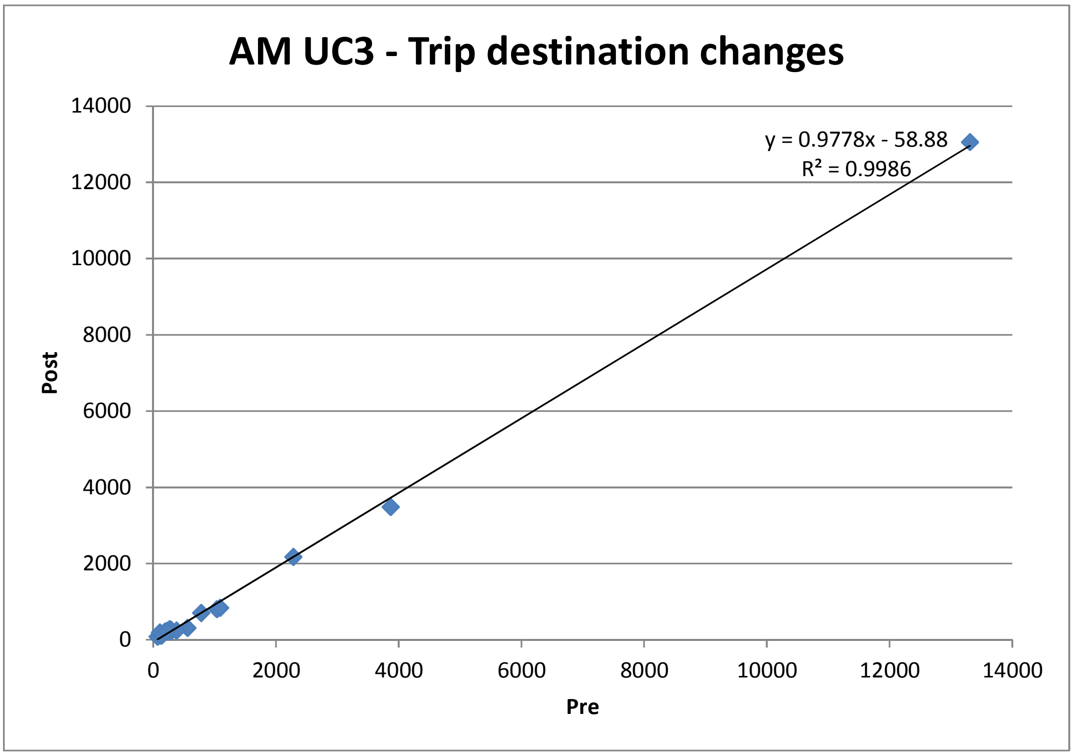

PM UC5 - Trip destination changes
y = 0.85x + 10.106
R² = 0.9902
Post
Pre
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
2000
4000
6000
8000
10000
12000

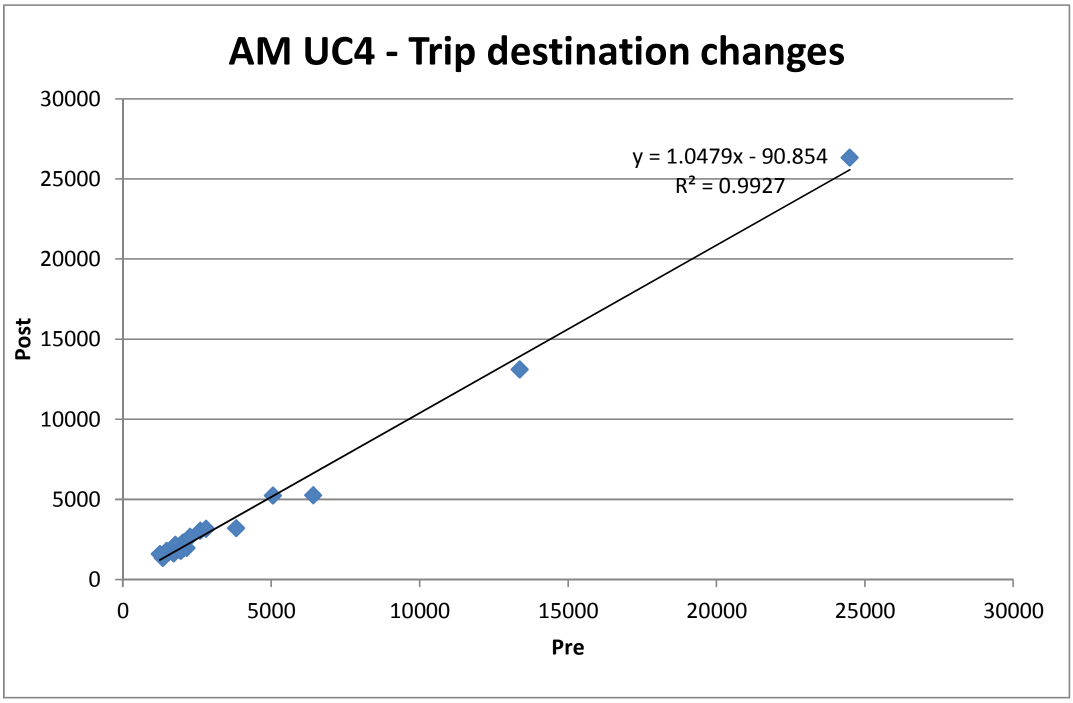
K.2 Matrix Estimation with all counts

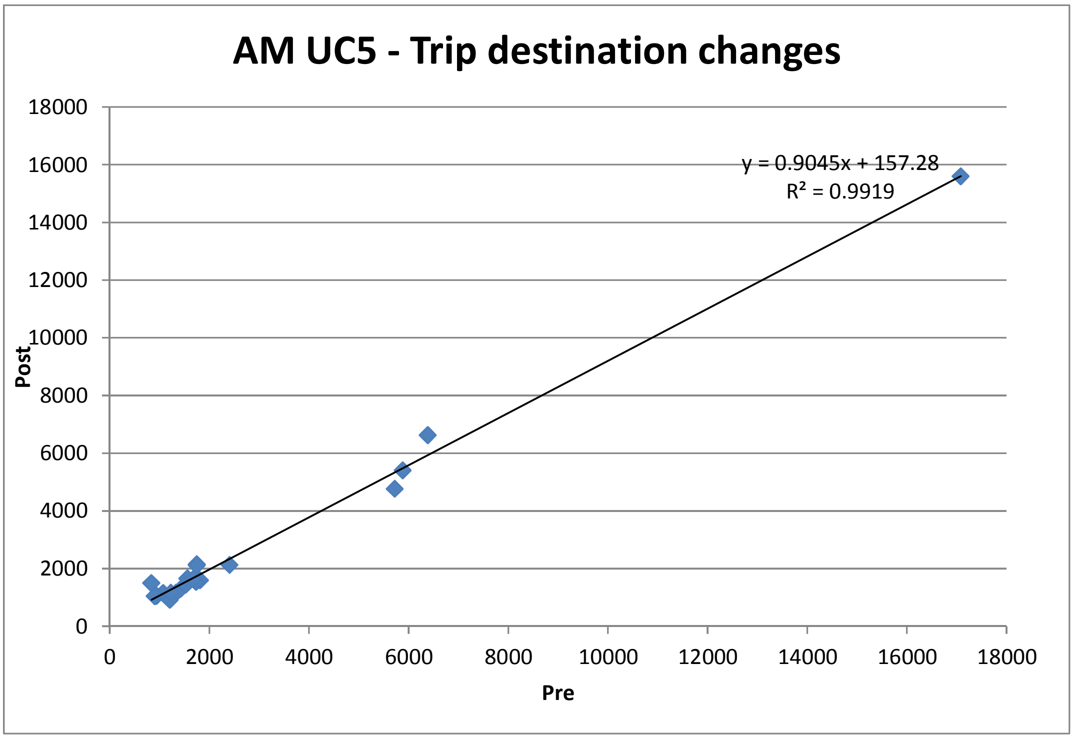
K.2.1 AM trip destination changes



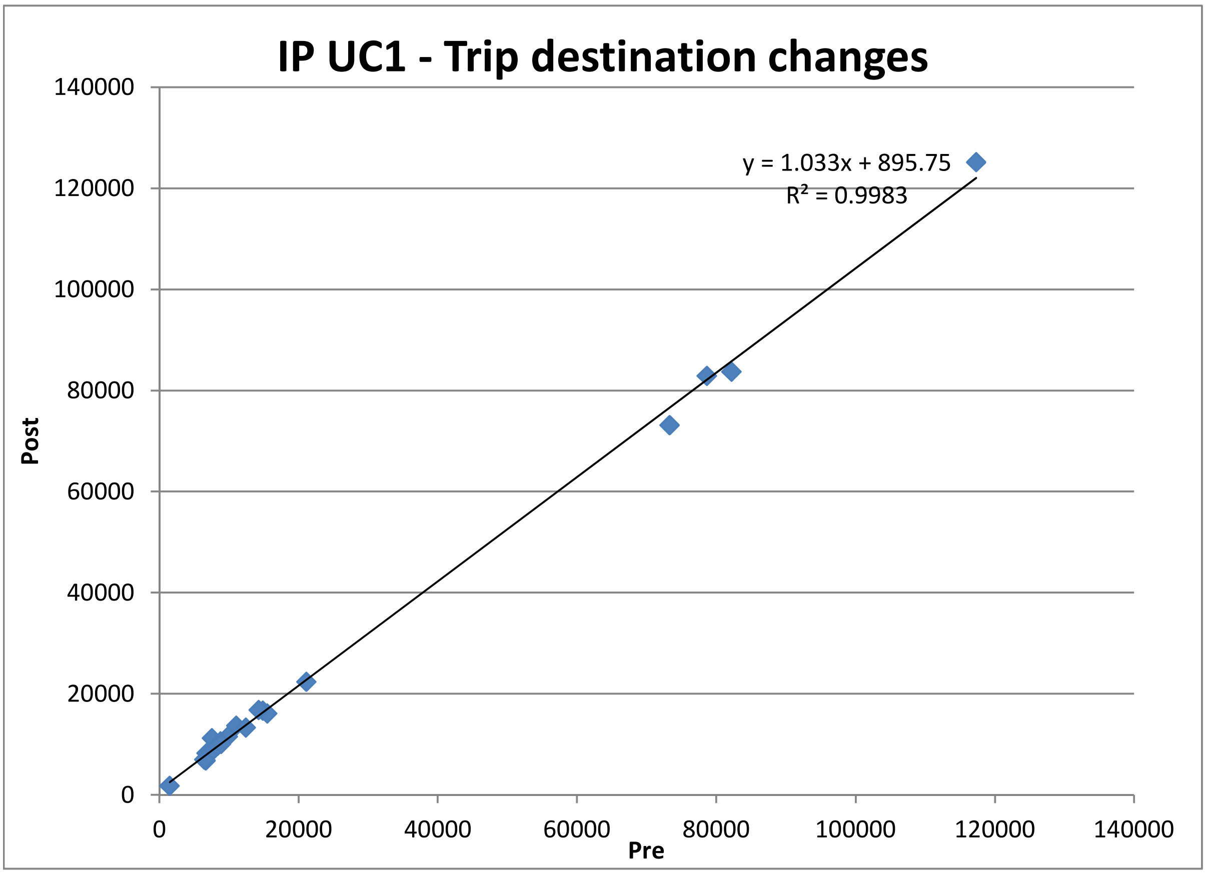

AM UC2 - Trip destination changes
y = 0.9873x + 275.88
R² = 0.9975
Post
Pre
0
5000
10000
15000
20000
25000
30000

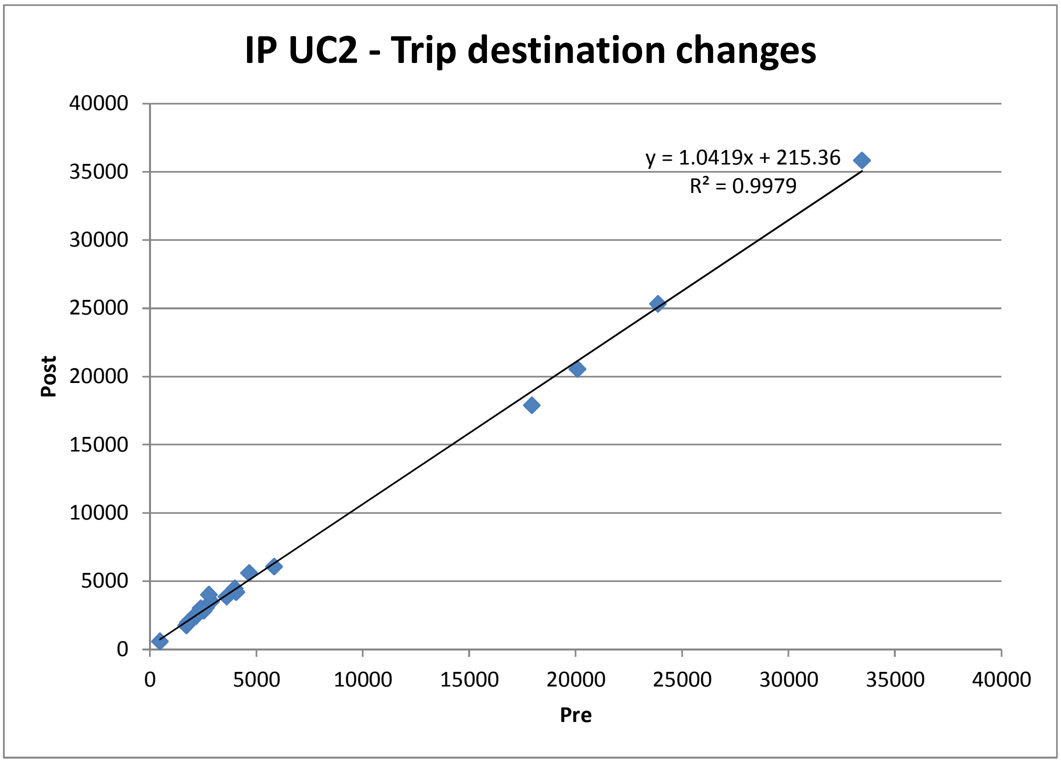

AM UC3 - Trip destination changes
y = 0.9778x - 58.88
R² = 0.9986
Post
Pre
0
2000
4000
6000
8000
10000
12000
14000

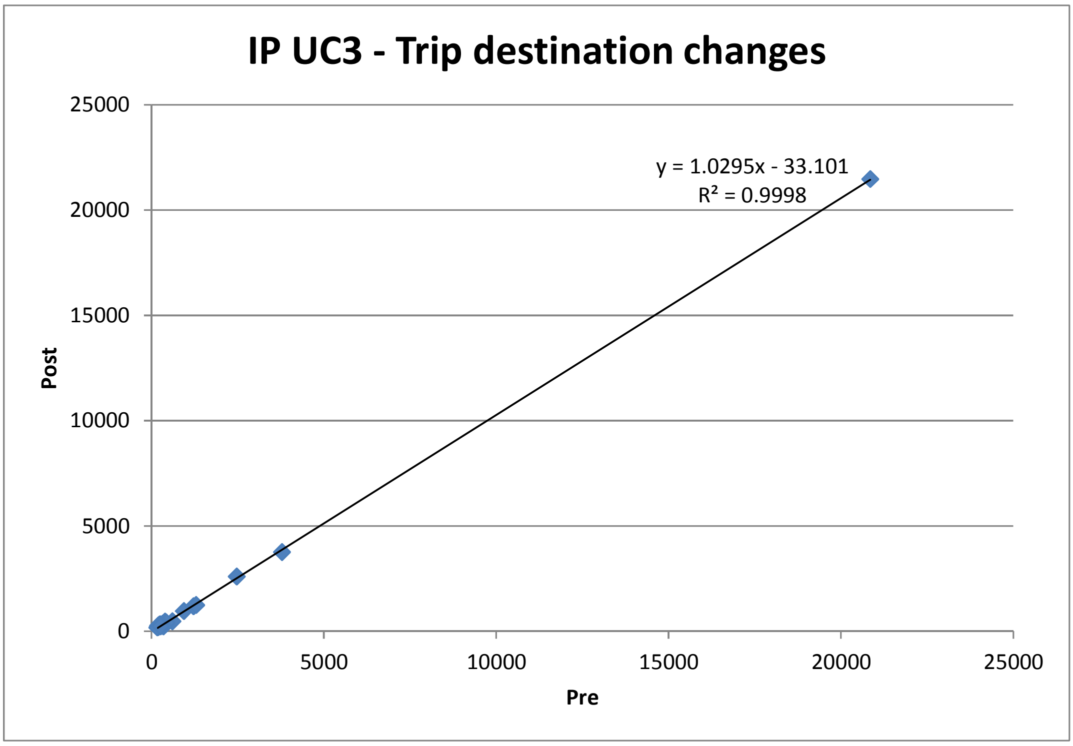

AM UC4 - Trip destination changes
y = 1.0479x - 90.854
R² = 0.9927
Post
Pre
30000
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000
30000

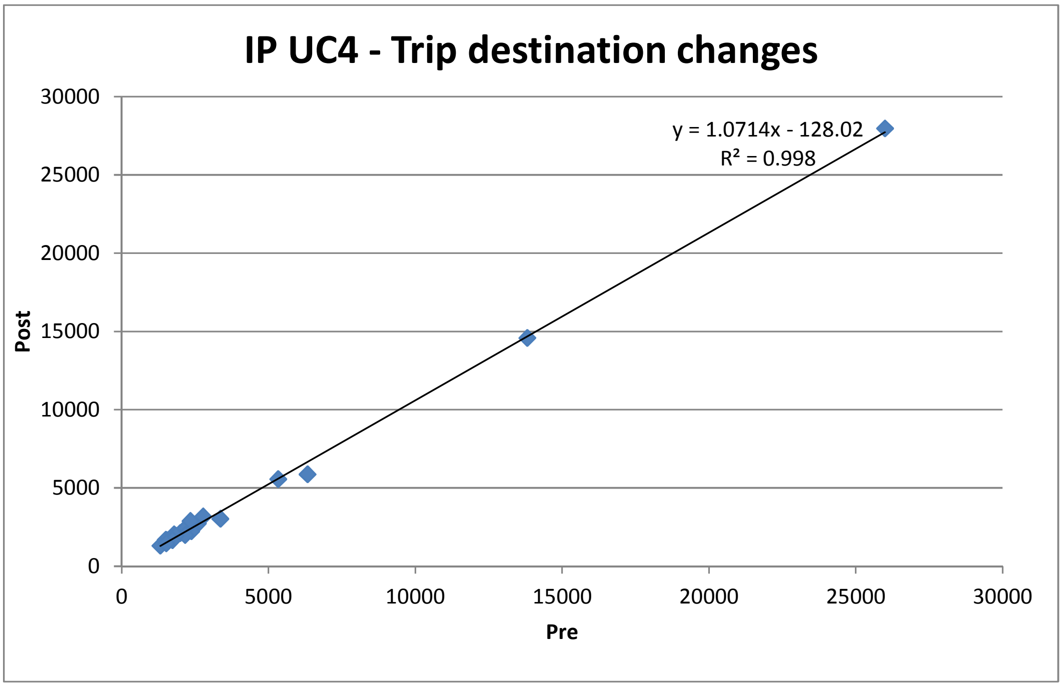

AM UC5 - Trip destination changes
y = 0.9045x + 157.28
R² = 0.9919
Post
Pre
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
2000
4000
6000
8000
10000
12000
14000
16000
18000

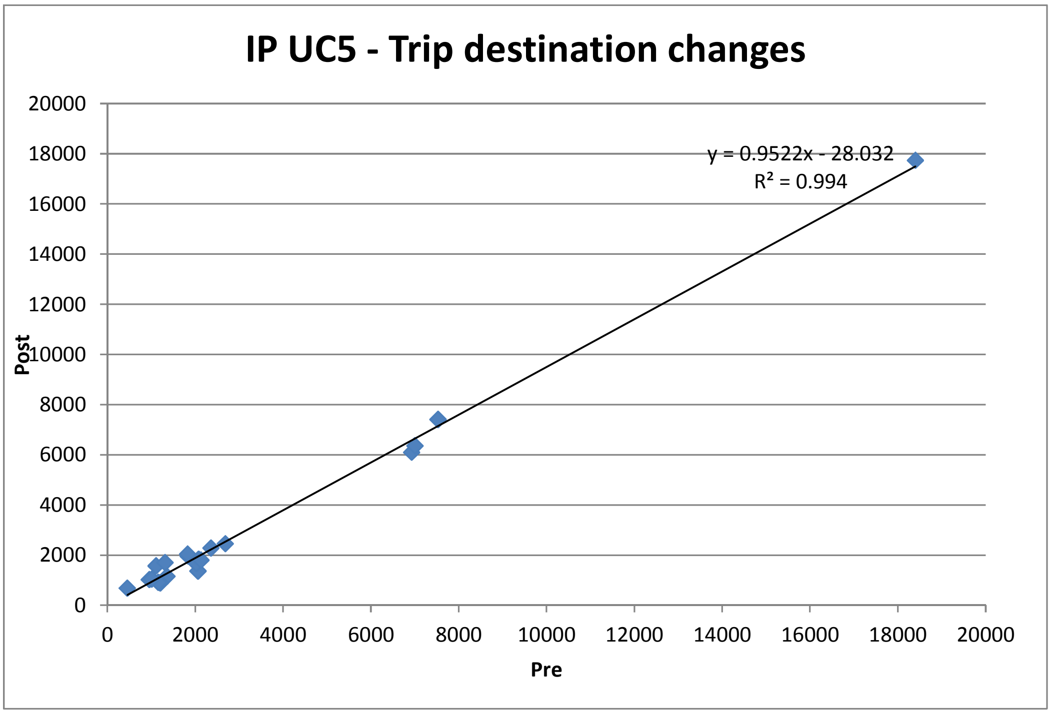
K.2.2 IP trip destination changes



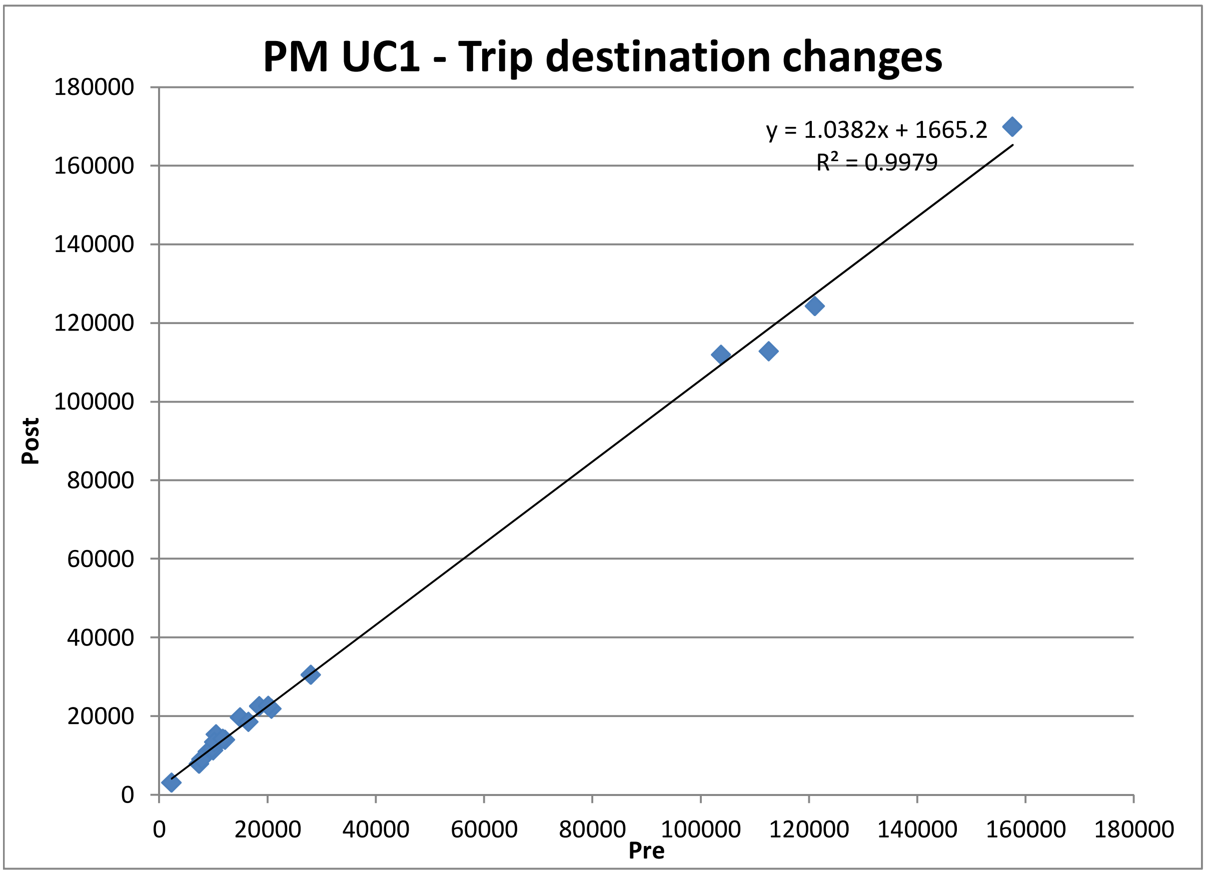

IP UC2 - Trip destination changes
y = 1.0419x + 215.36
R^2 = 0.9979
Post
Pre
0
5000
10000
15000
20000
25000
30000
35000
40000

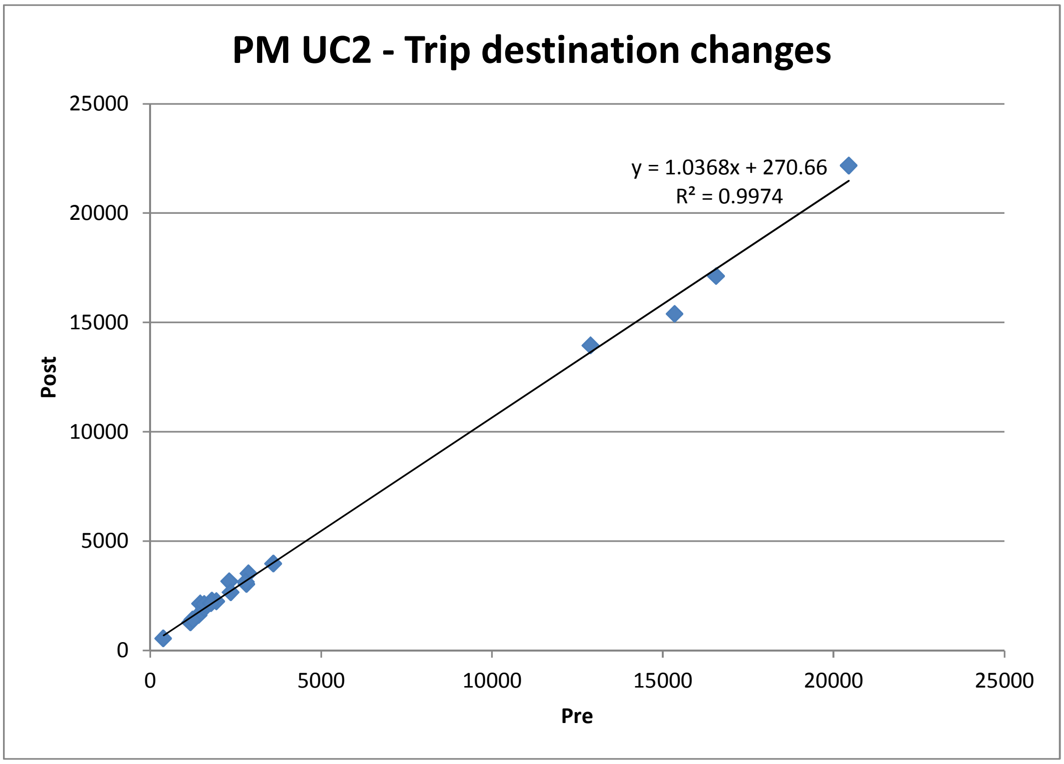

IP UC3 - Trip destination changes
y = 1.0295x - 33.101
R^2 = 0.9998
Post
Pre
0
5000
10000
15000
20000
25000

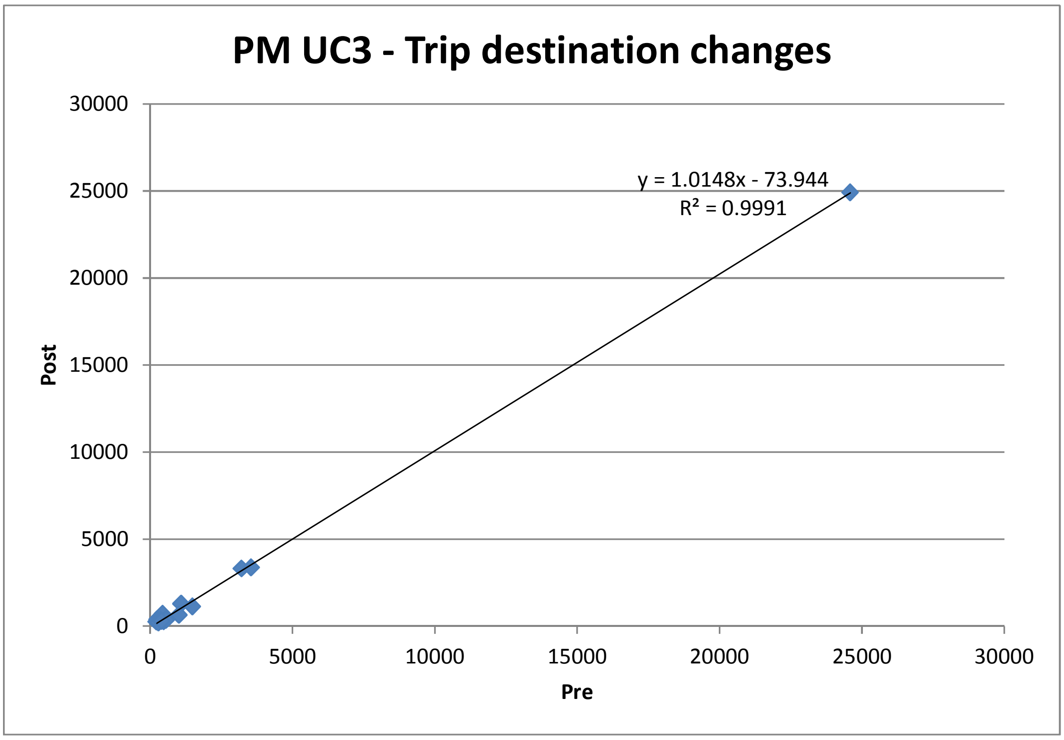

IP UC4 - Trip destination changes
y = 1.0714x - 128.02
R² = 0.998
Post
Pre
0
5000
10000
15000
20000
25000
30000

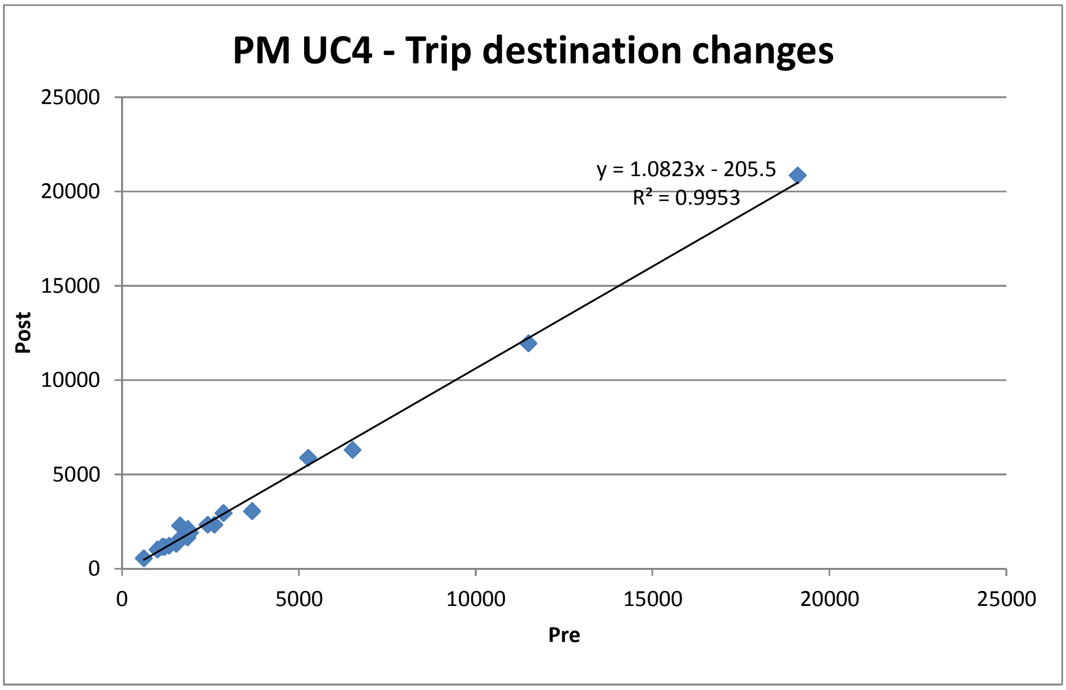

IP UC5 - Trip destination changes
y = 0.9522x - 28.032
R² = 0.994
Post
Pre
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000

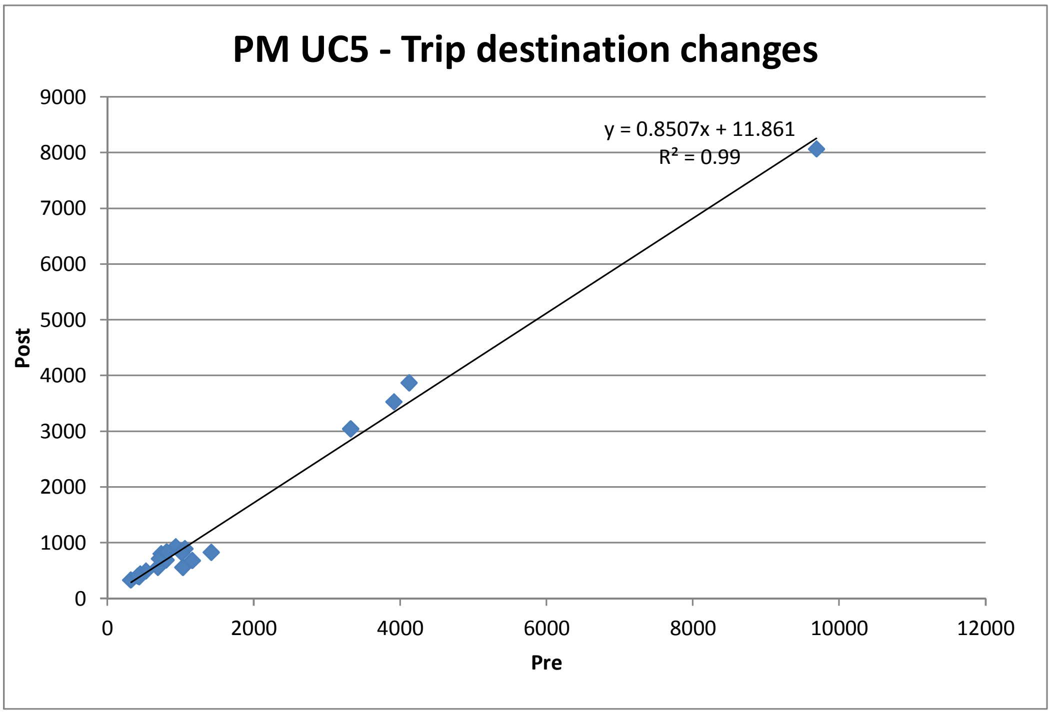
K.2.3 PM trip destination changes




PM UC2 - Trip destination changes
y = 1.0368x + 270.66
R² = 0.9974
Post
Pre
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000


PM UC3 - Trip destination changes
y = 1.0148x - 73.944
R² = 0.9991
Post
Pre
30000
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000
30000


PM UC4 - Trip destination changes
y = 1.0823x - 205.5
R² = 0.9953
25000
20000
15000
10000
5000
0
Post
0
5000
10000
15000
20000
25000
Pre


PM UC5 - Trip destination changes
y = 0.8507x + 11.861
R² = 0.99
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Post
0
2000
4000
6000
8000
10000
12000
Pre

Appendix L. Journey Time Graphs

L.1 Matrix Estimation with River Thames screenline as validation

L.1.1 Route 01: ELHAM Route 01 N (Includes Blackwall tunnel) Northbound

Figure L.1: AM Route 01: ELHAM Route 01 N (includes Blackwall tunnel) Northbound

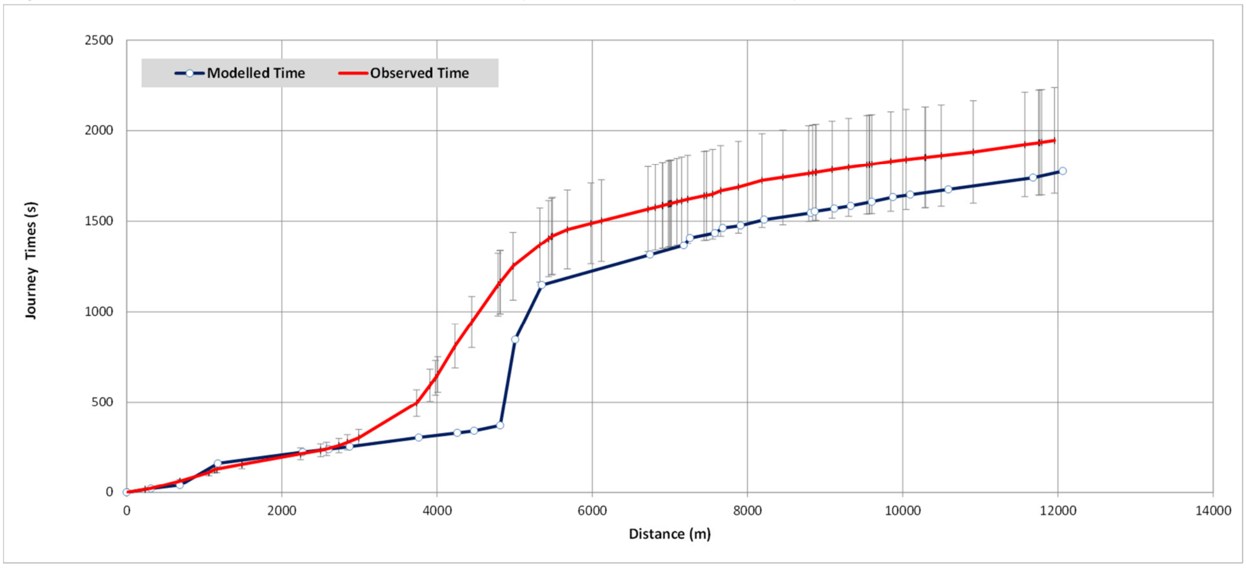


Figure L.2: IP Route 01: ELHAM Route 01 N (includes Blackwall tunnel) Northbound

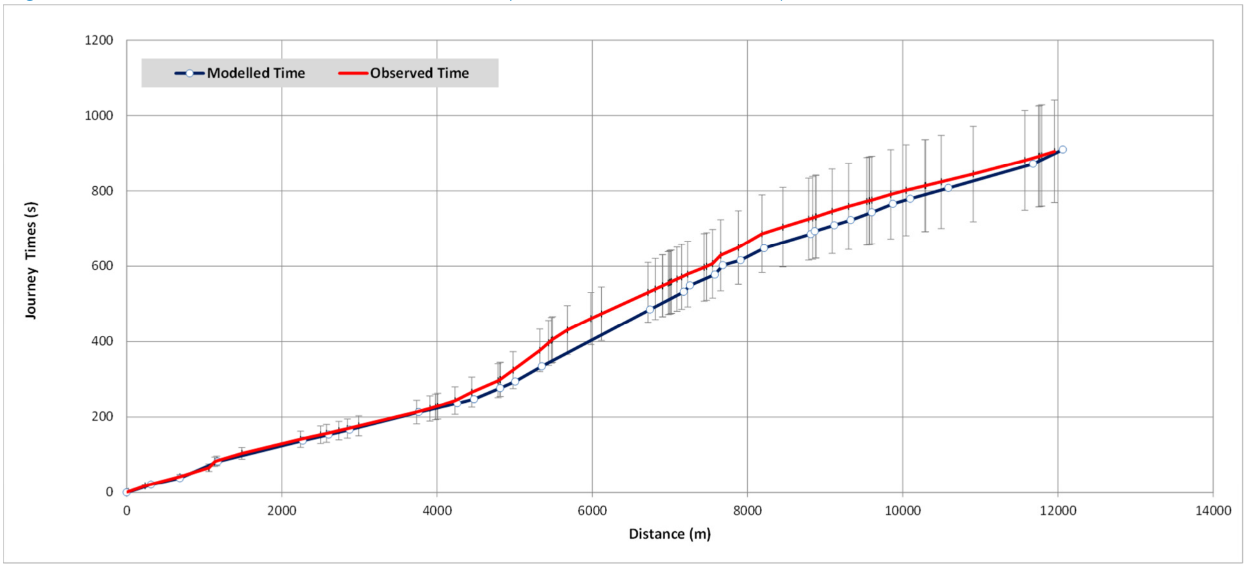
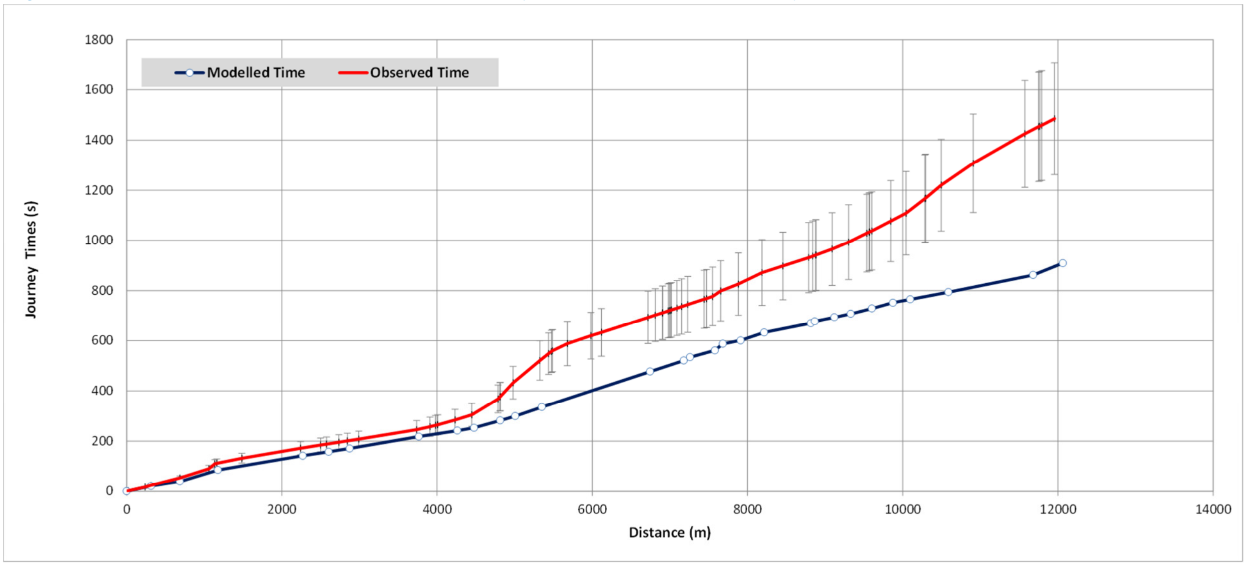


Figure L.3: PM Route 01: ELHAM Route 01 N (includes Blackwall tunnel) Northbound



L.1.2 Route 02: ELHAM Route 01-S (includes Blackwall tunnel) Southbound

Figure L.4: AM Route 02: ELHAM Route 01 S (includes Blackwall tunnel) Southbound

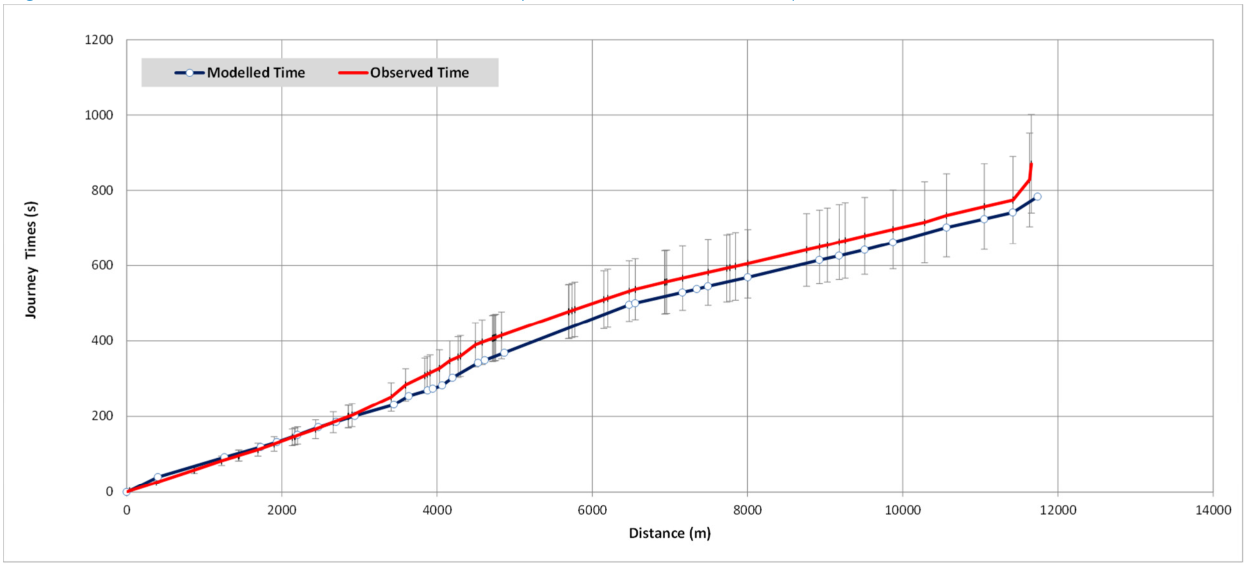


Figure L.5: IP Route 02: ELHAM Route 01 S (includes Blackwall tunnel) Southbound

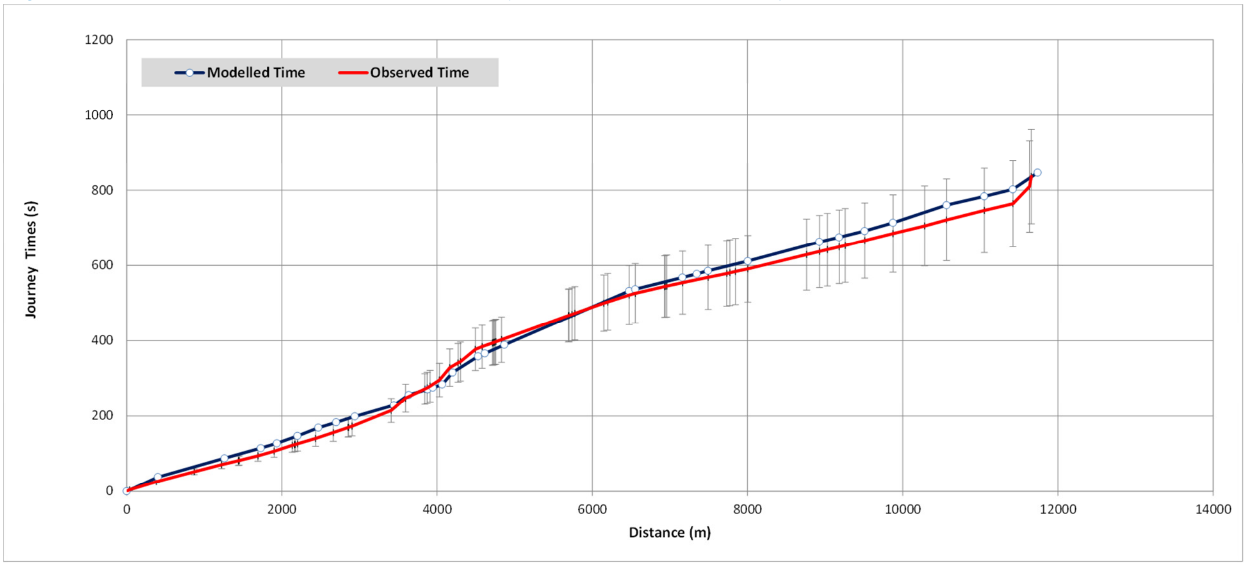
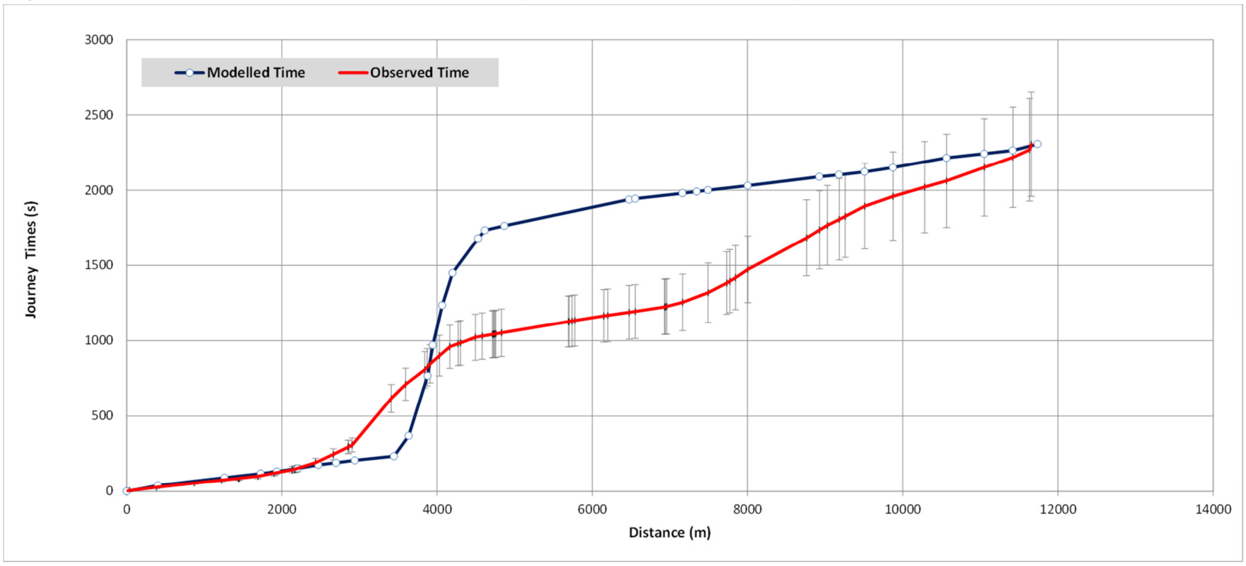


Figure L.6: PM Route 02: ELHAM Route 01 S (includes Blackwall tunnel) Southbound



L.1.3 Route 87: M25 Route 20-A (includes Dartford Crossing) Northbound

Figure L.7: AM: Route 87: M25 Route 20 A (includes Dartford Crossing) Northbound

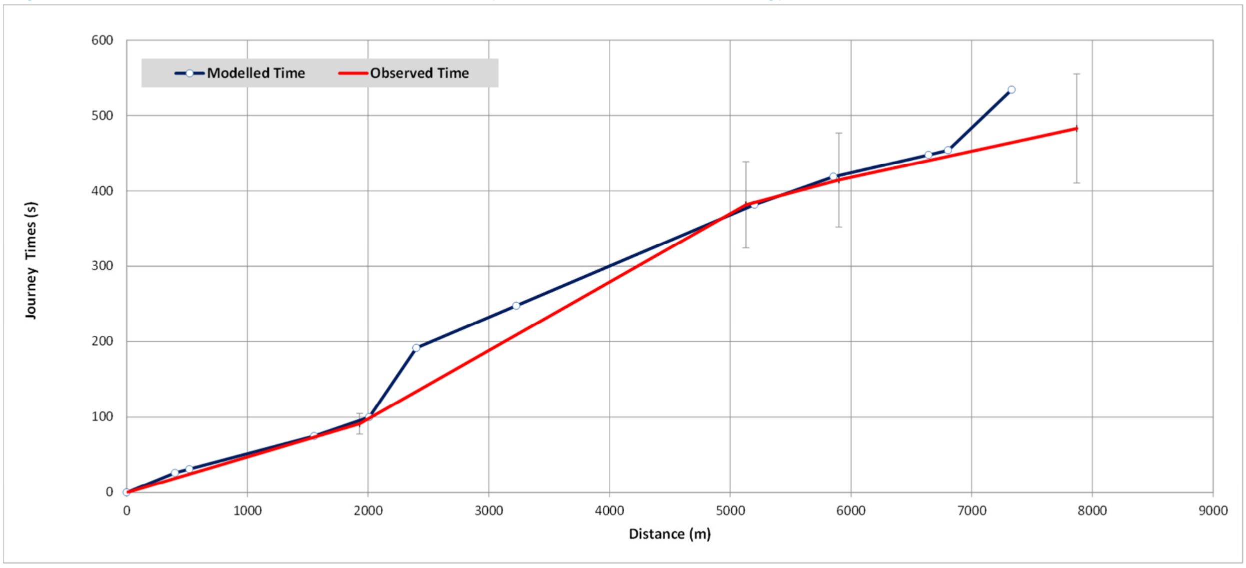


Figure L.8: IP: Route 87: M25 Route 20 A (includes Dartford Crossing) Northbound

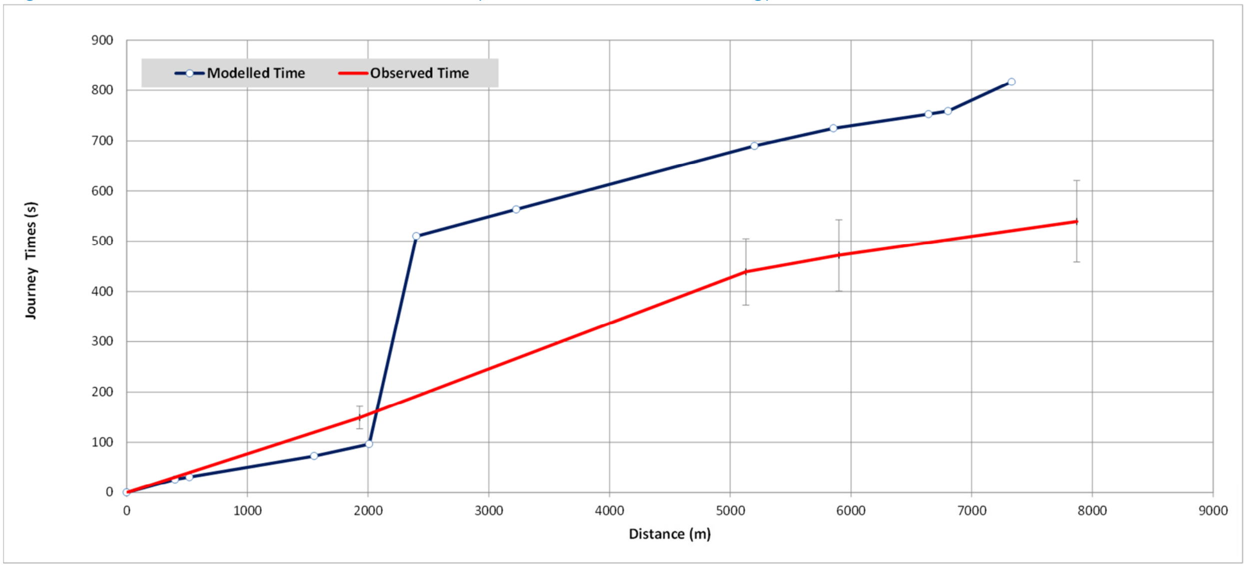
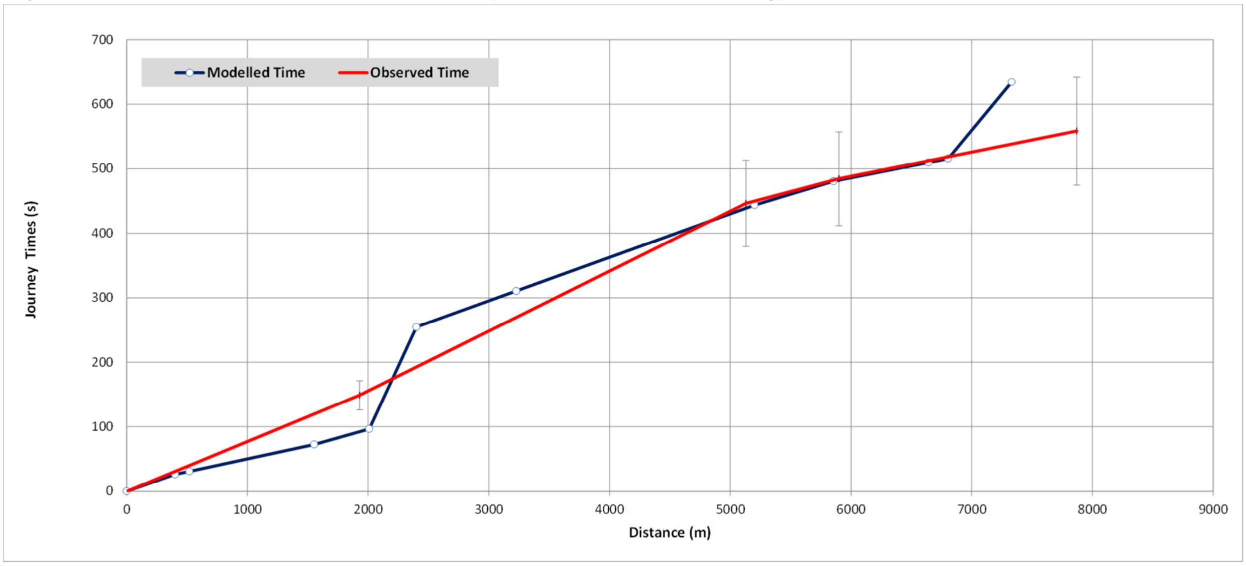


Figure L.9: PM: Route 87: M25 Route 20 A (includes Dartford Crossing) Northbound



L.1.4 Route 88: M25 Route 20 C (includes Dartford Crossing). Southbound

Figure L.10: AM: Route 88: M25 Route 20 C (includes Dartford Crossing) Southbound

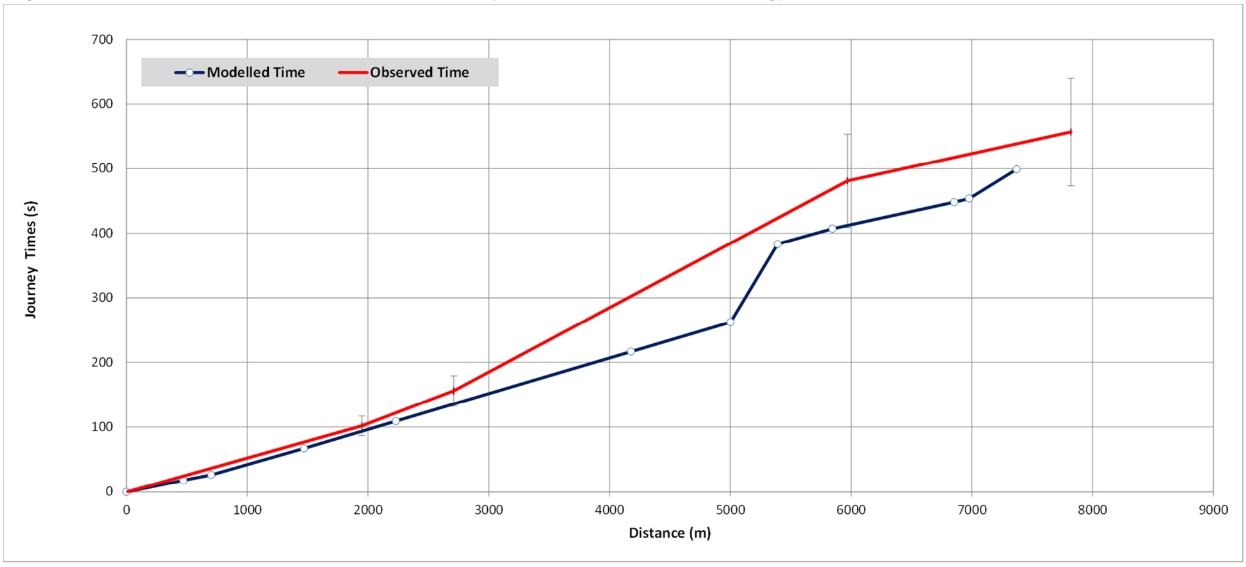


Figure L.11: IP: Route 88: M25 Route 20 C (includes Dartford Crossing) Southbound

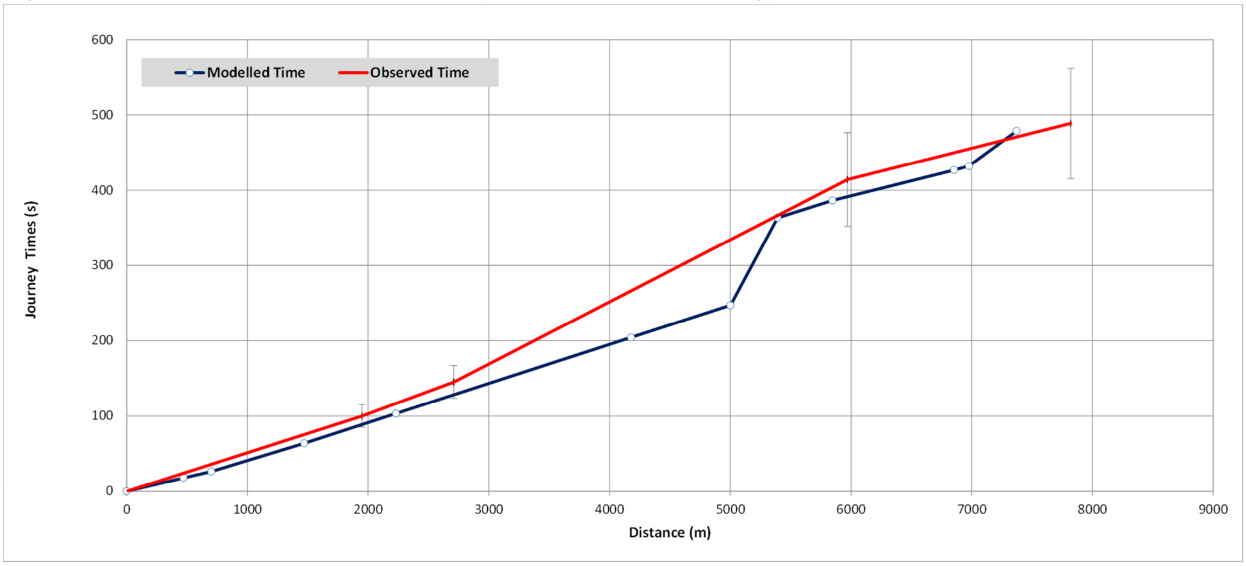
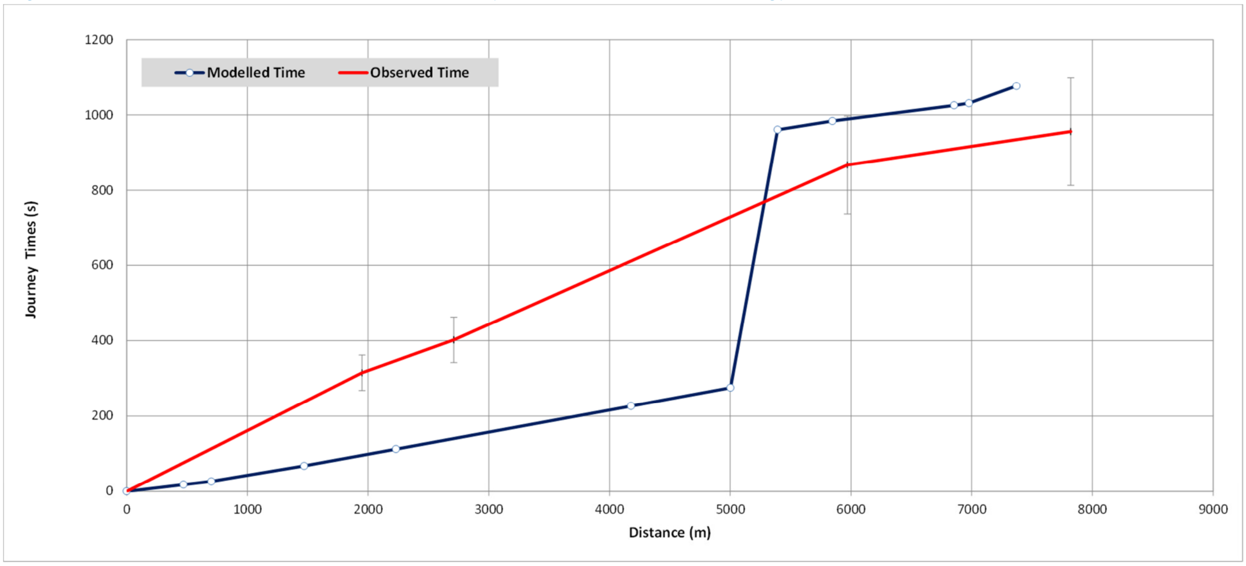


Figure L.12: PM: Route 88: M25 Route 20 C (includes Dartford Crossing) Southbound



L.2 Matrix Estimation with all counts

L.2.1 Route 01: ELHAM Route 01 N (Includes Blackwall tunnel) Northbound

Figure L.13: AM Route 01: ELHAM Route 01 N (includes Blackwall tunnel) Northbound

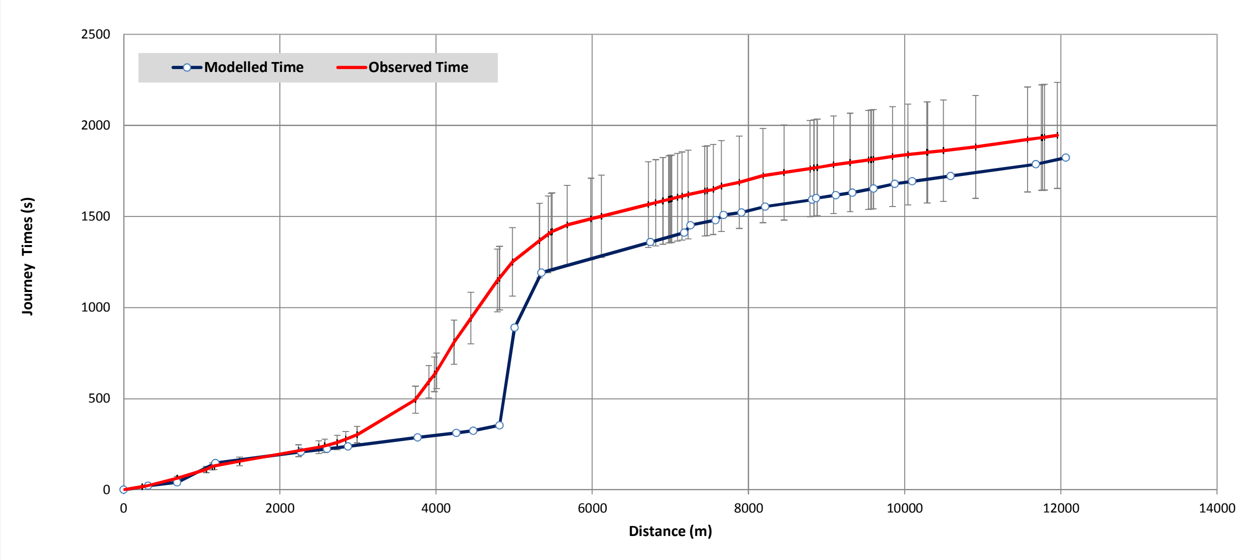


Figure L.14: IP Route 01: ELHAM Route 01 N (includes Blackwall tunnel) Northbound

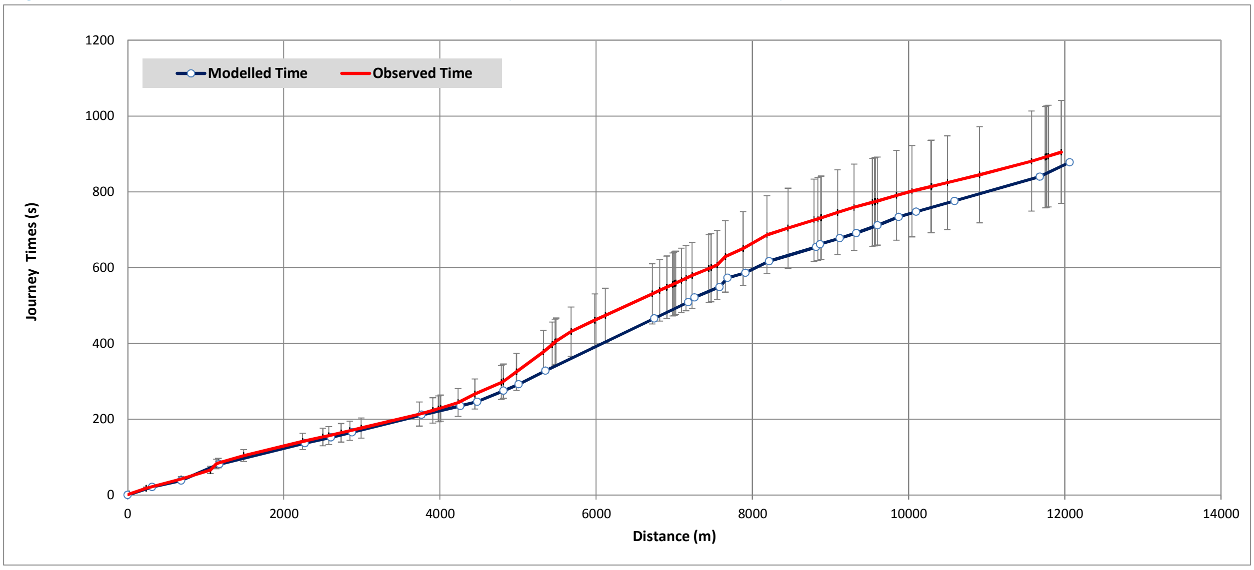
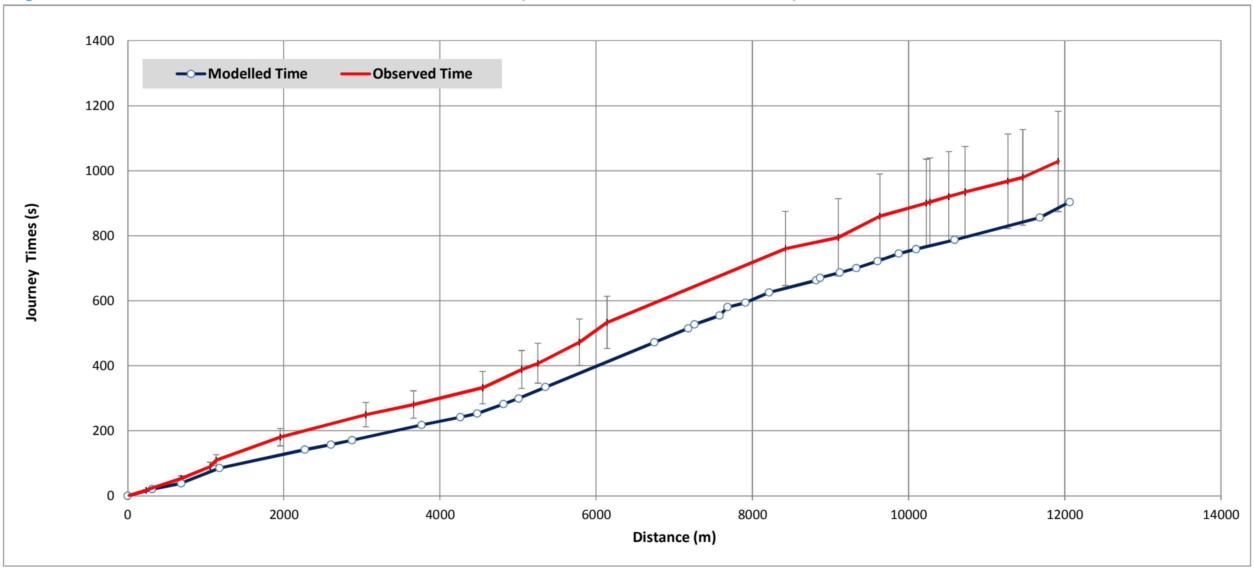


Figure L.15: PM Route 01: ELHAM Route 01 N (includes Blackwall tunnel) Northbound



L.2.2 Route 02: ELHAM Route 01-S (includes Blackwall tunnel) Southbound

Figure L.16: AM Route 02: ELHAM Route 01 S (includes Blackwall tunnel) Southbound

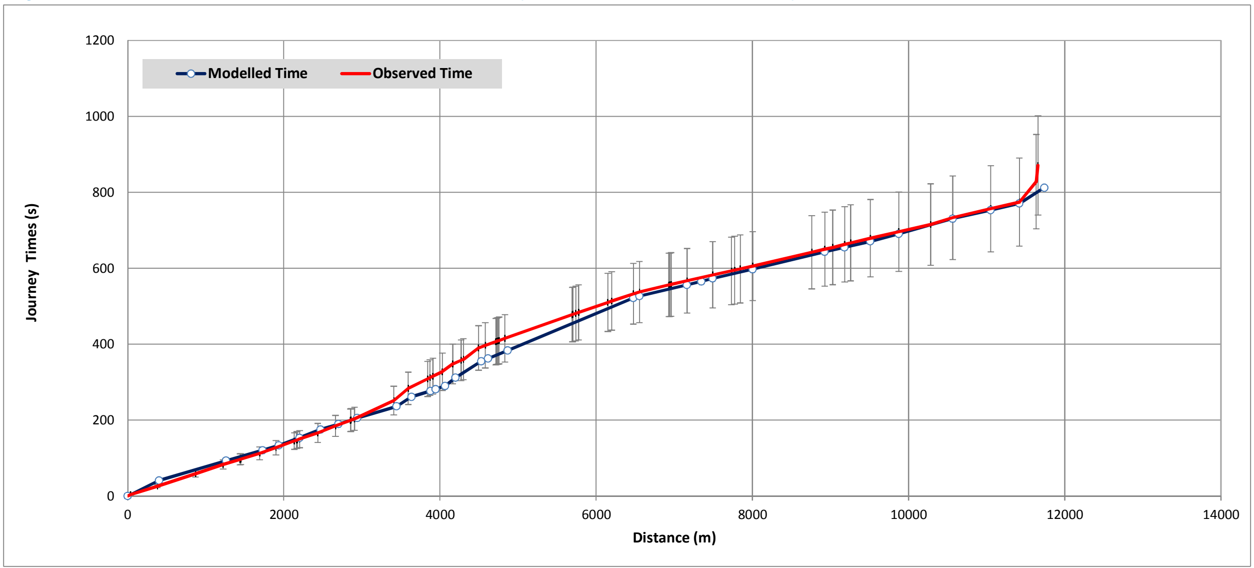


Figure L.17: IP Route 02: ELHAM Route 01 S (includes Blackwall tunnel) Southbound

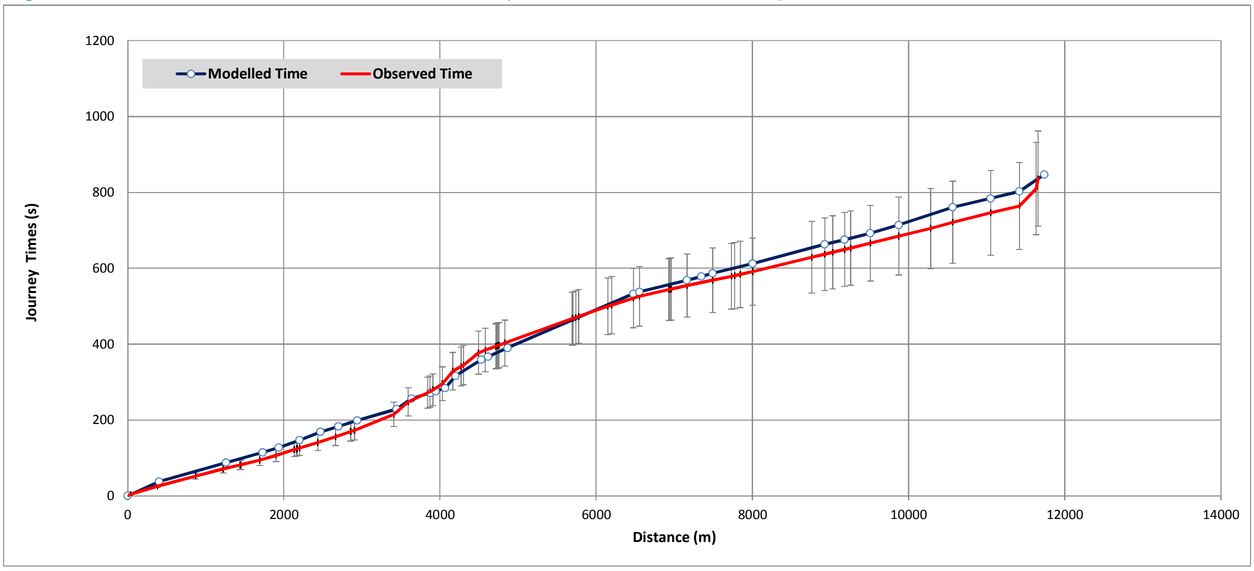
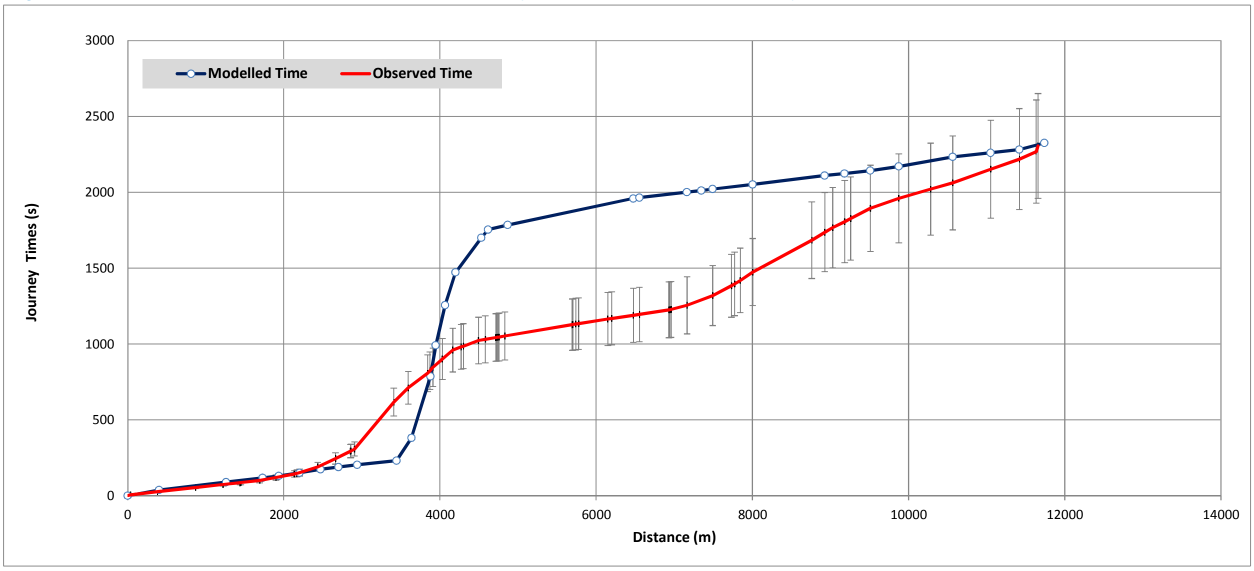


Figure L.18: PM Route 02: ELHAM Route 01 S (includes Blackwall tunnel) Southbound



L.2.3 Route 87: M25 Route 20-A (includes Dartford Crossing) Northbound

Figure L.19: AM: Route 87: M25 Route 20 A (includes Dartford Crossing) Northbound

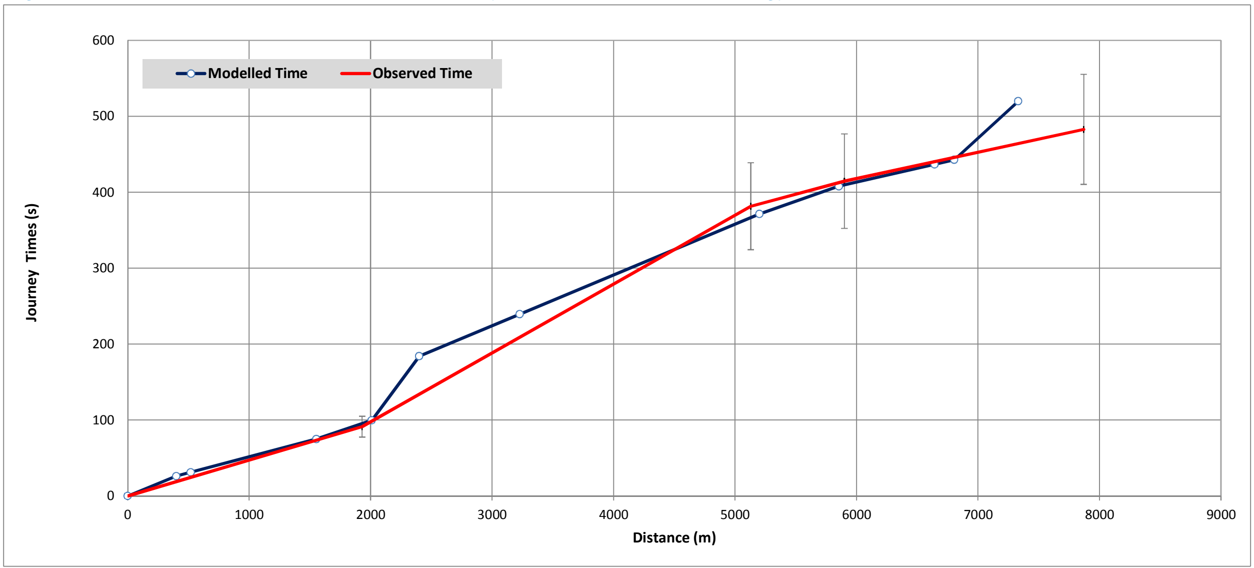
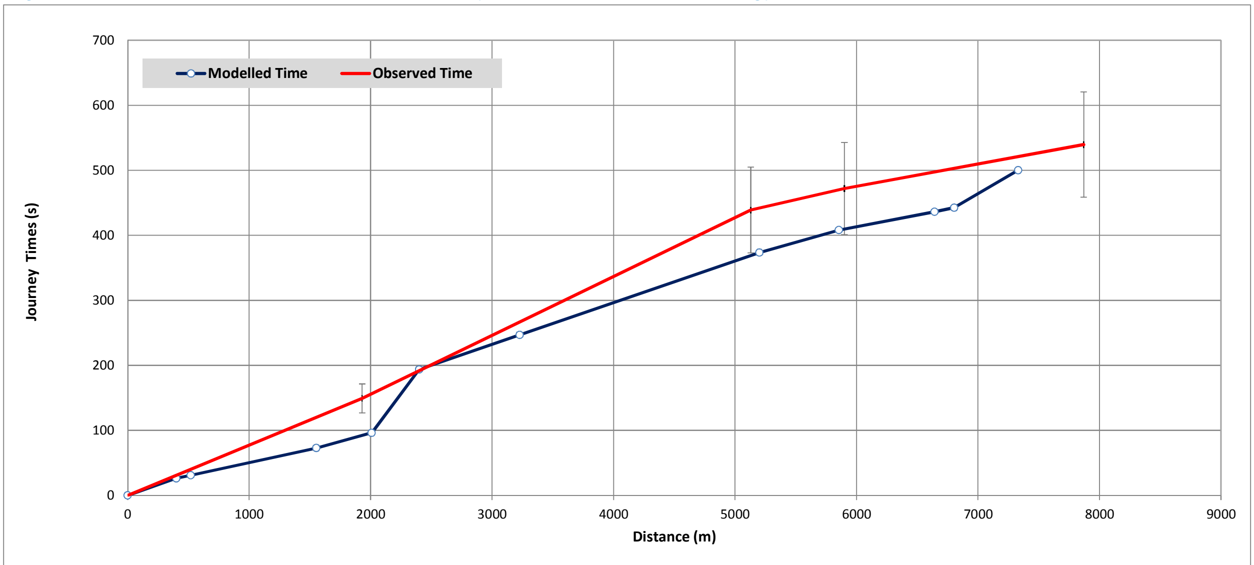
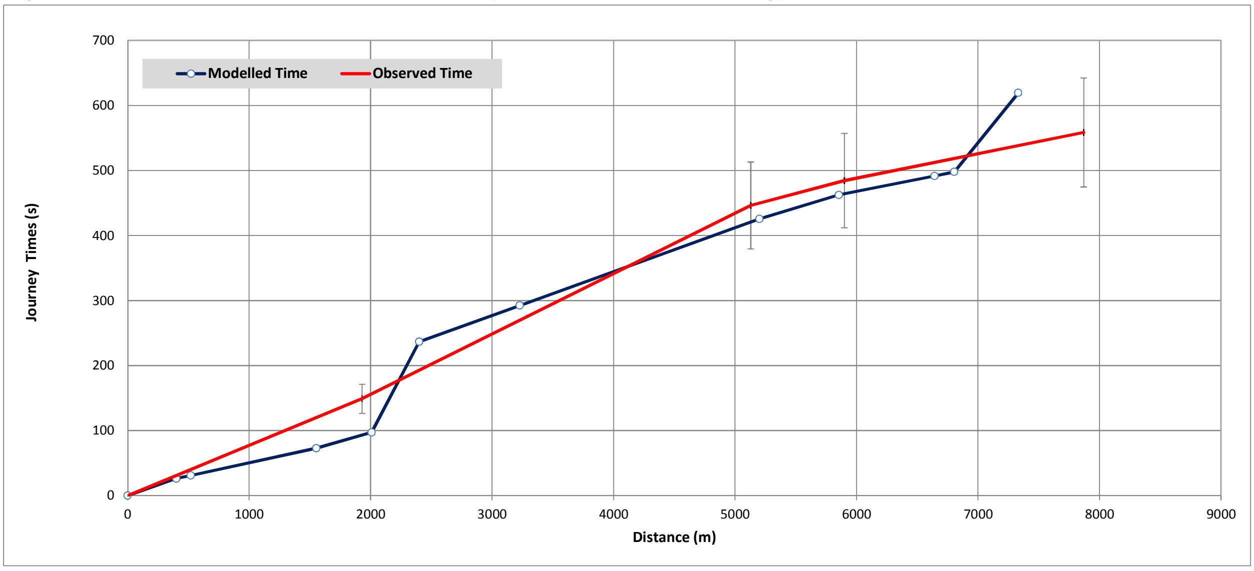


Figure L.20: IP: Route 87: M25 Route 20 A (includes Dartford Crossing) Northbound



Source: Insert source text here

Figure L.21: PM: Route 87: M25 Route 20 A (includes Dartford Crossing) Northbound



L.2.4 Route 88: M25 Route 20 C (includes Dartford Crossing). Southbound

Figure L.22: AM: Route 88: M25 Route 20 C (includes Dartford Crossing) Southbound

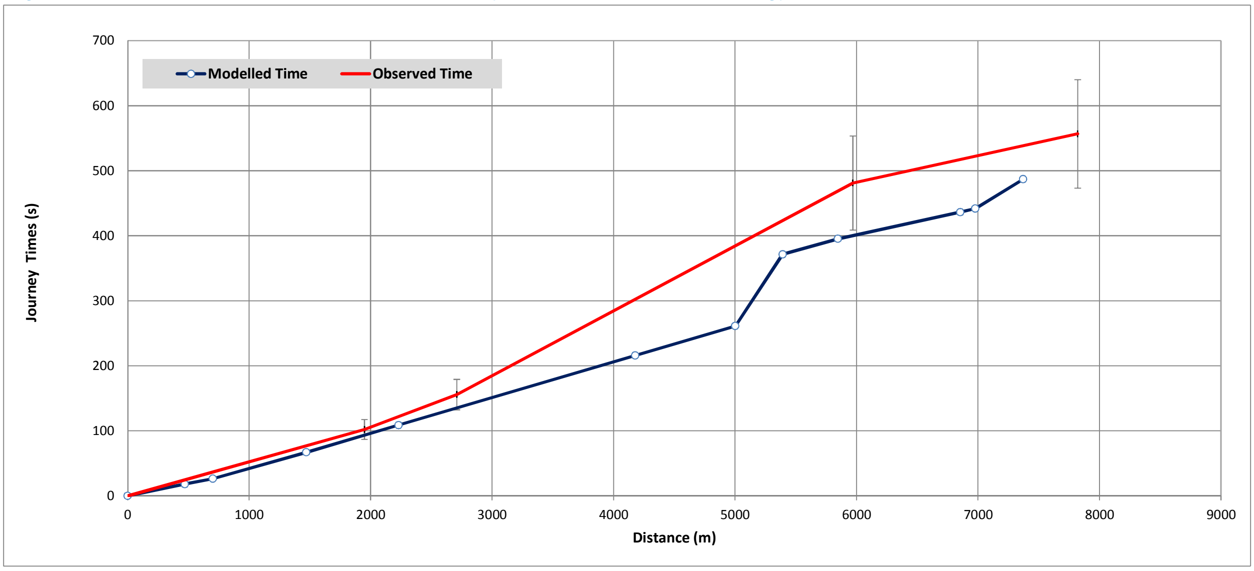


Figure L.23: IP: Route 88: M25 Route 20 C (includes Dartford Crossing) Southbound

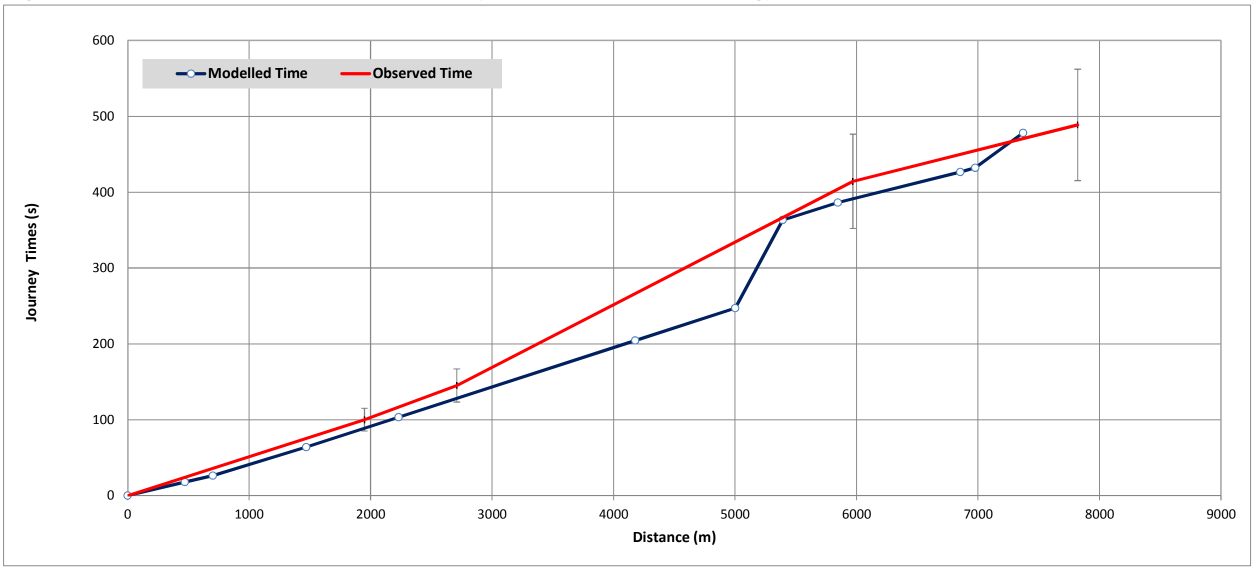
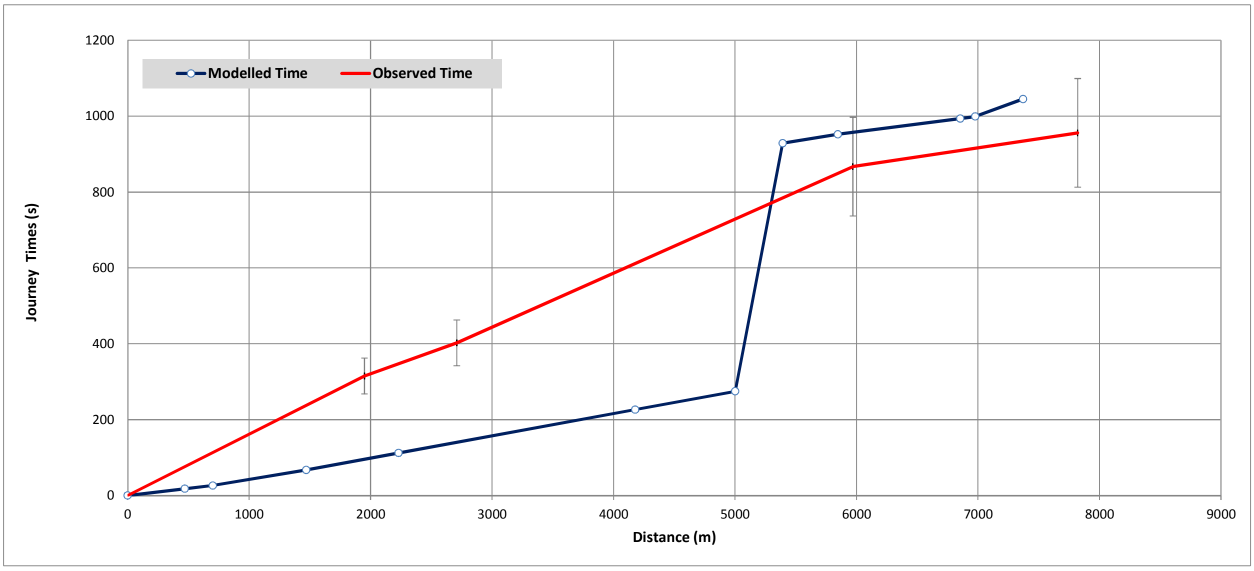


Figure L.24: PM: Route 88: M25 Route 20 C (includes Dartford Crossing) Southbound



Appendix M. Income Segmentation Technical Note

Technical Note 002

Title	Technical Note 002 - Incorporation of Income Segmentation in ELHAM matrices		
Document Number	289407/TN/002	**Revision**	A
Author	T Annesley N Ingles	**Date**	23/04/2012
Approver	I Johnston	**Date**	23/04/2012

1. Introduction

The user classes incorporated in the ELHAM matrices comprise cars in and out of work time (IWT and OWT), taxis, LGVs and OGVs; and each have their own values of time, for use in the assignments in each modelled period. However, there are circumstances in which additional disaggregation is required, as advocated in WebTAG Unit 3.12.2 (February 2007). The following comment is made in that document:

> 2.1.1 The Unit notes that for schemes specifically involving pricing, some additional segmentation by willingness-to-pay or income, and possibly also by trip distance, may be required.

Given that the river crossings to be appraised on this project are likely to be tolled, this guidance is applicable in this case. The appropriate way forward was considered to be to take the OWT car matrix in each time period, and split it into three income groups: low, medium and high. The remaining matrices are relatively small in comparison, with generally higher values of time, and it was not considered necessary to disaggregate these elements.

Jacobs Consultancy had undertaken a similar exercise for the LTS model, as part of the series of medium term enhancements (MTE) made to the model in 2007 (full details are given in Reference 1). The methodology developed was then incorporated by Halcrow in the Thames Gateway Bridge V2007 model, developed during 2007 and 2008 (and set out in chapter 7 of Reference 2). The assumption was made then that the proportion of drivers in each of the three income bands, for different movements, and their relative values of time, would remain unchanged in the future years when forecasting – although of course the average income in each category and average values of time would change. These assumptions continue to apply in the present context.

Although carried out five years ago using 2001 LATS household interview data, Jacobs' methodology and the results obtained are still considered current within TfL, and it is understood that no subsequent refinements have been made. The decision was therefore taken to continue using Jacobs' results in the current context (as on the TGB study), and apply broadly the same procedures in their application. The purpose of this Technical Note is to set out the detailed methodology adopted, and to present the results obtained in the context of the ELHAM matrices.

Section 2 of the note describes the Jacobs' methodology in more detail, and outlines how it was applied to the LTS matrices at the time. Section 3 then presents the application of the methodology in the present context, and provides a description of the results obtained when disaggregating the ELHAM base year matrices. The calculation of the values of time in each of the three income groups is then set out in Section 4.

2. The existing methodology, and previous LTS application

2.1 Introduction

The income segmentation methodology developed by Jacobs Consultancy for the LTS model was set up for application to the vehicle matrices produced for input to the highway assignment model; the same stage at which it is intended to be applied in this context. As noted above, the methodology was based on the LATS 2001 household interview data.

The work which was involved fell into three distinct parts. The first was development of an explanatory model to sub-divide existing car OWT trips of different types by income band; the second was development of a methodology to apply the results obtained within the context of the LTS model; and the third was to derive a value of time for each income group. Each of these three steps is important in the present context and each is summarised in turn.

2.2 Development of Explanatory Model

For the purpose of this exercise, Jacobs initially extracted all car driver trips out of work time from the LATS Household Interview data base, and separated them out by the five purpose categories applied in the LTS model :

- Car commute trips – white collar (WC)
- Car commute trips – blue collar (BC)
- Education
- Home based other
- Non home based other.

The car driver trips were then sub-divided into three income groups (relating to household income), originally intended to be of approximately equal size : < £20k, £20k - £50k, and > £50k in 2001 prices.

The requirement at this point was to develop a methodology to estimate the proportional split between the three income groups for trips in each purpose category, over every origin-destination pair. To this end, a multinomial logit model was developed, similar in form to the models conventionally applied to model modal split. As explanatory variables, trip length and origin/destination sector were tested, but the latter was rejected because of statistical problems (correlation with other variables).

The end product, therefore, was a table showing for each purpose and trip length group, the proportional split between the three income groups. This is shown in Table 3.4 of Reference 1, and for convenience, the results are repeated here in **Table 2.1**.

Table 2.1 : Proportion of trips in each income band, as predicted by Income Segment Model

Purpose	*Income*	*Trip Length*		
		< 3 kms	3 – 12 kms	> 12 kms
Work White Collar	< £20k	23.3%	19.0%	10.4%
	20k – 50k	49.6%	53.3%	51.6%
	> £50k	27.1%	27.6%	38.0%
Work Blue Collar	< £20k	37.7%	36.2%	24.6%
	20k – 50k	47.4%	50.3%	58.6%
	> £50k	14.9%	13.5%	16.8%
Education	< £20k	28.9%	26.2%	28.3%
	20k – 50k	46.2%	45.4%	37.3%
	> £50k	24.9%	28.4%	34.3%
HB Other	< £20k	36.9%	37.0%	32.8%
	20k – 50k	41.8%	42.4%	42.3%
	> £50k	21.3%	20.6%	24.9%
NHB Other	< £20k	28.3%	28.2%	24.3%
	20k – 50k	46.7%	46.0%	46.6%
	> £50k	25.0%	25.8%	29.2%

Source : Table 3.4 in Reference 1

2.3 Implementation within context of LTS Model

The basic procedure adopted by Jacobs in the LTS context was to take the car driver trips by purpose and time period created for use at the highway assignment stage, and in the case of cars out of work time, separate into the three income bands using the proportions set out in Table 2.1 above. Cars travelling in work time were retained as a single category, as were taxis and cars not sensitive to the Central London congestion charge. However, there are issues complicating this process.

The underlying issue is that the car driver matrices created for use in the highway assignments are obtained from two sources. The first, the cost dependent or Part A matrices, are fed through by purpose from the distribution and modal split (DMS) models. These are the matrices to which the above procedure can be applied directly. However, there is a second category, the non cost dependent or Part B matrices, which are not available by purpose. These comprise the matrices of park-and-ride trips (from the modal split model), plus external trips. The external area in LTS is split into two categories: the Rest of the South East (ROSE) and external. The external trips for which no purpose information is available comprise trips with one or both ends in the external area; and trips with both ends in ROSE (also NHB trips with one or other end in ROSE).

The methodology adopted in these cases was as follows. Internal trips with no purpose information available are split by income group using the final proportions derived for the O/D pair in question for trips for which purpose information is available. In the case of external trips, global factors (i.e. the average over the whole matrix) are applied. In the case of the NHB trips, the standard methodology is applied for ROSE-Internal trips; i.e. any NHB trips in this category are proportioned between the income groups using the overall proportions derived over any (HB) trips for which purpose information is available.

This methodology is set out in much greater detail in Figure 5-C of Reference 1.

2.4 Calculation of Value of Time by Income Segment

When adopting income segmentation in an assignment model, it is necessary to define a value of time associated with each income band.

Jacobs sought to derive separate values of time by purpose (limited to commuting and other), and for the three income bands. Details are given in section 4.2 of Reference 1; the methodology and results are summarised here.

The average household income in each category was initially derived from the LATS household interview data. In order to convert this to values of time, use was made of a formula set out in WebTAG (Section 11 of Unit 3.12.2). Apart from the household income, the main explanatory variables comprise : average trip length, and income and cost/distance elasticities.

Using this formula, the values derived relate to the year 1994; they are 1994 values of time in 2001 prices. The 1994 values were subsequently adjusted to 2001 values, by factoring up by the GDP growth over the two years, dampened down by application of the VoT/GDP elasticity (0.8). However, the resulting overall value of time appeared too low compared with the value given for that year in WebTAG. In addition, in LTS, it was considered appropriate to control to a London value, given that London earnings are 33% greater than Great Britain as a whole. A new control value was derived comprising these two elements, and the values of time were factored up to be consistent with this. Throughout this process, the same adjustment factors were applied to all the cells; the original relativity between the elements was retained.

The final values obtained are set out in Table 4.3 of section 4.3 of Reference 1, and for convenience are repeated here in Table 2.2. These are values per person, not per vehicle.

Table 2.2 : Recommended 2001 Values of Time in 2001 prices for London (p/min)

Income	*Commute*	*Other*	*Commute/Other combined*
< 20k	7.04	7.22	7.18
20k – 50k	10.54	8.63	9.42
> 50k	14.86	10.08	12.04
Overall VoT	11.20	8.56	9.54

Source : Table 4.3 in Reference 1

3. Implementation of the process in the current context

3.1 Selection of Methodology

For implementation of this process in the context of ELHAM, given that the work outlined above is now somewhat dated, the option was initially considered of re-calculating the income segmentation parameters using the more recent LTDS data. However, given time and budget constraints on the project, this was not considered a realistic way forward, and it was agreed that we should proceed using the disaggregation factors as set out in Table 2.1 above.

The methodology initially intended was very similar to that implemented in the TGB model, as set out in Reference 2. It comprised the following steps: take the current LTS 6.2 income segmented OWT matrices (which had been developed by TfL using the parameters set out in Table 2.1), convert these to the ELHAM zone system, and derive the proportional splits between the three income groups at the individual zone level. However, when setting this process in motion, it was found that the income segmented matrices contained no trips into or out of Central London (the congestion charge area). It was clear that (although not the original intention) the income segmentation had been incorporated in the LTS model solely for the purpose of modelling the response to the congestion charge at the assignment stage. Although many car trips into and out of Central London would be sensitive to the congestion charge, only those who have taken the decision to pay will be included in the assignment matrices. These do not require income segmentation as they would have no choice other than to enter or leave the area.

However, for the present application (assessment of demand on a new tolled river crossing), this element is very important; select link assignments show that around 9% of the trips in the Blackwall Tunnel during the AM peak period in 2007 northbound have a destination within Central London. Consequently, this methodology as outlined could not be applied; we could not use the existing income segmented LTS matrices. To replace this, there were considered to be two main alternatives:

1) Take the LTS 6.2 OWT matrices by purpose, and apply the income segmentation to these, individually. Then aggregate over the purposes to create a total matrix by each income segment. Convert these all purpose matrices to the ELHAM zone system, and use these to disaggregate the ELHAM matrices by income segment at individual zone level.

2) Split the ELHAM OWT matrices by purpose, for each of the three time periods, using the equivalent LTS matrices converted to the ELHAM zone system. This could be done either at individual zone level, or at a more aggregate level if considered preferable. Apply the income segmentation factors to the individual purpose matrices at the individual zone level. Aggregate over the purposes to create the set of three matrices by income band as required, in each time period.

It is likely that the two methodologies would produce very similar results, certainly at an aggregate level. However, on balance, the first approach was considered preferable. The primary reason for this is that the purpose split in the individual period LTS matrices has been shown in previous work carried out on the HAMs development project to be somewhat unreliable, with significant variations from the purpose splits obtained from the CRISP RSI data collected for this project. If implementing option (1), the LTS purpose splits would remain a fundamental element in the process; this is unavoidable given that the income segmentation parameters were calculated by purpose. However, we would retain consistency with the LTS model in terms of the overall income group proportions, and we would not be incorporating these somewhat spurious purpose splits into ELHAM.

3.2 Implementation of Methodology and Results Obtained

The main inputs to the selected process (methodology (1) above) comprise:

- the income segmentation proportions by purpose and trip length category, as set out in Table 2.1;
- a matrix of crow-fly zone-to-zone trip lengths, calculated using the grid reference of each zone centroid;
- the base year LTS 6.2 car driver matrices by trip purpose; and
- the matrix of ELHAM base year car driver OWT trips, requiring disaggregation.

As before, the income segmentation was carried out at the level of individual zone-zone movement, with the proportions applied depending upon the purpose and length of the trip. The output matrices consist of the input purpose matrix split into the three income bands. These were then combined over the purposes, to create a total matrix in each income band. From these, matrices of proportions of trips in each income band, for each individual zone-zone movement, were created.

In the case of external movements (both ends external, or one end internal and the other outside the South East, as noted above), overall global proportions were applied. It was found from the original work using the income segmented LTS matrices that these were not the matrix-wide averages (as originally intended) but revised values as follows in all three time periods : Band 1 : 19%, Band 2 : 49% and Band 3 : 32%. Clearly a smaller proportion in the lowest income band for these external movements is now assumed in the LTS model; this seems a sensible revision, and these revised proportions have been applied in the current work.

At this point, comparisons could be made between the income group proportions in the original segmented LTS matrices, and in the work undertaken in the present exercise, as set out above. The overall proportions were extracted over the whole matrix, excluding trips to and from Central London (not included in the original segmented LTS matrices, as noted above), and also excluding external trips (proportions set the same in both sets). The results are as follows:

Table 3.1: Income Group Proportions in LTS Matrices – Initial segmented matrices vs. current set

Income	*LTS segmented matrices*			**Current application**		
	AM	IP	PM	AM	IP	PM
Group 1	25.9%	30.9%	28.2%	25.9%	31.7%	28.7%
Group 2	48.2%	45.0%	47.0%	48.4%	44.8%	46.9%
Group 3	26.0%	24.1%	24.8%	25.7%	23.5%	24.4%

Note : internal trips only excluding Central London

Minor differences are apparent between the second set and the first. This reflects the fact that the components of the two matrices are not identical even though trips into and out of Central London have been excluded. The first set comprises all trips (from the Part A and Part B matrices as set out in section 2.4) excluding the non cost dependent which are assigned separately (typically about 15% in most cells outside Central London). The second set comprises only the Part A matrices output from the DMS model, excluding park-and-ride trips. Another major difference is that the first set would be post matrix estimation in LTS, and the second set pre matrix estimation.

The next stage in the process, as set out in the previous sub-section, was to take the matrices of income group proportions, convert to the ELHAM zone system, and apply them to the ELHAM OWT matrices at the individual zone level. As noted above, global proportions with a relatively low proportion in income group 1 are applied in the case of external movements. Some instances were found of cells (zone-zone movements) with non-zero values in the ELHAM matrix but with no trips in the LTS matrix (and hence zero proportions). However, the numbers of these were so small (a fraction of 1% in each time period, including just 35 trips crossing the river on the east side of London in the AM peak), it was considered adequate to use the global proportions as applied to external movements. The resulting overall proportions obtained were as follows – first excluding Central London and external for consistency with the previous comparison, and secondly the total matrices:

Table 3.2 : Income Group Proportions in ELHAM base year matrices

Income	*Excluding Central London and external*			**Total matrices**		
	AM	IP	PM	AM	IP	PM
Group 1	24.8%	29.9%	26.8%	23.7%	28.2%	25.2%
Group 2	48.8%	45.5%	47.8%	48.8%	46.1%	48.0%
Group 3	26.4%	24.5%	25.4%	27.4%	25.7%	26.8%

It can be seen that the first set of results show a slightly greater emphasis towards the high income end, suggesting that the average trip length in the ELHAM matrices (in the case of internal movements excluding Central London) is a little greater than the LTS matrices. The second set show a greater emphasis towards the high income end again, due to the fact that the proportions applied in the external area are oriented in this direction, as indicated earlier.

4. Derivation of Average values of time

The calculation of average values of time in each income segment, in the original application of this methodology in the LTS model, is set out in section 2.4. Those values formed the basis for the calculation of values of time by income segment for the Car OWT trips as part of this study.

The key difference in the updated calculation is that the Jacobs weighting to take account of higher earnings in London (33%) as described in Section 2.4 has been taken out. Instead, the Jacobs VoT without London earnings adjustment has been factored to match a national non-work VoT of 7.59 p/minute (2001 prices and values) based on WebTAG information.

Furthermore, the Jacobs VoT were split into “commute” and “other” car OWT trips. To take account of the different purposes WebTAG VoT per vehicle (WebTAG 3.5.6, Table 9) have been used as a starting point but replacing the national vehicle occupancy by the HAMs occupancies for commute and others for each time period. The resulting VoT are shown in **Table 4.1**.

Table 4.1 : Car out-of work VoT (p/min, 2009 prices and values)

	AM	IP	PM
Commute	12.18	12.39	12.39
Other	15.20	14.73	16.06

Using the relationship of the Jacobs income segmented VoT and the proportion of commute and other trips from the HAMs model as shown in **Table 4.2** and controlling the resulting income segmented values to the original HAMs OWT VoT the final income segmented VoT for this study have been calculated as shown in **Table 4.3**.

Table 4.2 : Proportion of out-of work trips

	AM	IP	PM
Commute	61%	20%	43%
Other	39%	80%	57%

Table 4.3 : Car out-of-work VoT by income (p/min, 2009 prices and values)

	AM	IP	PM
Under 20K	9.74	11.54	11.13
20-50K	13.08	14.28	14.33
over 50K	16.97	17.22	17.94

References

1 London Transportation Studies (LTS). LTS Development – MTE Income Segmentation. Jacobs Consultancy. October 2007.

2 Transport for London. Thames Gateway Bridge V2007 Model Validation Report. Halcrow Group Limited. December 2008.