Transport Model for Scotland

Highways Assignment Model – 2005 rebase - Calibration and Validation - Final Report

Prepared for
Transport Scotland

May 2007

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Document Control

Project Title:	**TMfS**
MVA Project Number:	C32142
Document Type:	Report
WP Reference:	GSP
Directory & File Name:	h:\contracts\live\c3214200_transport model for scotland\reports\tmfs05 cal val\hway\tmfs05 ham cal_val_v5 final draft.doc

Document Approval

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Issue	Date	Distribution	Comments
1	19/07/06	Chris Robinson	Chapters 1-4 first draft
2	5/9/06	Chris Robinson Grant Paterson	Chapters 1-7 first draft
3	21/8/06	Stephen Canning	Draft
4	21/9/06	Kevin Lumsden	For Review
5	28/11/06	Transport Scotland STPR Team TTAA	Draft
6	15/05/07	Transport Scotland STPR Team TTAA TMfS User Group	Final Report

Summary

In August 2001, the Scottish Executive appointed MVA to a term commission to maintain and further enhance CSTM3. This commission was named Transport Model for Scotland (TMfS). During this commission, TMfS was developed with a Base Year representative of 2002. During 2005 and 2006, TMfS was further enhanced, and as part of these enhancements, the model was calibrated and validated to a 2005 base year.

This report details the development, calibration and validation of the updated TMfS Highway Assignment Model (HAM) and the context within which it has been developed.

This report covers:

- the sources and processes used for updating the highway network, including link type changes, capacity and capacity index changes, modelled junction updates and the reporting of checking processes conducted;

- the sources and processes used for updating the assignment matrices, including zone boundary changes (for example, to allow for better representation of airport demand), creation of new prior matrices and new data used, discussion of the matrix estimation process and comparisons of matrices at stages in development;

- model calibration results, including strategic flow analysis, key link analysis and additional screenline analysis; and

- model validation results, including journey time analysis of 59 routes throughout the modelled area, screenline analysis of validation sites, freight flows and specific journey purpose flows as well as trip length distribution analysis.

The conclusions arising from this work are that the model is generally fit for purpose as a strategic highway model that can be used to assess major schemes and policy decisions as part of the TMfS modelling system. In addition, it is also fit for use as a source of travel demand and network structure for more localised models.

Each potential application of the model should be assessed in detail prior to ensure that the quality of the model is appropriate for the desired output as the quality of data input and consequently output differs across the entire modelled area.

Abbreviations

Unless otherwise stated in the text, the abbreviations that may be used within this report are listed in the table below:

CI	Capacity Index
CSTM3	Central Scotland Transport Model 3
CSTM3A	Central Scotland Transport Model 3A
CSTCS	Central Scotland Transport Corridor Studies
CvT	Cost versus Time
DALSAM	Dalkeith Sub Area Model
EATM	Edinburgh Area Transport Modal
GEH	Statistic for comparing modelled flows against observations
GIS	Graphical Information Services
HAM	Highway Assignment Model
KWAM	Kincardine Wide Area Model
LUTI	Land Use and Transport Interaction
OS	Ordinance Survey
PCUs	Passenger Car Units
RSI	Road Side Interview
SITM	Strathclyde Integrated Transport Model
STS	Scottish Transport Statistics
TMfS	Transport Model for Scotland

1 Introduction

1.1 Background

1.1.1 In 2001, MVA was commissioned by the Scottish Executive (now Transport Scotland) to undertake the Transport Model for Scotland (TMfS) project. The purpose was to build on existing transport models (eg CSTM3 and CSTM3A) and develop, support and maintain a methodologically enhanced and geographically expanded multi-modal forecasting tool.

1.1.2 The development of TMfS was completed in August 2004. The model has a Base Year of 2002. Since completion, the model has since been used for a range of infrastructure and policy assessments by MVA, other consultants, Local Authorities, the Scottish Executive and Transport Scotland.

1.2 2005 rebase

1.2.1 In December 2005, MVA was instructed by Transport Scotland to undertake a rebase of TMfS to a 2005 Base Year. This work involved the update and enhancement of the model to incorporate newly available data and other procedural enhancements.

1.2.2 This report describes the rebase of the TMfS Highway Assignment Model to a 2005 Base Year. Separate reports detail the other aspects of the TMfS 2005 rebase such as the Public Transport Model and Demand Model:

- TMfS05 PTAM Cal Val Final Report, MVA May 2007; and
- TMfS05 Demand Model Development Report, MVA May 2007.

1.2.3 The rebased TMfS:05 HAM was developed by drawing upon a variety of sources for network and junction information and by incorporating new traffic count data.

1.2.4 This report describes the development, calibration and validation of the 2005 TMfS Highway Assignment Model and the context within which it has been developed.

1.2.5 Figure 1.1 illustrates the geographical coverage of the TMfS modelled area.

1.2.6 Throughout this report, the original 2002 Base Year TMfS network will be referred to TMfS:02 and the new TMfS 2005 Rebase Model as TMfS:05.

1.2.7 This report assumes that the reader is familiar with the terminology and processes involved in transport model procedures of this nature. For further information, please refer to the TMfS Website, www.tmfs.org.uk.

1.3 Model Objectives

1.3.1 The key objectives of TMfS are to:

- provide robust traffic forecasts on all Trunk Roads within the model area over a twenty year horizon;
- enable traffic, economic and land-use assessments of proposed major inter-urban road schemes for corridor assessment and route option assessment;
- test the effects of the interaction between major inter-urban road and public transport schemes and major transport policy options such as;
  - schemes to improve inter-urban public transport;
  - schemes or policies aimed at reducing congestion in accordance with the Road Traffic Reduction Act, National Targets Act and Transport White Papers; and
  - schemes which introduce road user charging (road tolls or congestion charging);
- provide consistent information and a framework for local scheme models as a basis for the development of Local Transport Strategies or with a view to testing potential strategies.

1.4 Structure of this report

1.4.1 Following this introductory Chapter, this Report includes the following Chapters:

- Chapter 2 describes the work undertaken on the network development. This covers the updating of all network and junction information and provides a description of the sources used;
- Chapter 3 describes the development of the base year assignment matrices and matrix estimation process used to create the TMfS:05 highway assignment matrices;
- Chapter 4 describes the development of the TMfS Final Highway Assignment Model and the incorporation of the ‘Cost versus Time’ Assignment method;
- Chapter 5 discusses the model calibration data through the presentation of screenline analysis on key strategic routes within the network;
- Chapter 6 discusses the model validation through the presentation of screenline and journey time analysis throughout the modelled network; and
- Chapter 7 provides conclusions and recommendations.

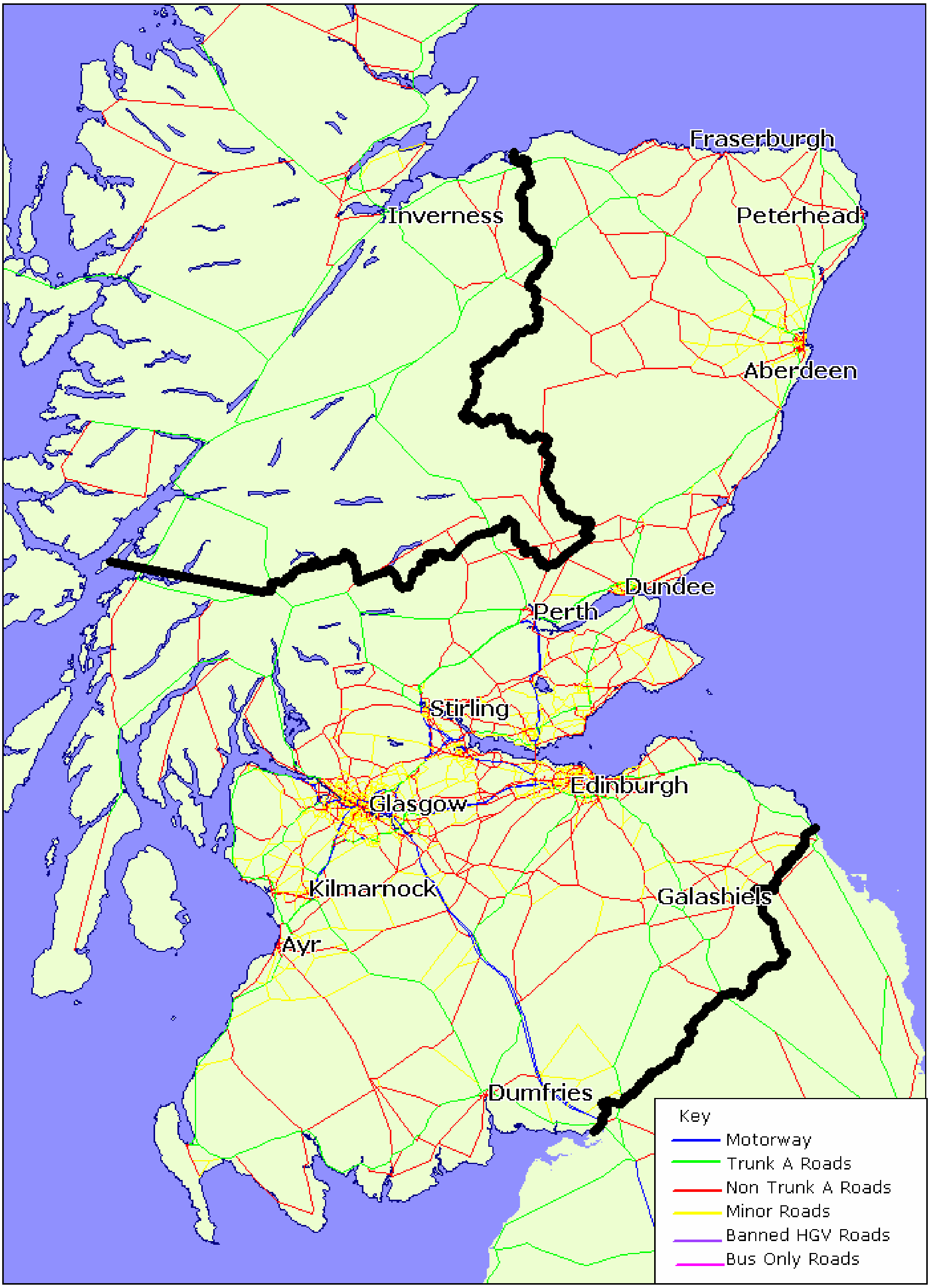

Figure 1.1 TMfS:05 Modelled Area

1 Introduction

2 Network Development

2.1 Introduction

2.1.1 This chapter considers the network developments that have been incorporated into the new 2005 rebased model.

2.1.2 Schemes incorporated in the 2005 Highway network are detailed below:

- A876 Kincardine Bridge Eastern Link;
- Glasgow Southern Orbital;
- M77 Extension (Fenwick to Malletsheugh);
- M876 Junction 2 Slip Road;
- A8011 Central Way, Cumbernauld;
- M8 Kingston Bridge;
- Network amendments near Gartcosh Park and Ride;
- Bargeddie Junction amendments;
- Ravenscraig Link Roads;
- M8 Junction 21 improvements;
- Cambuslang and Rutherglen Town Centre improvements;
- A71/A72 Garrion Bridge improvements;
- Central Edinburgh Traffic Management (CETM);
- Holyrood area network amendments;
- A1 Haddington to Dunbar dualling;
- Forth Road Bridge toll increases;
- Thornybank Road closure in Dalkeith; and
- A92 Dundee to Arbroath.

2.1.3 It should be noted that Finnieston Bridge, although due for completion in 2005, is not included in this rebase model as it was not completed at the time of the Highway network construction.

2.1.4 In addition to the network amendments mentioned above, 2005 Scottish Road Traffic Database (SRTDb) data have been used in model development. Some of these counts have been used in the calibration process where they have been utilised within the matrix estimation process 'MVESTM' while others have been used in the validation process. These processes are explained later within this report.

2.1.5 The remainder of this chapter is split into the following sections:

- link types;
- link capacities;
- speed/flow curve definition;
- link distance checks;
- link connectivity checks; and
- modelled junction data.

2.2 Link types

2.2.1 The link types used in the TMfS:05 are in line with those used in the Scottish Transport Statistics Note 24 (see Table 2.1), these remain consistent with TMfS:02. This Link Type numbering system has allowed analysis of model output to be easily compared with published statistics.

Table 2.1 Scottish Transport Statistics Link Type Definitions

STS Link Type Number	Description
1	Trunk – Motorway
2	Trunk – Motorway slips
3	Trunk – A Roads Non-Built up
4	Trunk – A Roads Built up
5	Non Trunk – A Roads Non-Built up
6	Non Trunk – A Roads Built up
7	Minor Roads Non Built up
8	Minor Roads Built up

2.2.2 In addition to those link types detailed in Table 2.1, two additional link types have been used in the network:

- 9 – Banned HGV; and
- 10 – Bus Only.

2.3 Link capacities

2.3.1 The link capacities in TMfS:05 remain consistent with those used in TMfS:02.

2.3.2 Table 2.2 highlights the capacities (measured as PCUs per lane and not per carriageway) applied throughout the network. As part of the calibration process, these have also been manually amended in many areas. This process was undertaken to supplement the automated procedure and ensure that capacities provided a more appropriate reflection of conditions.

Table 2.2 Uniform Capacities by Link Type

	Link Type 1	Link Type 2	Link Type 3	Link Type 4	Link Type 5	Link Type 6	Link Type 7	Link Type 8
Capacity per lane	2400	1800	1800	1800	1600	1600	1000	800

2.4 Speed/flow curve definition

2.4.1 Table 2.3 presents a descriptive list of TMfS speed/flow curves. These descriptions should not be taken literally but as an indication of the particular speed/flow curve specification. No changes have been made to the speed flow definitions for the updated TMfS:05 from those used in TMfS:02.

Table 2.3 Speed/Flow Curve and Capacity Index Equivalence List

TMfS CI	Description
	City/ Urban Capacity Indices
1	40mph urban road (Tail)
2	40mph urban road (No Tail)
3	30mph urban road (Tail)
4	30mph urban road (No Tail)
5	30mph city centre road (Tail)
6	70mph urban motorway
7	<70mph urban motorway
8	30mph urban road junction approach
9	30mph city centre road junction approach
10	Urban expressway
	Suburban Capacity Indices
11	30mph suburban road (Tail)
12	30mph suburban road (No Tail)
13	Major suburban road
14	30mph suburban road junction approach
15	>30mph junction approach
	Motorway, Dual, Rural Capacity Indices
16	Rural routes
17	Wide single (10m) designed to TD9
18	Ramp at grade separated junction
19	Rural motorway two lanes
20	Ramp junction approach
21	Rural motorway three or more lanes
22	Rural all purpose three or more lanes
23	Rural all purpose two lanes
	Other Capacity Indices
24	Traffic calming
25	50mph expressway

2.4.2 There are three types of curves used in the model (see Figure 2.1):

1. conventional – representing link and junction capacity constraints;

2. approach to a node that is not a junction or is not modelled as a junction; and

3. approach to a modelled junction.

2.4.3 Curve One (conventional) has an initial speed up to volume/capacity (V/C) limit and then drops linearly to the speed at capacity. Beyond capacity, it uses the so-called 'DOT 1A Tail' curve. Curve Two uses the same formula to capacity. Beyond capacity, speed is fixed at the capacity speed since on such links, only the link capacity/speed relationship operates, ie the downstream junction capacity is governed by a link with a Type One curve. Curve Three (modelled junction approach) is a fixed speed equal to the free-flow speed. On links approaching modelled junctions, all delay is calculated by the junction modelling delay procedures. The exceptions are that the major arms at a priority junction or the circulating carriageway on large roundabouts are modelled as a series of priority junctions, which are based on time dependent queuing theory as used in ARCADY/PICADY/OSCADY.

2.4.4 This procedure ensures that intervening 'dummy nodes' (eg for presentation only) do not affect the overall link journey times.

2.4.5 The speed/flow curves used in the TMfS are shown in Table 2.4.

Table 2.4 TMfS speed/flow curves

Speed/flow Curve	Capacity Index
Type1	1, 3, 5-7, 10-11, 13, 16-19, 21-25
Type2	2, 4, 12
Type3	8-9, 14-15, 20

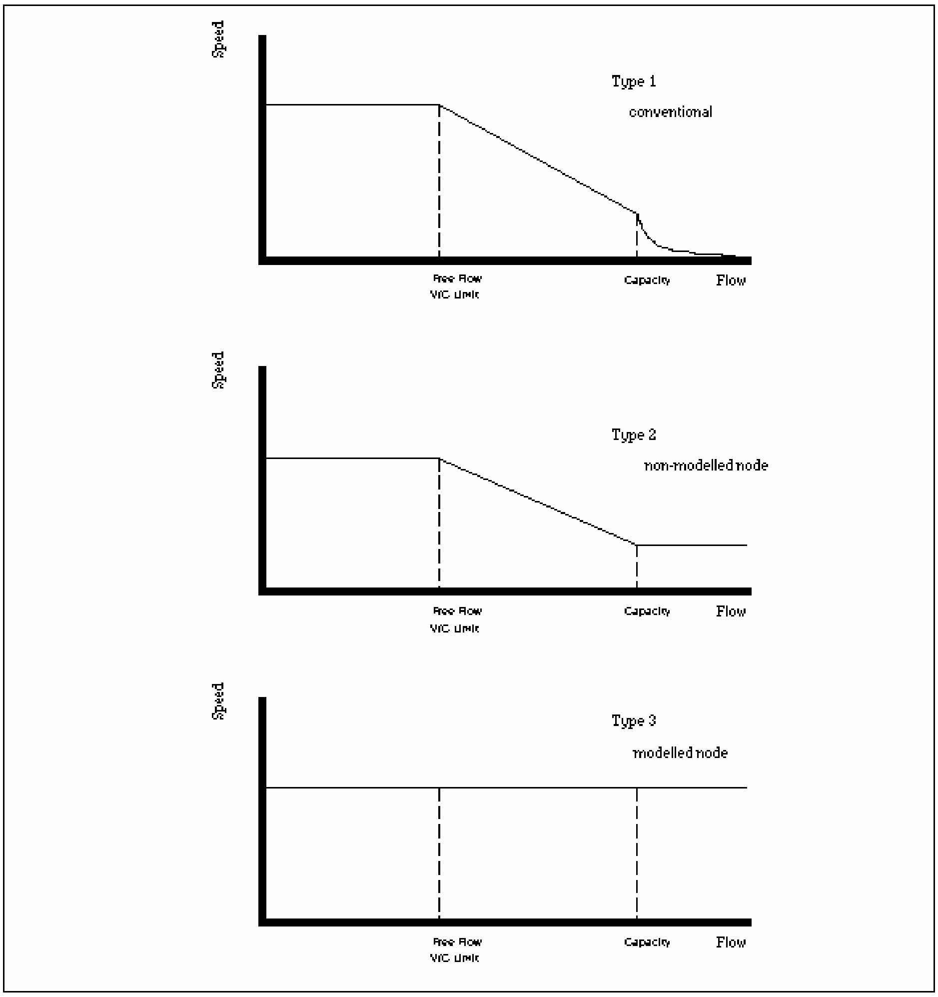

Figure 2.1 Speed Flow Curve Types

2.5 Link distance checks

2.5.1 The link distances for TMfS:05 are analysed in this section. Table 2.5 provides the results of the comparison between the Scottish Transport Statistics Note 24 (STS) and the TMfS:05 base network for Motorway and Trunk A Roads only. The analysis shows there to be a comparable representation of the modelled distance for these strategic link types. The differences noted for Trunk A Roads are related to areas not covered by the model (eg the 'external north' area).

Table 2.5 TMfS:05 Motorway and Trunk A link distance analysis (kms)

Road Type	STS (S)	TMfS (T)
Motorway	383	390
Trunk A	2893	2797
Grand Total	3276	3187

2.6 Link connectivity checks

2.6.1 The network connectivity was checked and updated by:

- incorporating relevant details from sub-area models and their respective audits, such as DALSAM; and
- map based checks using 1:50,000 OS tiles, road maps and web resources.

2.6.2 Figures 2.2 and 2.3 show the detail of the TMfS:05 highway network.

2.7 Modelled junction data

2.7.1 As stated in Section 2.1, the TMfS:05 Base Highway model was developed from TMfS:02 and, prior to that, the CSTM3A base network. Although extensive checks were made for the 2002 network, it was deemed necessary to re-check the approaches to modelled junctions.

2.7.2 This process was undertaken to avoid lengthy approaches to roundabouts, priority and signalised junctions. Any links with a distance in excess of 500 metres were manually checked and if necessary recoded to have a distance of 500 metres. This allowed vehicles approaching modelled junctions to maintain a greater speed for a longer distance than previously coded.

2.7.3 To complement the amendments made to the modelled junction approaches, the capacity indices, which designate the speed approaching the junction, were checked and where necessary amended.

2.7.4 Appendix A contains the extent of the areas within which modelled junctions are included in the model.

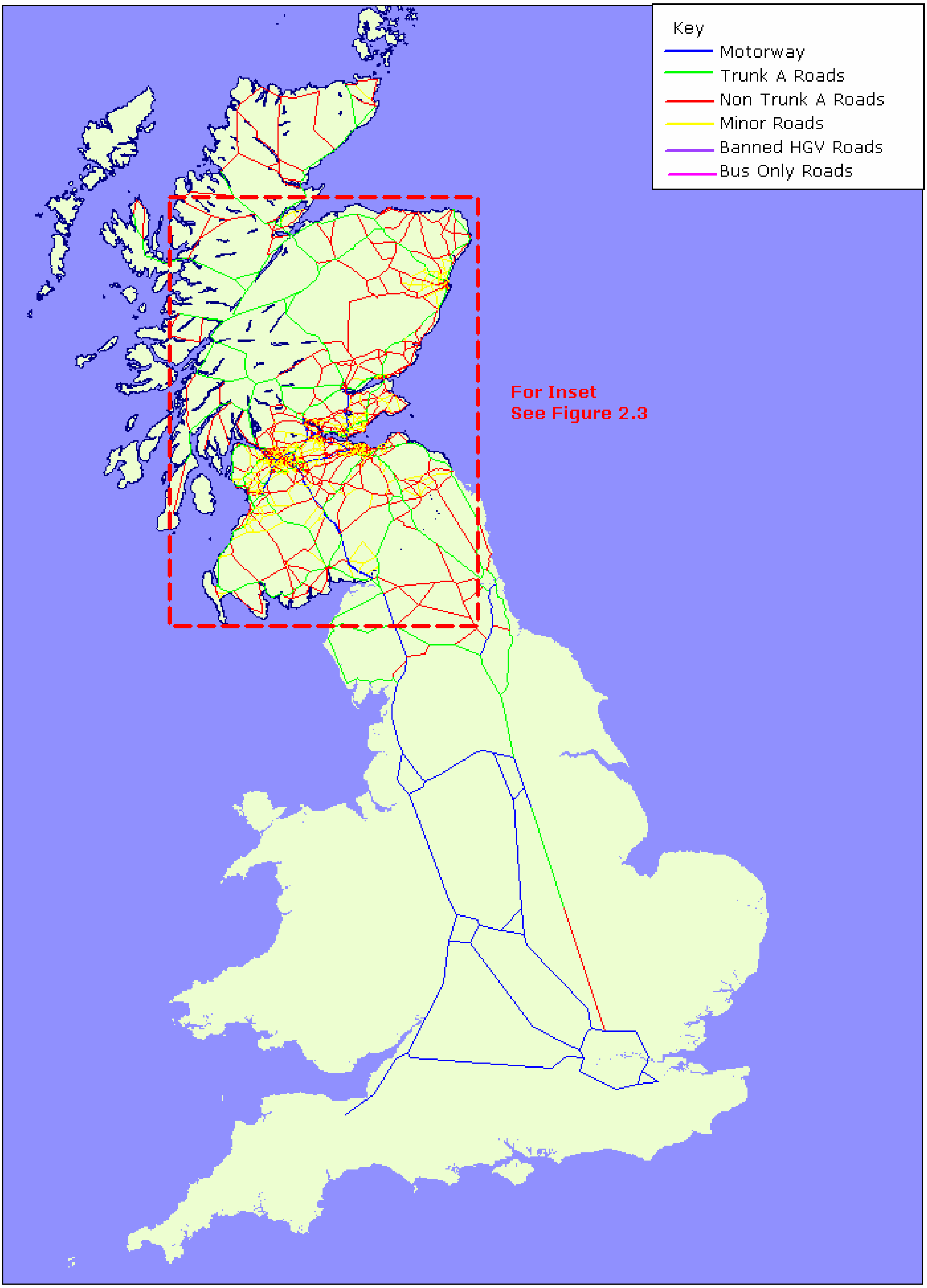

Figure 2.2 HAM Network Coverage

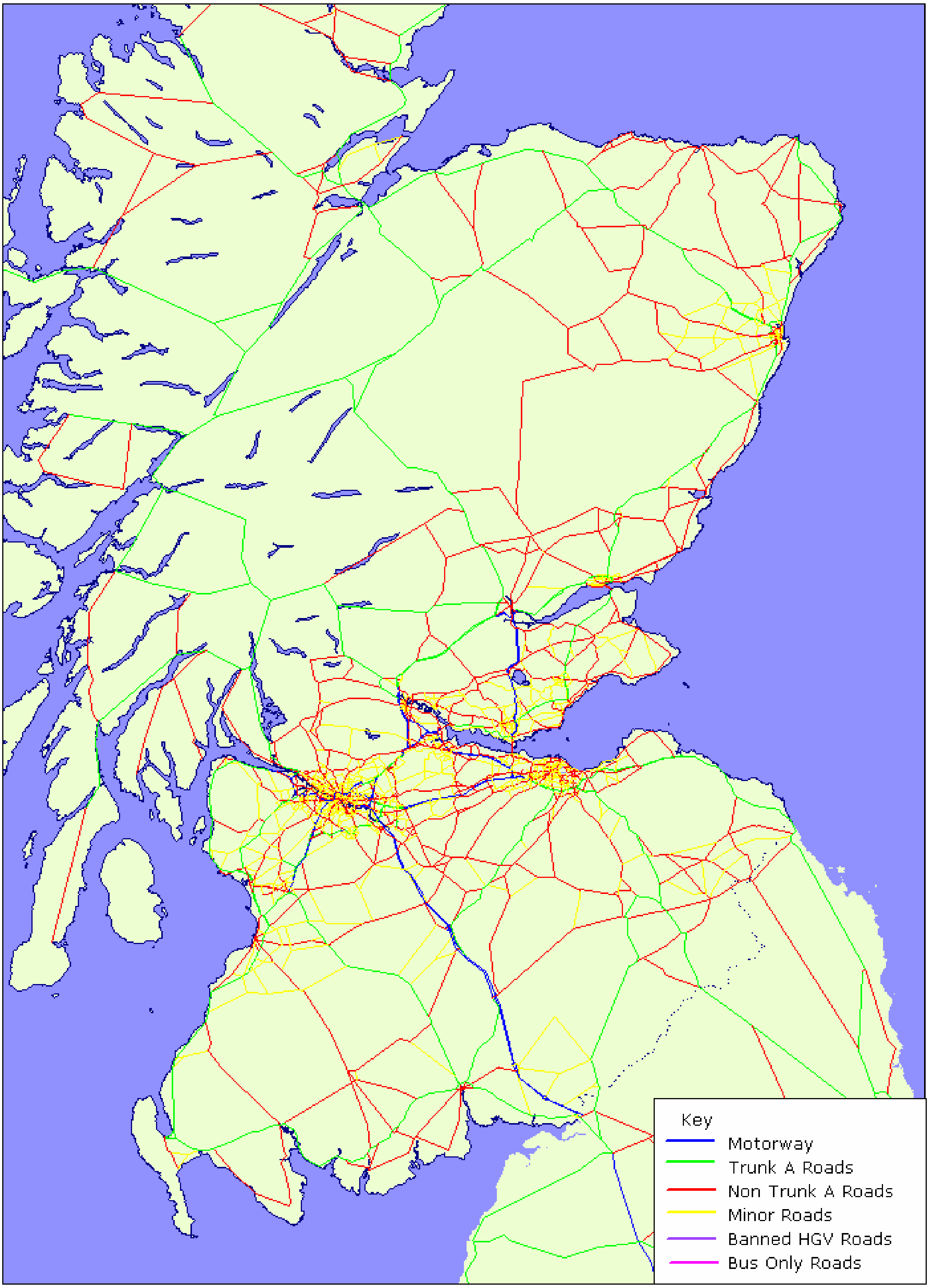

Figure 2.3 HAM Network (Insert from Figure 2.2)

3 Matrix Development

3.1 Introduction

3.1.1 Matrix development for TMfS:05 involved enhancing the original TMfS:02 matrices through the following processes:

- conversion to the new TMfS:05 zone structure;
- zonal trip rate amendments;
- park and ride amendments; and
- matrix estimation.

3.1.2 The remainder of this chapter details the matrix development procedure introduced above: Section 3.2 describes the change in the zone system; Section 3.3 describes the matrix data used and Section 3.4 describes the development of the final matrices prior to matrix estimation while Section 3.5 describes the matrix estimation process used. All figures referred to are presented at the end of the chapter.

3.1.3 To present a comparison of the matrix totals during the stages of development a 14 sector system was developed (see Figure 3.1). This disaggregation of the modelled area facilitates the assessment of changes to the matrix in terms of travel patterns across the TMfS area.

3.2 Change in zone system

3.2.1 The TMfS:02 zoning system was developed based on amalgamations of 2001 Census Output Area Boundaries. The updated version of the model retained this zone structure, although those zones, which contained airports, were split. The purpose of this amendment was to allow for the separate modelling of airports.

3.2.2 The adoption of this new system means that, in forecast years, those zones, which represent airports, have their growth calculated directly from airport growth predictions and are excluded from the trip end and demand models.

3.2.3 Figures 3.2, 3.3 and 3.4 illustrate the new zones created in the areas around Edinburgh, Prestwick and Aberdeen airports respectively. No new zones were required for Glasgow airport as it already had its own zone. Figure 3.5 shows the final network wide zoning system. To see the model zoning system in more detail, see www.tmfs.org.uk

3.3 Matrix Data

3.3.1 The matrices for TMfS:05 were built using forecast matrices from TMfS:02. 2005 output planning data from the TELMoS model was also used to adjust trip rates in those parts of the matrix, which were deemed to have an unusually high or low level of trip making.

3.3.2 No new RSI data was collected or used within the TMfS:05. The RSI sites used in the original TMfS are described in detail in the TMfS:02 Calibration and Validation Report.

3.4 Prior development

3.4.1 The prior matrix for TMfS was developed in three principal stages, as illustrated in Figure 3.6.

3.4.2 TMfS:02 forecast matrices were used as the starting point for the creation of the new TMfS:05 matrices. The TMfS:02 prior matrices, which underlie these matrices, were built from CSTM3 matrices, CSTCS RSI matrices, Glasgow SATURN matrices, ASAM matrices and A80 Traffic Model Highway Matrices.

3.4.3 These TMfS:02 forecast matrices were then converted into the new TMfS:05 zoning system as described in section 3.2. This was, achieved by splitting the airport zones. The part containing the airport retained the same pattern as the old zone as it was the dominant trip generator of the zone. The remainder of the zone was, given a similar travel pattern to that of a nearby zone with comparable trip generating attributes.

3.4.4 Having done this, amendments were, made to the assignment matrices based on the most up to date 2005 planning data available at the time of calibration. This data was, used to amend those zonal trip rates, which were deemed abnormally low or high. The process used to do this was as follows:

• using planning data and trip matrix productions and attractions, production and attraction rates for each zone were, calculated along with model wide rates;

• 95% confidence intervals were then calculated for both production and attraction rates. Zones whose rates fell outside these values were, amended by applying the upper or lower 95th percentile rate to these zones; and

• finally, the revised productions and attractions were, factored to ensure a match with the original productions and attractions. These revised production/attraction trip ends were then ‘furnessed’, using the original matrix to obtain the pattern.

3.4.5 The base network was then assigned with these matrices in order to attain network costs. These matrices and costs were, then run through the Park and Ride process to produce post Park and Ride Prior demand matrices. This was, undertaken to achieve a better trip pattern, than the absolute origin and destination used before. These matrices were, then used in the matrix estimation process. The reader should note that the Park and Ride procedure is linked between time periods, and that all trips will have a corresponding reverse trip.

3.4.6 Those Park and Ride sites included are shown in Table 3.1 below.

P&R Site	Type	P&R Site	Type	P&R Site	Type
Existing Sites in original TMfS P&R Model		**Rail Station Sites to be added to P&R Model**		**Rail Station Sites to be added to P&R Model**	
Bridge of Don	Bus	Stirling	Rail	Uphall	Rail
Kingswells	Bus	Perth	Rail	Aberdour	Rail
Perth P&R	Bus	Johnstone	Rail	Dunfermline Queen Margaret	Rail
Croy	Rail	Newton	Rail	Bearsden	Rail
Cumbernauld	Rail	Ayr	Rail	Hairmyres	Rail
Falkirk Grahamston	Rail	Hamilton Central	Rail	Glengarnock	Rail
Falkirk High	Rail	Dunfermline Town	Rail	Drem	Rail
Greenfaulds	Rail	Whitecraigs	Rail	Livingston North	Rail
Larbert	Rail	East Kilbride	Rail	Shettleston	Rail
Lenzie	Rail	Kilwinning	Rail	Longniddry	Rail
Linlithgow	Rail	Dalmeny	Rail	Helensburgh Central	Rail
Polmont	Rail	Troon	Rail	Blantyre	Rail
Newcraighall	Rail	Airdrie	Rail	Williamwood	Rail
North Berwick	Rail	Leuchars	Rail	Bargeddie	Rail
Dunbar	Rail	Milngavie	Rail	Glenrothes with Thornton	Rail
Musselburgh	Rail	Bathgate	Rail	Inverurie	Rail
Prestonpans	Rail	Bishopton	Rail	Montrose	Rail
Wallyford	Rail	Westerton	Rail	Paisley Gilmour St	Rail
Ferrytoll	Bus	Giffnock	Rail	South Gyle	Rail
Inverkeithing	Rail	Prestwick Town	Rail		
Kirkcaldy	Rail	Kilmarnock	Rail		
Bus Sites to be added to P&R Model		Saltcoats	Rail		
Ellon	Bus	Dyce	Rail		
Hermiston	Bus	Wemyss Bay	Rail		
Ingilston	Bus	Uddingston	Rail		

Figure 3.1 Park and Ride sites included in the Base Model

3.5 Matrix Estimation

3.5.1 The calibration of the assignment process was undertaken using the CUBE based Matrix Estimation program MVESTM.

3.5.2 MVESTM uses a wide variety of data sources, each of which has a confidence level assigned to it. Through this approach, it is possible to manipulate MVESTM to make changes in the areas where the expressed level of confidence is lower. This feature was used to estimate the 2005 HAM matrices and used the following data:

- prior matrix (with a confidence of 60);
- trip end data (with a confidence of 80);
- paths; and
- traffic counts (with a confidence of 100 for those updated with 2005 SRTDb data, old counts from 2002 were given a confidence of 55).

Prior Matrix

3.5.3 All OD pairs were given the same confidence. The pattern from the RSI sites is contained within the forecast matrix from TMfS:02, which was used as the starting point for the prior matrices. As there was already a high level of confidence in this pattern, it was decided that all movements should be given the same level of confidence.

Trip Ends

3.5.4 The trip ends were given a higher confidence level than that of the matrix. The confidence level expressed in the trip ends was higher as these had been amended by the planning data adjustments.

Paths

3.5.5 MVESTM also requires a set traveller paths from the model. The trip points used in the estimation process were representative of the best paths available after a run of the model with a new matrix. MVESTM and the traffic model were run iteratively with successively improving paths and costs being fed into the MVESTM program. ‘Burrell paths’ were built after each modelled time period achieved convergence following capacity restraint assignment. MVESTM was provided with three sets of paths built separately for each time period after the last iteration of assignment. It was considered that these were most appropriate as they were shown to represent stable network conditions.

Traffic Counts

3.5.6 The count data used for the estimation process was that collected for the RSIs used in matrix development. In addition, a selection of 2005 SRTDb count sites were also included. From these count locations, count screenlines were created for use in MVESTM. Appendix B contains graphical representations of the locations of the screenlines used in calibration. Traffic counts were given a high confidence if they had been collected since the previous calibration of the model and a lower confidence if the count had been used in the previous calibration of TMfS.

3.6 Matrix Development Comparisons

3.6.1 Tables 3.2 to 3.13 detail the peak hour matrix totals for the Pre-Planning Data Amendments, Pre-Park and Ride Prior, Post Park and Ride Prior (Prior meaning before MVESTM) and Final Highway matrix totals. For all analysis, the matrix values are in PCUs × 10.

3.6.2 From the tables it can be seen that the alterations due to the planning data do not change the matrices significantly at a 14 sector level. However, zones with anomalous trip rates have been removed.

3.6.3 It can be seen from these matrices that a small number of short distance trips have been added due to the Park and Ride, particularly Fife to Edinburgh in the AM and Edinburgh to Fife in the PM. This is as a result of large Park and Ride sites, like Ferrytoll, attracting trips to Park and Ride. Longer distance movements see a small decrease in the number of trips.

3.6.4 The MVESTM procedure, has also added a small number of short distance trips. There are a number of movements which have experienced

3.6.5 Dundee to Perth movements have experienced increases in the matrix estimation process. The reason this has occurred is that the new SRTDb counts from 2005 for the A90 between Perth and Dundee are around 50% higher than those used in TMfS:02. The Prior MVESTM matrix is an amended TMfS:02 forecast matrix, which did not generate this level of growth on this link. Due to this increased count, which, as a result of being from 2005, has a high confidence, the matrix estimation process has added in additional trips making this movement.

3.6.6 Glasgow and Strathclyde to Edinburgh movements have experienced decreases during the matrix estimation phase. This is due to a similar reason to that stated in 3.6.5. However, the change in this case is not as significant. In this case, the new SRTDb counts are lower than the forecast growth in traffic (particularly along the M8). Because of these new counts, the matrix estimation process reduced the number of trips in this corridor.

3.6.7 A similar situation exists in the Scottish Borders, particularly in the Galashiels area, where the new SRTDb counts that were used, were significantly higher than the forecast TMfS:02 counts. This resulted in an increase in trips in this area during the matrix estimation process. However, it should, be noted that in this geographical area, many intra-zonal trips are missing from the matrix through an absence of observed travel pattern data and larger zones.

3.6.8 Some of the PM sector-to-sector matrix totals also change significantly during the matrix estimation process. A PM forecast matrix is largely based upon a transpose of the AM Peak matrix. The issues discussed in 3.6.5 to 3.6.7 can be seen in the PM matrix, but in reverse.

3.6.9 Overall, the change in the matrix from the prior matrices to the final post-MVESTM matrices in absolute terms is very small.

Table 3.2 AM Peak Hour TMfS:05 Pre-Planning Data Adjustments (PCUs × 10)

OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	460893	57070	12041	8683	4952	8626	956	1163	2398	2712	279	887	957	1095	562711
2	92290	68159	6694	13136	5488	12610	1707	1020	2445	1574	144	1884	442	1714	209305
3	12451	8350	224678	11432	2184	4078	394	40	141	14207	12531	4908	1869	436	297699
4	15301	15407	8724	189445	19893	28989	2021	263	277	3857	505	3626	1067	681	290056
5	7408	6912	1317	12883	714168	162409	9219	1156	921	533	180	316	1184	2913	921519
6	15710	18677	3456	23011	253492	470502	20540	2635	451	1468	1688	1600	2504	2435	818170
7	1302	2172	161	2114	14281	21250	93759	975	447	251	4	181	7512	648	145057
8	2096	1397	86	708	1069	1622	2543	78563	886	50	0	37	1046	889	90993
9	8701	4620	236	233	3634	472	203	857	6589	43	1	75	27	3467	29158
10	1867	2078	9291	7279	1812	2380	282	122	48	22675	7147	3576	3061	1623	63240
11	612	236	5056	186	153	177	1	353	0	5698	35916	10594	70	236	59288
12	674	908	4064	615	494	675	102	22	99	4105	21612	320662	893	2188	357112
13	168	363	661	136	5333	1491	1865	1	459	3814	429	594	755	263	16332
14	1404	1890	499	278	2835	2872	2207	609	2244	193	182	854	218	0	16285
Total	620878	188238	276964	270140	1029785	718153	135797	87780	17406	61179	80617	349795	21604	18588	3876924

Table 3.3 AM Peak Hour TMfS:05 Prior Before Park and Ride (PCUs × 10)

OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	449563	55755	10845	8259	4565	7742	904	1131	2719	2539	246	1469	865	988	547590
2	90529	68583	6401	12715	5349	12140	1608	1040	2772	1499	131	1982	419	1640	206809
3	14437	9032	228796	11916	2294	4255	397	88	204	14569	12666	5396	1801	430	306280
4	17147	16420	8858	192987	20600	28967	1977	266	299	3940	489	4306	1039	677	297970
5	8283	7450	1299	13030	672175	157577	9039	1201	1109	553	182	663	1201	2921	876682
6	15980	19215	3709	23209	258197	471889	20903	3033	489	1459	1042	1722	2590	2472	825910
7	1478	2422	165	2221	15008	22429	95451	1332	483	287	4	209	7741	663	149893
8	3004	1529	86	731	1213	2344	3008	81809	1819	59	0	41	1266	866	97774
9	9271	4782	215	233	3427	429	292	1293	7841	39	0	71	25	3457	31375
10	2147	2269	9529	7601	1910	2421	292	141	68	23376	7229	3854	2888	1620	65345
11	716	264	5259	195	164	180	1	347	0	5913	36755	11517	45	235	61591
12	849	1100	4232	662	722	814	113	63	135	4488	21866	337886	1149	2354	376434
13	189	365	613	135	5488	1524	2141	1	463	3715	394	746	902	261	16938
14	1724	1909	651	248	2915	1886	2258	663	2431	182	172	1013	233	0	16285
Total	615318	191095	280658	274141	994029	714595	138382	92409	20833	62618	81175	370877	22163	18585	3876877

Table 3.4 AM Peak Hour TMfS:05 Prior Before MVESTM (PCUs × 10)

OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	449157	56250	10844	8271	4559	7736	903	1130	2719	2538	246	1469	865	988	547676
2	86849	73816	6401	13055	5263	12146	1607	1040	2772	1499	131	1982	419	1639	208621
3	11195	8942	233446	11997	2272	4254	396	88	204	14578	12237	5396	1801	430	307238
4	15650	17243	8894	195404	19836	29402	1976	266	299	3924	488	4014	1039	677	299111
5	8276	7449	1296	13027	672283	157645	9038	1201	1109	552	180	663	1201	2921	876840
6	15611	19515	3707	23426	253005	478779	20913	3032	489	1458	1041	1722	2590	2472	827759
7	1477	2422	164	2221	13959	22806	97518	1332	483	287	3	209	7741	663	151285
8	3003	1529	86	731	1155	2343	3073	81809	1819	59	0	41	1266	866	97779
9	9211	4851	215	233	3427	429	292	1293	7841	39	0	71	25	3457	31383
10	1796	2250	10134	7762	1751	2420	292	141	67	23482	7198	3854	2888	1620	65656
11	620	263	5356	195	161	177	1	347	0	5913	36755	11517	45	235	61586
12	716	1099	4423	662	721	813	113	63	135	4488	21858	338247	1149	2354	376842
13	180	365	631	135	5488	1524	2141	1	463	3715	394	746	905	261	16949
14	1723	1912	651	248	2915	1886	2258	663	2431	182	172	1013	233	0	16286
Total	605466	197907	286248	277366	986795	722361	140521	92405	20832	62715	80704	370944	22165	18584	3885013

Table 3.5 AM Peak Hour TMfS:05 Final Matrix (PCUs × 10)

OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	452257	60601	10736	8111	4152	7351	951	1180	2751	3143	210	1641	698	1087	554868
2	83883	76536	6372	12991	5146	12477	1345	1104	2700	1737	135	1518	211	1770	207925
3	11097	8159	231494	11258	1358	2668	280	51	188	15187	12793	5130	2383	331	302377
4	13501	15683	9585	197900	18065	28168	1885	212	244	4372	555	2793	505	590	294059
5	6140	6075	1068	11818	682430	158279	9354	1042	1292	550	359	390	970	2469	882235
6	11942	16659	3149	22246	249465	483308	21628	3257	449	1372	1048	1030	2308	2383	820244
7	1177	1930	145	2056	12247	23194	100507	1292	445	238	13	132	6042	706	150127
8	2675	1125	69	657	858	2273	2775	82541	1823	32	0	15	1023	1386	97254
9	8909	4043	179	219	3698	483	230	1292	10494	40	0	46	15	3424	33073
10	1591	1761	10749	7440	1335	1963	290	164	40	22810	10179	4388	2653	1156	66521
11	638	213	4722	398	239	248	1	221	0	8289	35552	11815	70	342	62748
12	506	731	3557	711	692	748	146	45	51	5315	21326	332290	1599	1861	369577
13	133	213	570	159	4834	1934	3700	1	293	3691	613	589	1529	277	18535
14	1826	1957	643	271	2187	1907	2256	756	2609	140	82	558	146	0	15339
Total	596276	195688	283037	276236	986705	725001	145350	93157	23381	66917	82866	362335	20152	17782	3874882

Table 3.6 Inter-Peak Hour TMfS:05 Pre-Planning Data Adjustments (PCUs × 10)

OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	358697	46300	6836	7437	6255	9088	871	1637	3044	1351	381	966	742	1339	444944
2	42581	50291	5808	9035	4068	12381	1696	604	2440	1202	649	1011	468	2279	134514
3	8249	5576	170556	7076	1885	3203	339	60	246	7987	4752	2045	700	820	213494
4	6791	10210	6970	129204	10024	20231	1835	238	303	2183	472	1127	958	1144	191691
5	5753	5469	1363	9459	552516	140991	6625	798	974	511	210	493	2509	2835	730506
6	8360	11086	2633	19682	138111	375706	15657	2109	795	1029	976	1310	2286	4290	584030
7	993	1820	388	1955	7029	12389	69795	1762	1878	146	13	226	2907	2040	103340
8	1893	640	104	485	1230	2664	2350	68237	1150	60	21	119	678	806	80437
9	2843	2399	168	255	864	788	842	1585	6700	136	14	170	510	3247	20520
10	1586	1295	7246	3941	684	1306	181	32	172	25425	4659	2870	3631	494	53525
11	595	618	5269	677	362	1545	20	24	23	4971	45461	12958	144	438	73104
12	1102	769	2332	1208	434	1441	246	99	255	2729	12160	230890	549	1473	255687
13	467	270	710	562	1910	1660	2387	495	449	3234	145	714	445	1434	14881
14	1230	3297	769	1004	2537	3622	1848	1052	3685	318	297	1113	1649	0	22422
Total	441141	140039	211149	191980	727909	587015	104693	78733	22113	51280	70212	256012	18176	22639	2923092

Table 3.7 Inter-Peak Hour TMfS:05 Prior Before Park and Ride (PCUs × 10)

OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	346747	47165	6909	7406	6161	8730	876	1960	3253	1359	396	1274	754	1387	434375
2	42154	51153	5917	9213	4145	12431	1724	672	2541	1223	652	1372	471	2259	135927
3	8333	5631	172592	7220	1878	3237	337	71	254	8081	4828	2465	701	836	216463
4	6878	10305	7131	130149	10238	20092	1819	345	332	2279	497	1871	972	1276	194185
5	5956	5604	1404	9704	534147	139349	6703	954	1051	532	223	969	2531	2957	712084
6	8570	11324	2824	19919	137163	372025	16189	2563	849	1127	1019	1710	2336	3390	581009
7	1043	1843	404	1979	7128	12466	70908	2223	1984	154	13	314	2939	2184	105583
8	2122	633	104	649	1286	2894	2586	70127	1317	73	22	203	737	940	83693
9	2978	2432	168	264	854	769	839	1874	7324	145	21	371	519	3270	21829
10	1592	1297	7267	3950	700	1311	179	53	182	25630	4679	3521	3606	523	54489
11	593	606	5267	681	369	1540	20	25	30	4962	45685	13841	141	438	74198
12	1240	917	2663	1800	656	1470	271	145	383	3327	12712	243737	542	1801	271663
13	463	266	709	588	1940	1674	2435	599	525	3212	146	747	444	1377	15125
14	1166	3221	763	991	2400	3409	1795	1109	3741	296	301	1655	1575	0	22422
Total	429835	142399	214124	194514	709065	581395	106680	82718	23765	52400	71194	274049	18269	22638	2923045

Table 3.8 Inter-Peak Hour TMfS:05 Prior Before MVESTM (PCUs × 10)

OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	346670	47107	6235	7232	6161	8680	876	1960	3234	1253	357	1204	746	1380	433094
2	42088	51598	5885	9264	4139	12498	1724	672	2603	1222	651	1372	471	2226	136413
3	7654	5599	174969	7274	1874	3237	337	71	254	8279	4809	2578	716	836	218487
4	6683	10356	7185	131322	10150	20179	1819	345	332	2272	494	1871	972	1276	195258
5	5956	5598	1400	9620	534168	139311	6570	946	1051	527	224	969	2531	2957	711826
6	8503	11391	2824	20007	137125	372290	16209	2564	849	1127	1019	1710	2336	3390	581345
7	1043	1843	404	1979	6993	12486	71486	2235	1984	154	13	314	2939	2184	106059
8	2122	633	105	649	1278	2894	2598	70127	1317	73	22	203	737	940	83697
9	2960	2494	168	264	854	769	839	1875	7324	145	21	371	519	3252	21854
10	1476	1295	7465	3944	695	1311	179	53	182	25893	4661	3521	3606	523	54803
11	552	606	5248	678	369	1540	20	25	30	4943	45685	13824	141	438	74098
12	1164	917	2776	1800	656	1470	271	145	383	3327	12695	244403	542	1801	272349
13	453	266	724	588	1940	1674	2435	599	525	3212	146	747	445	1377	15131
14	1159	3188	763	991	2400	3409	1795	1109	3723	296	301	1655	1575	0	22364
Total	428485	142891	216152	195613	708802	581748	107159	82723	23789	52725	71096	274741	18277	22579	2926780

Table 3.9 Inter-Peak Hour TMfS:05 Final Matrix (PCUs × 10)

OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	351987	48519	5387	6359	4438	6173	569	1688	3230	1087	279	981	563	1489	432747
2	41499	53697	6070	9029	3352	10666	1186	583	2619	1333	643	1319	398	2382	134776
3	6548	5676	174980	7267	1215	2216	208	42	225	8465	4465	2234	713	646	214902
4	5203	9301	7344	134159	8815	18174	1652	276	238	2197	604	1679	716	1038	191396
5	4779	4940	966	8958	540380	138179	6544	837	918	366	266	597	2156	2493	712378
6	6912	10383	1984	18614	135295	376579	16372	2434	765	793	1181	1096	2527	3814	578749
7	881	1587	270	1745	6225	13537	73061	1930	2083	115	12	197	2848	1991	106482
8	1992	578	74	560	1048	2664	2249	70905	1517	44	22	95	596	1109	83453
9	2637	2578	132	239	718	653	738	1632	9580	129	12	295	387	3351	23080
10	1049	1130	7082	3526	556	1026	129	32	118	25846	7314	3535	3375	373	55090
11	374	552	4600	608	283	1188	12	34	19	6061	45125	13878	149	309	73193
12	589	528	2179	1179	372	863	153	61	204	3238	12976	238812	589	947	262689
13	252	164	548	417	1830	2099	2616	638	341	3110	153	758	420	1534	14876
14	1238	3059	641	862	2091	3198	1757	1321	3713	202	309	962	1554	0	20905
Total	425939	142690	212255	193521	706617	577214	107243	82412	25571	52986	73364	266438	16990	21475	2904715

Table 3.10 PM Peak Hour TMfS:05 Pre-Planning Data Adjustments (PCUs × 10)

OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	494413	84035	16231	14050	4231	14947	1108	2263	11248	5610	1092	649	470	1547	651894
2	57233	78940	10097	15871	6227	21184	1273	579	3223	2561	346	943	409	3890	202775
3	12003	6288	244056	8457	2191	4098	220	67	349	11875	6010	4482	746	512	301353
4	7707	12627	9282	200128	15251	27283	2770	203	390	4418	221	798	513	1143	282737
5	6833	7995	1907	23323	703369	243035	17170	1148	3842	2206	228	1101	5846	3243	1021246
6	9032	16449	2187	27635	171202	505963	26992	3359	1178	1297	173	668	2588	2663	771386
7	627	1081	168	2421	10550	20434	84727	2539	517	247	2	171	5173	1264	129922
8	827	1184	50	207	1870	2351	1625	79262	1125	23	204	44	247	910	89928
9	2981	3066	141	176	2668	607	2904	1321	8198	33	1	9	126	3056	25288
10	4121	1431	13209	4309	765	1423	285	19	348	14981	5307	3762	3595	1168	54723
11	374	279	10770	702	563	1805	10	1	3	7465	68233	25110	396	204	115914
12	572	1446	2283	3550	272	1143	329	21	240	4882	12595	325826	677	674	354511
13	312	156	1593	695	1943	1806	2145	400	62	3775	74	929	549	1103	15543
14	1354	3015	455	814	3168	2616	3088	1052	4186	819	316	1691	517	0	23090
Total	598390	217992	312430	302338	924269	848695	144645	92234	34910	60192	94802	366183	21852	21377	4040309

Table 3.11 PM Peak Hour TMfS:05 Prior Before Park and Ride (PCUs × 10)

OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	476534	88140	18654	16718	5606	18011	1505	3850	12685	6299	1266	887	562	1758	652474
2	52782	80126	10354	16372	7530	23322	1505	840	3315	2624	375	1095	395	3835	204471
3	10573	6283	247647	8998	2697	5447	245	68	342	12159	6177	4475	745	510	306365
4	6510	12264	9111	199743	16927	29290	2987	216	383	4420	213	1194	519	1024	284801
5	5158	6396	1550	21199	672428	236388	16478	1234	3506	1817	199	1657	5660	2825	976496
6	6923	15126	2006	26291	172898	505560	27944	3527	1000	1144	154	672	2675	2398	768318
7	402	947	160	2476	11046	21382	86218	2772	529	241	2	170	5249	1175	132769
8	786	1291	88	263	2191	3306	2503	82261	1266	36	218	56	414	1330	96008
9	3025	3325	201	200	2789	727	3136	1761	9928	56	1	11	158	3254	28574
10	3879	1430	13261	4500	905	1599	389	20	373	15267	5275	4540	3571	1225	56234
11	322	281	10917	739	654	1386	11	1	2	7639	68814	25642	379	93	116881
12	960	1554	2643	4369	426	1622	458	29	590	5806	13355	344308	824	888	377830
13	259	138	1489	694	2011	1837	2388	535	59	3584	71	1226	586	1063	15938
14	1110	2790	419	778	3183	2674	3265	1018	4198	775	305	1873	703	0	23090
Total	569222	220092	318501	303340	901291	852550	149032	98132	38175	61866	96423	387806	22439	21379	4040248

Table 3.12 PM Peak Hour TMfS:05 Prior Before MVESTM (PCUs × 10)

OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	474969	85110	15603	15351	5591	17815	1488	3835	12576	6029	1169	784	553	1754	642627
2	53277	85360	10265	17195	7529	23622	1504	840	3384	2605	375	1095	395	3838	211282
3	10572	6283	252298	9034	2695	5445	244	68	342	12764	6274	4666	762	510	311957
4	6522	12604	9192	202161	16925	29507	2987	216	383	4581	213	1194	519	1024	288027
5	5146	6303	1526	20435	671759	231661	15680	1211	3502	1710	196	1654	5649	2823	969256
6	6919	15132	2005	26726	172965	512450	28321	3527	1000	1144	152	671	2675	2398	776086
7	401	947	160	2476	11046	21392	88286	2837	529	241	2	170	5249	1175	134908
8	785	1291	88	263	2190	3305	2503	82261	1266	36	218	56	414	1330	96004
9	3025	3325	201	200	2788	727	3136	1761	9928	56	1	11	158	3254	28573
10	3878	1430	13261	4481	904	1598	389	20	373	15390	5273	4540	3569	1225	56331
11	322	281	10486	738	652	1385	11	1	2	7624	68807	25628	379	93	116409
12	960	1553	2642	4077	425	1621	458	29	590	5805	13355	344669	824	888	377897
13	259	138	1489	694	2011	1837	2388	535	59	3584	71	1226	588	1063	15940
14	1110	2790	419	778	3183	2674	3265	1018	4198	775	305	1873	703	0	23089
Total	568145	222547	319635	304610	900663	855038	150660	98159	38129	62344	96410	388235	22437	21375	4048387

Table 3.13 PM Peak Hour TMfS:05 Final Matrix (PCUs × 10)

OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	478631	83827	15269	12716	3316	10273	1547	2781	11239	5658	1037	678	366	1586	628924
2	53424	86623	9591	17124	5046	17731	973	565	2910	2516	356	962	260	3752	201833
3	9596	5825	251568	8437	1380	3205	88	31	192	12989	5723	4114	742	328	304218
4	6887	14128	9112	205741	13273	28536	2748	185	369	4674	316	1204	689	1006	288867
5	6043	7465	1017	18419	687126	232600	15632	1068	3395	1334	332	1376	5039	2558	983403
6	7860	17653	1371	25157	167475	516697	29272	3266	1040	1026	234	561	2972	2427	777011
7	432	1021	93	1923	9684	24614	89746	2455	514	150	2	144	5164	1177	137117
8	726	1386	56	250	1757	3223	2145	82347	1284	25	116	46	337	1773	95471
9	2964	3060	143	159	2655	629	3092	1785	12429	36	1	8	66	3297	30325
10	5088	1636	12372	4466	651	1465	213	13	231	14381	8803	5070	3422	844	58655
11	245	190	9991	641	517	1152	9	1	1	9226	68023	23966	610	40	114612
12	595	966	2308	3023	241	893	238	18	316	5569	14083	332785	937	502	362473
13	163	93	1113	483	2322	2714	3105	684	19	3306	95	1338	534	1324	17293
14	1382	2723	306	755	2681	2348	2913	1313	4246	817	474	1421	640	0	22020
Total	574035	226595	314309	299294	898124	846080	151720	96511	38184	61707	99596	373673	21778	20614	4022221

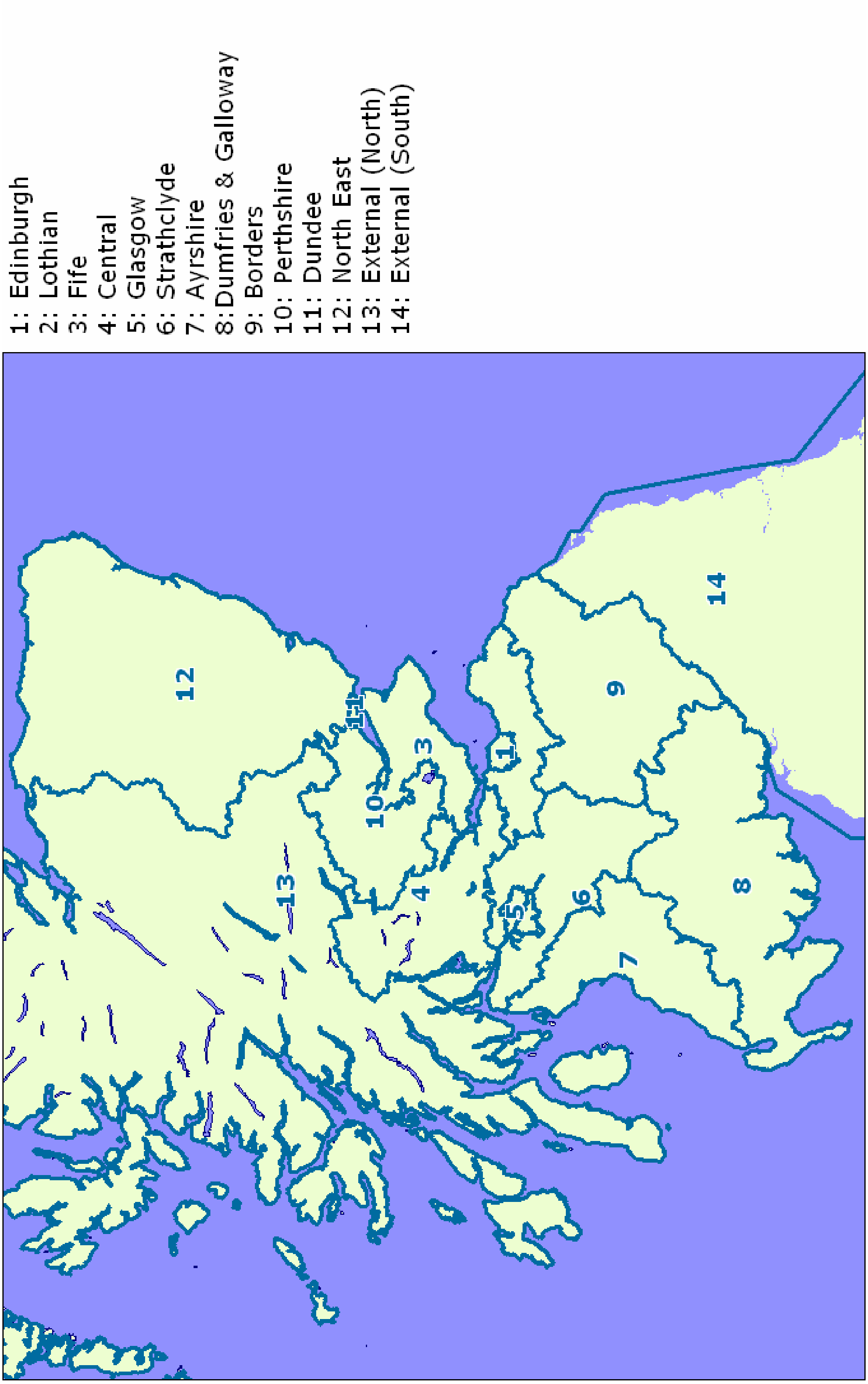

Figure 3.1 14 Sector Definition

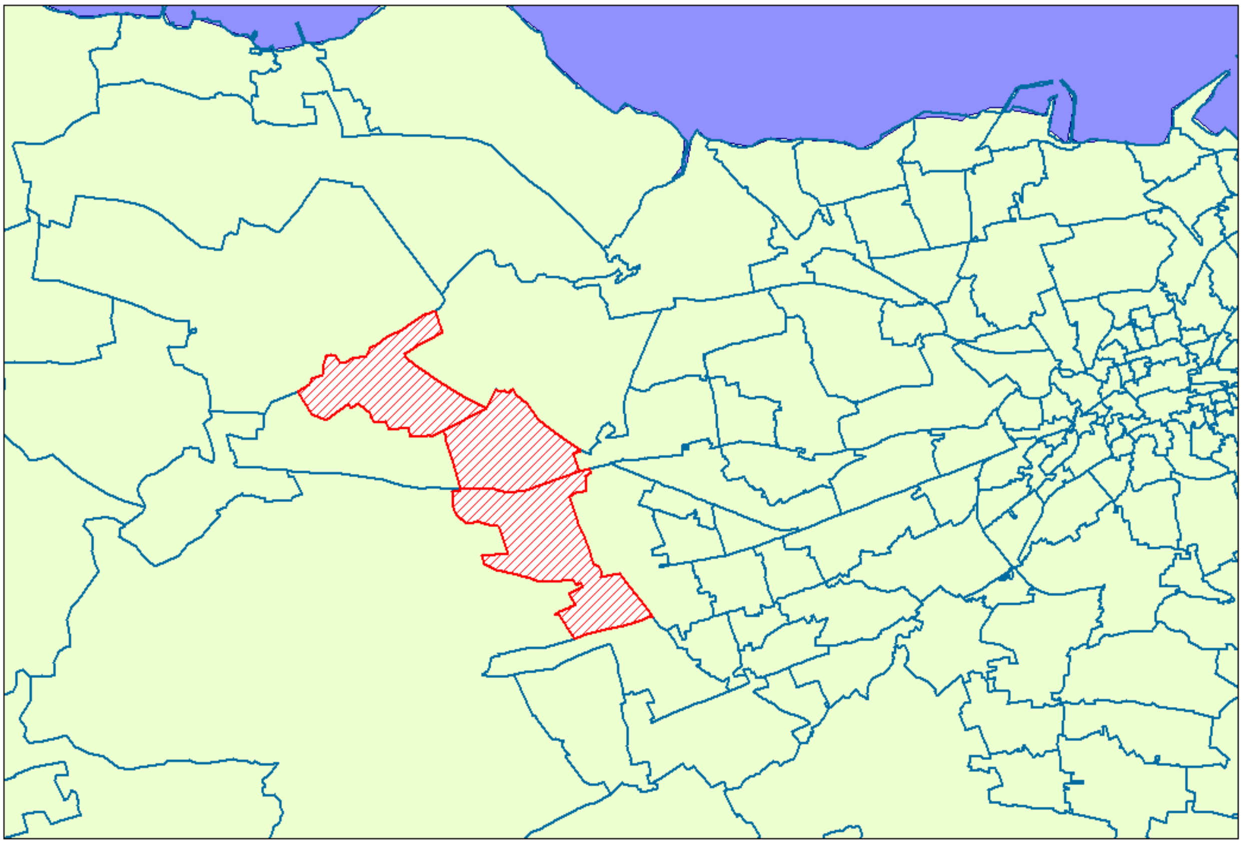

Figure 3.2 Zonal Disaggregation around Edinburgh Airport

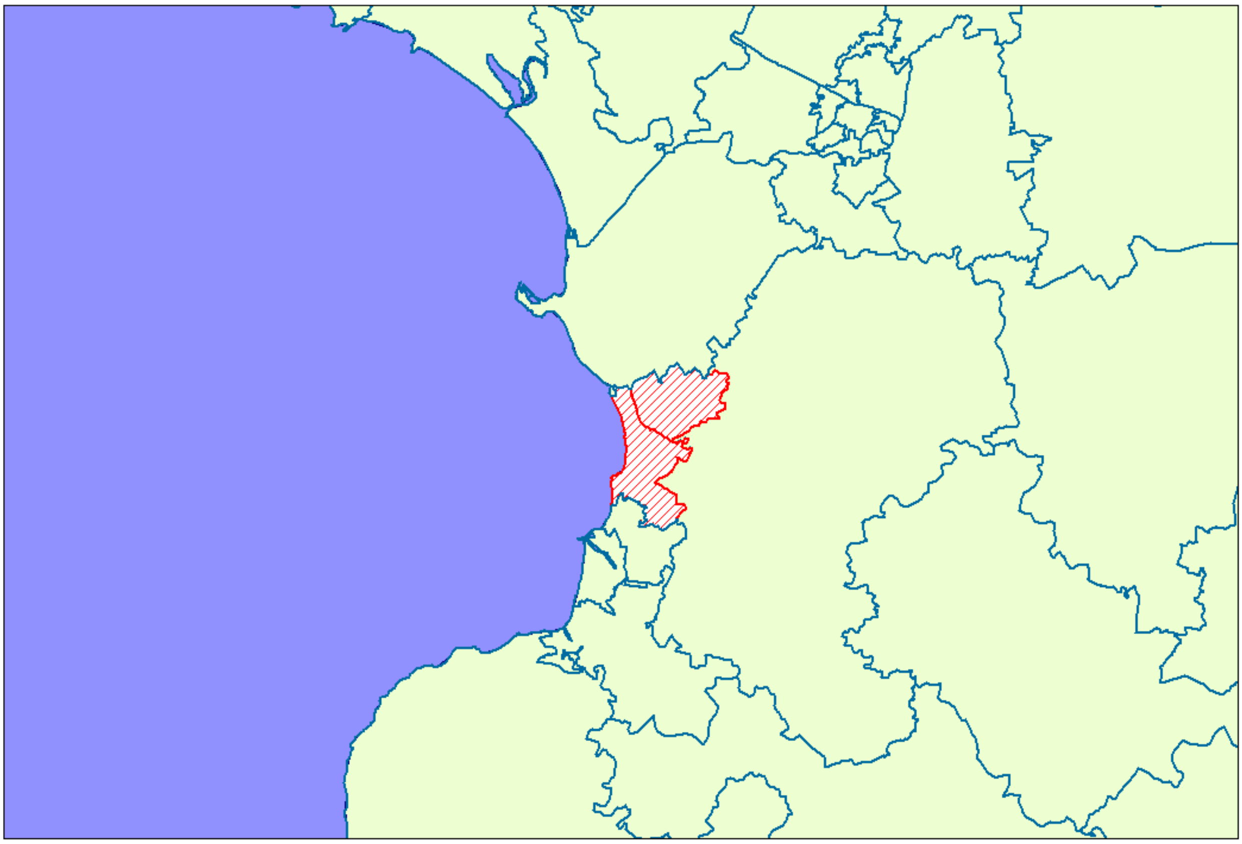

Figure 3.3 Zonal Disaggregation around Prestwick Airport

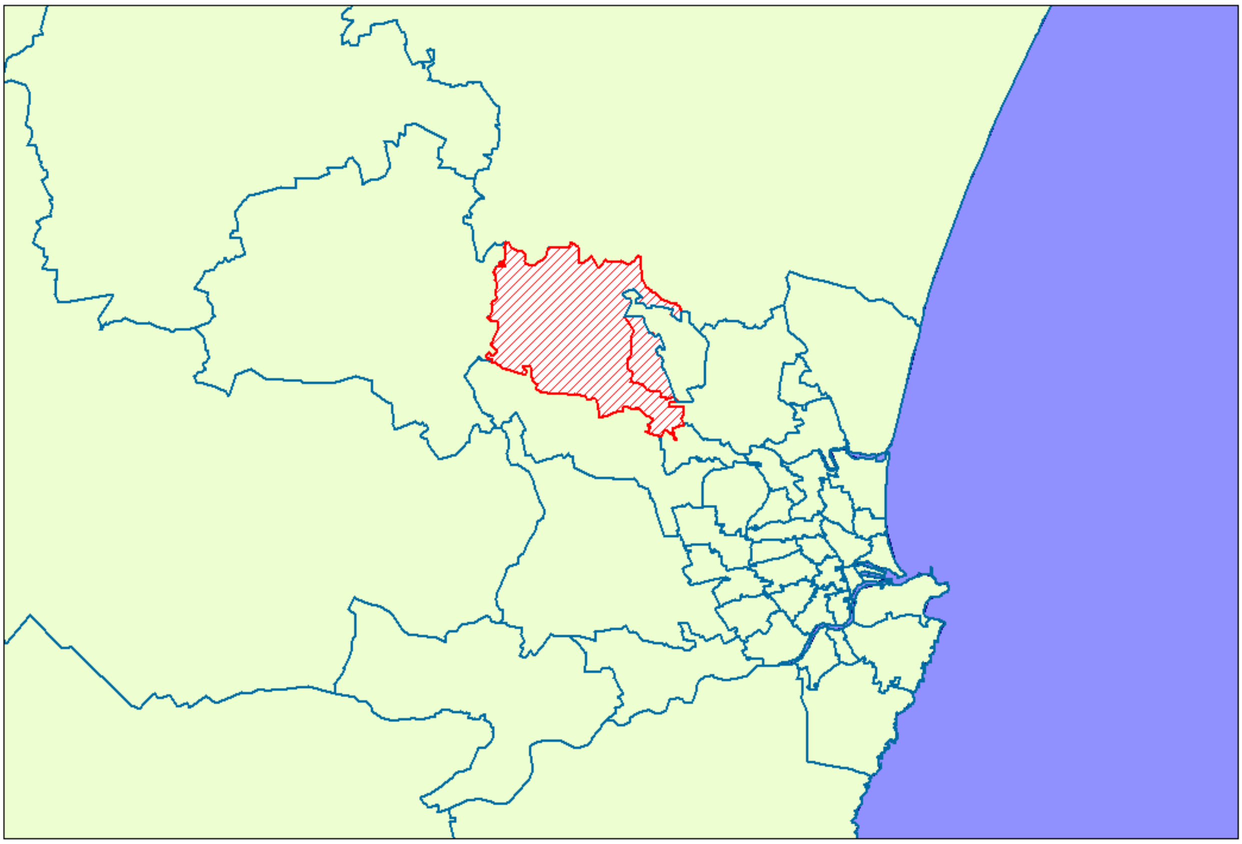

Figure 3.4 Zonal Disaggregation around Aberdeen Airport

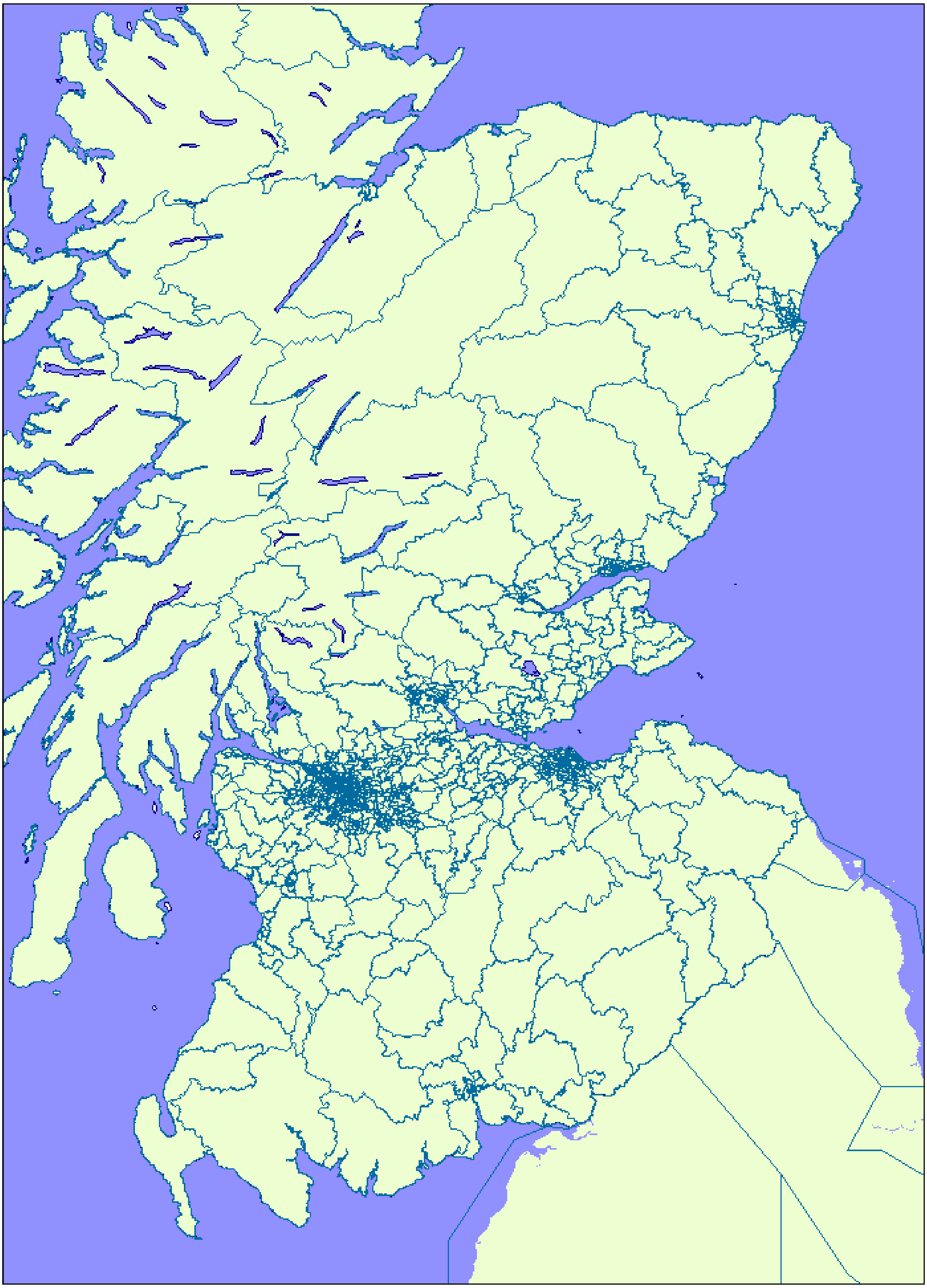

Figure 3.5 Zonal Definition of Model

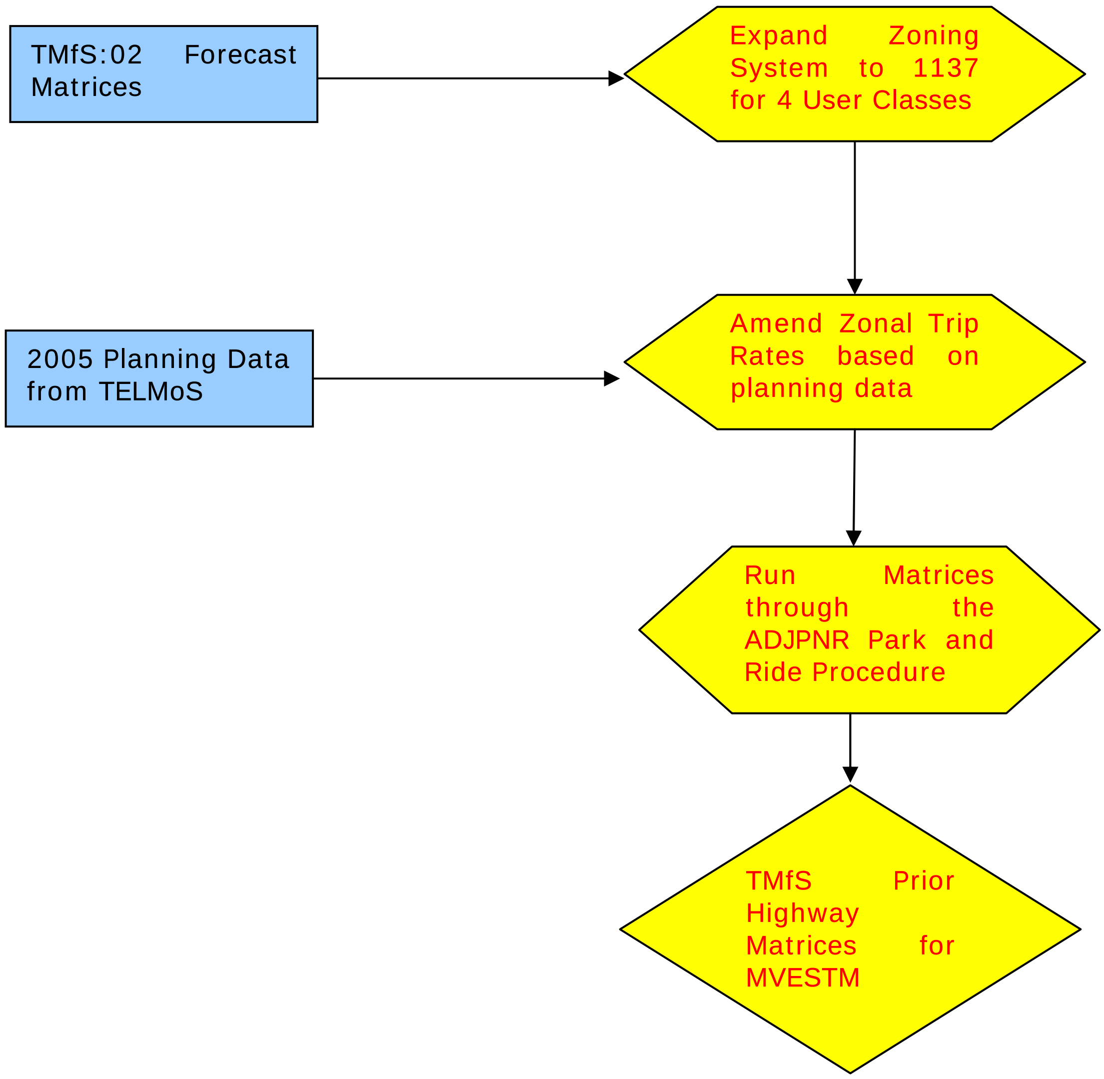

Figure 3.6 Prior Matrix Development Process

4 Assignment Model Development

4.1 Introduction

4.1.1 The assignment procedure adopted for TMfS:05 HAM is the same as that used in TMfS:02, namely a 'Volume Averaged Capacity Restraint Assignment' based on 'All or Nothing' paths at each iteration (for four user classes).

4.1.2 The TMfS:05 HAM includes:

- four separate user classes are assigned to the network. These are; Car In Work, Car Non Work, LGV and OGV; and
- the assignment adopts the principles of the 'Davis Method', which allows for modelling of tolls to be undertaken during the main assignment rather than as a separated modelling process.

4.1.3 This chapter will discuss the assignment procedure used for TMfS:05 HAM plus the incorporation of the 'Cost versus Time' Assignment Method.

4.2 Assignment procedure

4.2.1 The assignment procedure adopted is a 'Volume Averaged Capacity Restraint Assignment' based on 'All or Nothing' paths at each iteration. This procedure has the following benefits:

- model convergence can be checked;
- the assignment can continue for as many iterations as required to achieve a user pre-defined level of convergence;
- cars, goods and light vehicles are assigned using the same path building technique on every iteration; and
- 'All or Nothing' path building at each iteration gives a comprehensive multi-routing assignment.

4.2.2 The assignment procedure carries out a 'Volume Averaged Capacity Restraint' throughout the whole modelled area, based on 'All or Nothing' paths for 'n' iterations until the model is fully converged. The principal features of this assignment process are as follows:

- the model operates over three one hour time periods;
- 'All or Nothing' path building is carried out separately for the four user classes (car in work, car non work, LGV and OGV) using the CUBE program AVROAD; and
- 'Volume Averaged Capacity Restraint' (within the CUBE program AVCAP) ensures that each iteration of restraint is based on the average of all previous iterations (during capacity restraint calculations, all user classes are combined into total PCUs).

4.2.3 'Volume Averaged Capacity Restraint' is ideally suited to congested urban networks, where the level of traffic leads to different 'All or Nothing' paths on successive iterations, and so to multi-routing through the 'Volume Averaging' procedure. However, an uncongested rural area will tend to give mono-routing results because of the low level of traffic compared with capacity and the reduced routing choices. As a result, the optimum paths on the first iteration will remain the optimum throughout the assignment.

4.3 Cost versus Time Assignment Method

4.3.1 The ‘Cost versus Time Assignment Method’ (CvT Method) was incorporated within the TMfS:02 assignment procedure as it allows tolling tests to be undertaken without the requirement of a separate model, as was the case in both CSTM models (3 and 3A). This is still the case within TMfS:05.

4.3.2 The method is described in the paper entitled “Cost versus Time Equilibrium over a Network” by Fabien Leurent in the “European Journal of Operational Research”. The paper describes the theory and demonstrates that the method converges to equilibrium.

4.3.3 Rather than increase the number of user classes, this method varies the willingness to pay weighting applied to tolls in the route choice generalised cost from iteration to iteration. The willingness to pay weighting is in fact randomly sampled from a distribution, which is representative of the total population. The mechanics of the process are very similar to the stochastic user equilibrium process.

4.3.4 The generalised cost for route choice is defined for a link in the network as:

C = a * time + b * distance + c * toll

4.3.5 In the equation above, ‘a’ is a time parameter, ‘b’ a distance parameter and ‘c’ a cost parameter.

4.3.6 Where ‘C’ is the link generalised cost and ‘a’, ‘b’ and ‘c’ are parameters. In the CSTM, tolling model there was one value of ‘c’ for each user class (for a particular year) and these values are fixed for the whole assignment. In the CvT method, there are no additional user classes compared with the standard (ie non-toll) model but the parameter ‘c’ (one for each user class) is varied by random sampling at each iteration of the highway assignment procedure.

4.3.7 The distributions from which the ‘willingness to pay’ for each user class are randomly sampled remain the same between TMfS:02 and TMfS:05.

4.4 Model Convergence

4.4.1 The previous methodology for calculating model convergence as used in CSTM3 did not require the inclusion of the tolling element of the generalised cost as this did not vary by iteration. As mentioned above, the CvT method varies the generalised cost co-efficient attached to tolls randomly from iteration to iteration. This required a change to the existing methodology to add the tolling cost to the network cost (ie time and distance) by iteration.

4.4.2 From the iteration number and the total cost, a normalised regression statistic is calculated using the following formula (which provides the gradient of the line of the graph of iteration number ’X’ versus total cost).

$$a = \frac{n\sum xy - \sum x \sum y}{n\sum (x)^2 - (\sum x)^2} / c$$

where:

- *a* is the gradient;
- *x* is the iteration number;
- *y* is the total cost;
- *c* is the total cost on the current iteration; and
- *n* is the number of iterations over which the regression is calculated.

4.4.3 The regression statistic is normalised using the total cost of the current iteration, to leave it unitless as a pure parameter.

4.4.4 The HAM acceptance criteria is that the level of convergence must be less than or equal to the DMRB recommended value of 1% on three successive iterations for the assignment procedure to automatically terminate. This is a very exacting level of convergence for this size of model and is necessary to ensure that reliable data is passed to other elements of the modelling process, most importantly, the economic analysis element.

4.4.5 The number of iterations required to reach convergence within the base model were:

- AM Peak – 77 iterations;
- Inter-Peak – 36 iterations; and
- PM Peak – 68 iterations.

5 Calibration

5.1 Introduction

5.1.1 In this chapter, the model is examined in detail to demonstrate its level of calibration. Journey time validation and validation against independent counts are presented in the following chapter. All observed and modelled values are in PCUs.

5.1.2 The screenline locations and traffic count data used for calibration purposes are those used in the MVESTM process. In total, 649 sites have been used in the MVESTM procedure. Of these 649 sites, 92 formed part of multi-point screenlines and, as such, are duplicates. The number of unique screenlines is 557.

5.1.3 The analysis of the modelled screenline and link flows makes use of a summary statistic known as GEH, which is defined as:

$$GEH = ((\text{observed}-\text{modelled})^2/(0.5*(\text{observed}+\text{modelled})))^{0.5}$$

5.1.4 The GEH value is designed to be more tolerant of large percentage differences at lower flows. For example, one would not normally be concerned about a modelled flow that differed from a count by 40% if the count was only 100, but one would if the count were 1000. The reason for introducing such a statistic is the inability of either the absolute difference or the relative difference between the modelled flow and count to reflect differences over a wide range of flows such as are present in the HAM.

5.1.5 For a model such as the HAM, given its size, complexity, and the magnitude of traffic flows, we would normally expect screenline GEH values to meet the following targets to achieve a high standard of calibration:

- GEH<5 60% of all sites;
- GEH<7 80% of all sites;
- GEH<10 95% of all sites; and
- GEH<12 100% of all sites.

5.2 Key Strategic Screenline Flows

5.2.1 Key strategic screenlines are defined for the purposes of model calibration, as shown in Appendix B. One strategic screenline covers traffic flows across the Forth Estuary on the Kincardine Bridge, the Forth Road Bridge and at Stirling (calibration screenlines 17 and 117). The results for TMfS:05 are presented in Table 5.1 and the results for TMfS:02 are detailed in Table 5.2 for purposes of comparison.

Table 5.1 TMfS:05 Forth Estuary Strategic Screenline

Direction	Time Period	Observed	Modelled	Dif	% Dif	GEH
Northbound	AM	4696	4652	-44	-0.9	0.6
	IP	3446	3456	10	0.3	0.2
	PM	6096	5694	-402	-6.6	5.2
Southbound	AM	5072	5179	107	2.1	1.5
	IP	3312	3606	294	8.9	5.0
	PM	4387	4530	143	3.3	2.1

Table 5.2 TMfS:02 Forth Estuary Strategic Screenline

Direction	Time Period	Observed	Modelled	Dif	% Dif	GEH
Northbound	AM	4467	4321	146	3.3	2.2
	IP	3352	3239	113	3.4	2.0
	PM	5664	5447	217	3.8	2.9
Southbound	AM	5271	5281	-10	-0.2	0.1
	IP	3537	3605	-68	-1.9	1.1
	PM	4790	4530	260	5.4	3.8

5.2.2 TMfS:05 Northbound screenlines show that observed and modelled flows differ by between a GEH of 0.2 and 5.2 and the Southbound screenline differs by between a GEH of 1.5 and 5.0. Comparing TMfS:05 GEH's with those of TMfS:02 GEH's, the Northbound AM and Inter-Peak demonstrate an improvement along with the Southbound PM peak. Although the opposite directions and time periods show changes in GEH values, these are deemed minimal with the high level of calibration demonstrated.

5.2.3 The strategic screenline across the River Clyde includes all crossings from the Albert Bridge, east of Glasgow City Centre, to the Erskine Bridge in the west (calibration screenlines 246 and 346). Table 5.3 presents TMfS:05 observed versus modelled flows for this screenline while Table 5.4 presents TMfS:02 screenline data.

Table 5.3 TMfS:05 Clyde Strategic Screenline

Direction	Time Period	Observed	Modelled	Dif	% Dif	GEH
Northbound	AM	15426	15137	-289	-1.9	2.3
	IP	9807	10130	323	3.3	3.2
	PM	11208	11433	225	2.0	2.1
Southbound	AM	12386	13816	1430	11.6	12.5
	IP	10183	10679	-496	-4.8	4.9
	PM	15848	16480	-632	-4.0	5.0

Table 5.4 TMfS:02 Clyde Strategic Screenline

Direction	Time Period	Observed	Modelled	Dif	% Dif	GEH
Northbound	AM	13973	14604	631	4.5	5.3
	IP	9835	9867	32	0.3	0.3
	PM	11823	11573	-250	-2.1	2.3
Southbound	AM	12262	12335	73	0.6	0.7
	IP	9562	9474	-88	-0.9	0.9
	PM	15277	14326	-951	6.2	7.8

5.2.4 TMfS:05 Northbound screenlines show that observed and modelled flows differ by between a GEH of 2.1 and 3.2 and the Southbound screenline differs by between a GEH of 5.0 and 12.5. TMfS:05 results improve as a result of the Northbound AM and PM Peak in the rebased network. Other GEH values worsen, in particular the Southbound AM Peak. The modelled flow has increased by 1,500 vehicles from TMfS:02 while the observed count only increases by 100 vehicles. The difference in flow in this instance has led to a large GEH value. The principal reason for this increase is during calibration, modelled flows will increase to complement adjacent counts, which may be either new or updated from that in TMfS:02.

5.2.5 The high GEH southbound in the AM Peak is partly due to the mixture of old and new count data used. In this instance, the new count is lower than the forecast growth in flow. Part of the reason for this is due to the unavailability of 2005 count data in certain locations and therefore, 2002 data has been used which may underestimate the actual conditions. MVESTM could not remove enough of the forecast trips from this screenline to match these lower counts. This mixture of old and new data also leads to wide variability of GEH scores on individual links across the Clyde estuary.

5.2.6 Table 5.5 presents TMfS:05 results for Strategic Screenline Three, which covers traffic flows across the Tay Bridge (calibration screenlines 27 and 127). Table 5.6 presents the results for TMfS:02 for comparison.

Table 5.5 TMfS:05 Tay Strategic Screenline

Direction	Time Period	Observed	Modelled	Dif	% Dif	GEH
Northbound	AM	1957	1793	-164	-8.4	3.8
	IP	725	745	20	2.8	0.7
	PM	909	991	82	9.0	2.7
Southbound	AM	718	837	119	16.6	4.3
	IP	722	716	-6	-0.8	0.2
	PM	1442	1292	-150	-10.4	4.1

Table 5.6 TMfS:02 Tay Strategic Screenline

Direction	Time Period	Observed	Modelled	Dif	% Dif	GEH
Northbound	AM	1957	1813	-144	-7.4	3.3
	IP	725	665	-60	-8.3	2.3
	PM	909	855	-54	-5.9	1.8
Southbound	AM	718	670	-48	-6.7	1.8
	IP	722	633	-89	-12.3	3.4
	PM	1442	1312	-130	-9.0	3.5

5.2.7 TMfS:05 Northbound screenlines show that observed and modelled flows differ by between a GEH of 0.7 and 3.8 and the Southbound screenlines differ between a GEH of 0.2 and 4.3. The GEH values of the screenlines display minimal changes between TMfS:02 and TMfS:05. As can be seen from the observed values for the Tay strategic screenline, no new count data has been used in the calibration process.

5.3 Other screenline flows

5.3.1 As discussed in paragraph 5.1.2, the calibration screenlines presented in this chapter are the same as those used in the MVESTM process (Appendix B).

5.3.2 Given that the principal aim of this project is to predict strategic road flows throughout the modelled area, the calibration sites can be conveniently divided into two groups:

- key links (single points on major roads); and
- multi-point screenlines.

Key Links

5.3.3 Traffic count data was available for most key trunk and principal roads within the modelled area. The majority of new TMfS:05 count data was obtained from SRTDb. The links presented here may also exist as part of multi-point screenlines but are presented separately, given the importance of these routes to the objectives of the model. Appendix C presents tables for the AM peak, Inter-Peak and PM peak observed/modelled total flows for the 253 Key Links, which have been used to achieve calibration throughout the HAM. Previously in TMfS:02, 137 Key Links were reported. The GEH statistic (described in paragraph 5.1.4) has been used to assess the overall acceptability of these results. For ease of comparison between the TMfS:02 and the TMfS:05 results, the TMfS:02 results are contained in brackets in all tables.

5.3.4 These Key Links cover the major roads of the modelled area. Table 5.7 details the GEH analysis.

Table 5.7 Key Links Flow GEH Analysis

	% of sites with GEH value (TMfS:02 values in brackets)				
Time Period	≤5	≤7	≤10	≤12	≤15
AM	62 (60)	78 (75)	89 (90)	95 (95)	100 (99)
IP	79 (75)	90 (89)	96 (96)	99 (99)	100 (100)
PM	66 (62)	79 (78)	91 (92)	95 (97)	99 (99)
Target	60%	80%	95%	100%	

5.3.5 The vast majority of the GEH values are better than the target of 12, indicating that the major routes of the modelled area are sufficiently well calibrated. The GEH percentages compare favourably against those of TMfS:02 results. In addition, TMfS:05 is calibrated to a significantly larger database of traffic counts than TMfS:02 . In this instance, the number of sites that have GEH values of ≤5 and ≤7 for all time periods are greater than TMfS:02 values.

5.3.6 The highest GEH statistics are 16.7 in the AM Peak; 14.7 in the Inter-Peak; and 18.3 in the PM Peak. For all those Key Links with a GEH value greater than 15 (1, 0 and 2 in the AM, Inter-Peak and PM peaks respectively), only one has less trips assigned than their traffic count. On investigation, the difficulties lie in the relative coarseness and large size of zones in the vicinity and the corresponding lack of assigned intrazonal trips, which would influence traffic flow on these links.

Multi-Point Screenlines

5.3.7 In addition to single link calibration points, a number of screenlines with multiple observations were prepared. These multi-point screenlines were used to calibrate the model across a cordon or along a wide screenline. Appendix D provides a detailed analysis of these multi-point screenline flows.

5.3.8 Table 5.8 summarises the screenline GEH analysis for each time period for all 41 multi-point screenlines used in the calibration of the model. Previously, 48 two-way multi-point screenlines were used in TMfS:02. In general, the screenline GEH value is better than the target of 12. Table 5.8 shows that the majority of GEH values lay within or close to their target levels.

Table 5.8: Multi Point Screenlines GEH Analysis

	% of sites with GEH value (TMfS:02 values in brackets)				
Time Period	≤5	≤7	≤10	≤12	≤15
AM	62 (57)	77 (81)	91 (94)	97 (95)	100 (100)
IP	67 (78)	81 (88)	94 (95)	99 (98)	100 (100)
PM	62 (71)	75 (79)	90 (92)	96 (96)	99 (99)
Target	60%	80%	95%	100%	

5.3.9 Although the multi-point percentages are lower in some time periods than TMfS:02, it is noted that there was a significant increase in the total number of screenlines reported on and consequently a wider geographic area was covered. With this in mind, the majority of targets are met, confirming a good level of calibration.

5.3.10 Appendix E provides a detailed breakdown of the flows on each individual link used in calibrating the HAM for all three time periods. Table 5.9 summarises the GEH analysis of these 230 sites. Appendix E also shows these GEH values as coloured links on the network for each modelled time period.

Table 5.9 Link Flows – Calibration Screenlines

	% of sites with GEH value (TMfS:02 values in brackets)				
Time Period	≤5	≤7	≤10	≤12	≤15
AM	60 (60)	74 (76)	88 (90)	94 (95)	99 (99)
IP	72 (72)	84 (85)	95 (94)	99 (97)	100 (99)
PM	62 (60)	76 (75)	89 (89)	93 (94)	98 (98)
Target	60%	80%	95%	100%	

5.3.11 A large number of the links in the TMfS:05 network are within the GEH target of 12, and the vast majority are better than the target of 15. However, the highest GEH values are 23.2 in the AM peak, 16.0 in the Inter-Peak and 19.7 in the PM peak respectively. These sites were investigated and the difficulties lie in the relative coarseness and large size of zones in the vicinity and corresponding lack of assigned intra-zonal trips, which would increase traffic on these links. In total there are 649 screenlines used in the calibration process. Of these 649 screenlines, 92 formed part of multi-point screenlines, and as such, are duplicates. The actual number of unique screenlines is 557, which compares to 475 used in the calibration of TMfS:02. Of all the Key Links with a GEH value greater than 15, 8 are in the AM peak, 1 in the Inter-Peak and 14 in the PM peak.

5.3.12 The TMfS:05 values are similar to those of the TMfS:02 values, with changes being relatively marginal.

5.3.13 Appendix F contains graphical illustrations of the screenline results for the three time periods.

6 Validation

6.1 Introduction

6.1.1 Validation is the process of checking how well the model compares with data independent of the calibration process and will be presented using the following information:

- journey time data;
- count data not used in calibration; and
- trip length distribution analysis.

6.1.2 In addition, screenline analysis has been undertaken on HGVs. This analysis was not used during calibration as the calibration process considered flows in terms of total PCUs only.

6.2 Journey times

6.2.1 As part of the validation process, observed and modelled journey times have been compared across 59 routes throughout the modelled area, this includes two additional TMfS:05 journey times on the M8. Table 6.1 and Figure 6.1 (at the end of this chapter) detail the ‘Edinburgh Area Urban Journey Routes’. Each individual route is illustrated in Appendix G. Table 6.1 also shows the mean observed and modelled journey times for each route in each time period.

Table 6.1 Edinburgh Area Urban Journey Routes

			AM			IP			PM		
Route	**Direction**	**Description**	**Obs**	**Mod**	**GEH**	**Obs**	**Mod**	**GEH**	**Obs**	**Mod**	**GEH**
B1	1	A720 Lothianburn Junction to B701 Wester Hailes Road / Harvesters Way	34.6	44.4	1.6	30.3	34.3	0.7	38.2	43.0	0.7
	2	B701 Wester Hailes Road / Harvesters Way to A720 Lothianburn Junction	35.3	41.9	1.1	41.2	32.2	1.5	30.1	41.3	1.9
B2	1	A989 Tay St / A85 West of Bridge to A90 / A929 / A972 Dumbbell Roundabout	33.9	27.7	1.1	30.0	27.1	0.5	37.3	28.1	1.6
	2	A90 / A929 / A972 Dumbbell Roundabout to A989 Tay St / A85 West of Bridge	25.8	27.5	0.3	25.9	26.5	0.1	26.5	27.2	0.1
B8	1	M9 J3 Off Slip / A803 to A6095 Dumbbell Roundabout A1 Slips	58.5	54.4	0.5	45.2	44.6	0.1	49.5	51.9	0.3
	2	A6095 Dumbbell Roundabout A1 Slips to M9 J3 On Slip / A803	57.2	52.3	0.7	41.1	43.6	0.4	79.2	56.3	2.8
B11	1	A8 Glasgow Rd / Maybury Rd to A71 / A720 City Bypass	31.3	35.7	0.8	25.0	26.9	0.4	34.0	32.8	0.2
	2	A71 / A720 City Bypass to A8 Glasgow Rd / Maybury Rd	27.9	28.0	0.0	25.7	21.9	0.8	31.9	27.8	0.7
B12	1	A901 / A199 Commercial St to A902 / A90 Roundabout	31.8	34.1	0.4	31.7	29.4	0.4	38.4	38.5	0.0
	2	A902 / A90 Roundabout to A901 / A199 Commercial St	32.0	39.6	1.3	31.0	25.9	1.0	32.7	26.6	1.1
B13	1	A720 / A701 Burdiehouse Road to A1 West Slips / Newcraighall Roundabout	29.5	39.7	1.7	26.9	29.3	0.4	35.7	35.8	0.0

			AM			IP			PM		
Route	**Direction**	**Description**	**Obs**	**Mod**	**GEH**	**Obs**	**Mod**	**GEH**	**Obs**	**Mod**	**GEH**
	2	A1 West Slips / Newcraighall Roundabout to A720 / A701 Burdiehouse Road	42.4	32.6	1.6	30.4	28.9	0.3	34.1	37.2	0.5
B14	1	A720 / A772 Gilmerton Rd to A720 Sheriffhall Roundabout	21.2	22.8	0.3	18.4	17.9	0.1	23.5	19.9	0.8
	2	A720 Sheriffhall Roundabout to A720 / A772 Gilmerton Rd	20.5	20.6	0.0	16.8	18.0	0.3	20.4	19.8	0.1

6.2.2 Table 6.2 and Figure 6.2 (at the end of this chapter) detail the 'Glasgow Area Urban Journey Routes'. Each individual route is illustrated in Appendix G. Table 6.2 also shows the mean observed and modelled journey times for each route in each time period.

Table 6.2 Glasgow Area Urban Journey Routes

			AM			IP			PM		
Route	**Direction**	**Description**	**Obs**	**Mod**	**GEH**	**Obs**	**Mod**	**GEH**	**Obs**	**Mod**	**GEH**
C1	1	Port Glasgow - Hillington	16.9	15.0	0.5	16.6	14.9	0.5	17.9	14.9	0.7
	2	Hillington - Port Glasgow	16.1	15.4	0.2	14.9	15.2	0.1	18.5	15.3	0.8
C2	1	Carmyle - Motherwell	7.5	6.4	0.4	7.6	6.4	0.5	7.7	6.4	0.5
	2	Motherwell – Carmyle	8.2	6.3	0.7	8.2	6.3	0.7	8.4	6.3	0.8
C3	1	Irvine - Barrhead	30.3	30.0	0.1	28.0	29.0	0.2	30.1	29.6	0.1
	2	Barrhead – Irvine	28.2	29.5	0.2	26.1	29.4	0.6	28.3	30.7	0.4
C4	1	East Kilbride Circular (Anti-Clockwise)	19.3	16.1	0.7	14.8	16.1	0.3	20.0	17.3	0.6
	2	East Kilbride Circular (Clockwise)	17.1	16.3	0.2	14.6	15.6	0.3	16.9	15.7	0.3
C5	1	A77 Loganswell Farm – Central	55.2	35.3	3.0	36.7	30.2	1.1	33.3	30.0	0.6
	2	Central - A77 Loganswell Farm	30.5	28.9	0.3	31.0	29.1	0.3	50.7	35.2	2.4
C6	1	M77 J2 – Junction with A77	5.8	6.2	0.2	5.9	6.2	0.2	5.8	6.3	0.2
	2	Junction with A77 - M77 J2	11.6	6.5	1.7	5.0	6.3	0.5	6.4	6.3	0.0
C7	1	A726 Nitshill – A73 Newhouse	48.3	51.3	0.4	45.3	50.1	0.7	49.0	52.0	0.4
	2	A73 Newhouse - A726 Nitshill	58.9	52.8	0.8	50.4	47.6	0.4	56.9	53.0	0.5
C8	1	Govan – Kingston Bridge	14.8	11.3	1.0	13.5	11.1	0.7	17.3	11.4	1.6
	2	Kingston Bridge – Govan	12.0	10.7	0.4	13.0	10.5	0.7	14.3	11.5	0.8
C9	1	A814 Kilpatrick – Hope Street	25.2	23.7	0.3	22.5	21.0	0.3	23.7	22.5	0.2
	2	Hope Street - A814 Kilpatrick	23.7	22.9	0.2	22.4	22.1	0.1	24.1	29.1	1.0
C10	1	Dumbarton Road – Great Western Road	3.8	3.2	0.3	3.5	3.7	0.1	3.8	3.2	0.3
	2	Great Western Road - Dumbarton Road	3.5	3.0	0.3	3.3	3.5	0.1	3.4	3.0	0.2
C11	1	Johnstone - Bellahouston	27.9	25.8	0.4	26.1	24.4	0.4	28.4	24.7	0.7
	2	Bellahouston – Johnstone	32.4	27.3	0.9	27.2	26.2	0.2	31.3	28.9	0.4
C12	1	A80 Cumbernauld – M8	19.8	16.1	0.9	14.5	13.8	0.2	14.2	14.1	0.0
	2	M8 - A80 Cumbernauld	18.5	15.4	0.8	13.9	14.7	0.2	16.6	15.6	0.3
C14	1	A77 – East Kilbride	12.3	3.2	3.3	11.6	3.2	3.1	13.7	3.2	3.6
	2	East Kilbride – A77	13.0	10.8	0.6	12.3	10.7	0.5	14.3	11.3	0.8
C15	1	A8 – A728 (Cathcart Road)	37.4	41.4	0.6	36.6	32.6	0.7	37.1	41.0	0.6
	2	A728 (Cathcart Road) – A8	38.2	37.3	0.1	35.6	33.3	0.4	44.6	37.2	1.2
C16	1	Kingsway – Anniesland Cross	4.7	3.6	0.6	4.3	3.5	0.4	4.4	3.8	0.3
	2	Anniesland Cross – Kingsway	4.0	3.8	0.1	3.7	3.7	0.0	3.9	3.8	0.1
C17	1	A803 Springburn Circular (Anti-Clockwise)	46.3	51.2	0.7	43.8	46.8	0.5	45.4	50.1	0.7

			AM			IP			PM		
Route	**Direction**	**Description**	**Obs**	**Mod**	**GEH**	**Obs**	**Mod**	**GEH**	**Obs**	**Mod**	**GEH**
	2	A803 Springburn Circular (Clockwise)	54.7	50.2	0.6	48.9	46.9	0.3	50.1	51.6	0.2
C18	1	Partick - Hillfoot	14.3	14.7	0.1	11.8	14.6	0.8	14.3	17.8	0.9
	2	Hillfoot – Partick	16.9	15.7	0.3	12.4	12.9	0.1	14.5	14.0	0.1
C19	1	M77 J2 - A8 Bargeddie	26.3	15.3	2.4	16.9	14.7	0.6	33.0	16.7	3.3
	2	A8 Bargeddie - M77 J2	32.4	20.3	2.4	16.0	16.4	0.1	43.6	25.3	3.1
C20	1	Glasgow - Bearsden	13.3	13.1	0.1	14.8	12.5	0.6	18.6	20.5	0.4
	2	Bearsden – Glasgow	19.0	18.6	0.1	14.5	13.2	0.3	15.4	13.7	0.4
C21	1	A82 / A898 Junction Circular (Clockwise)	50.4	46.4	0.6	47.3	45.9	0.2	51.6	47.3	0.6
	2	A82 / A898 Junction Circular (Anti-Clockwise)	52.2	46.8	0.8	49.7	45.4	0.6	50.8	46.3	0.6
C22	1	Great Western Road (M8 to A8014)	22.6	25.8	0.6	27.7	20.8	1.4	28.6	30.4	0.3
	2	Great Western Road (A8014 to M8)	31.0	28.1	0.5	25.4	19.0	1.4	27.6	25.5	0.4
C23	1	A725 Blantyre - Coatbridge	14.7	15.2	0.1	10.8	12.0	0.4	25.7	12.7	3.0
	2	Coatbridge - A725 Blantyre	15.7	15.8	0.0	16.3	13.2	0.8	16.3	18.6	0.5
C24	1	Bearsden - Kilsyth	31.2	27.9	0.6	29.7	28.2	0.3	31.6	27.6	0.7
	2	Kilsyth – Bearsden	30.7	28.9	0.3	30.0	29.1	0.2	45.9	29.9	2.6
C25	1	A807 - A814 Partick	19.4	24.7	1.1	20.5	16.8	0.8	27.0	26.6	0.1
	2	A814 Partick - A807	20.8	21.3	0.1	18.8	20.9	0.5	27.3	32.8	1.0
C27	1	A71/ A78 Irvine – A73 Newhouse	75.2	63.1	1.5	63.3	63.3	0.0	74.4	64.7	1.2
	2	A73 Newhouse - A71/ A78 Irvine	66.1	63.6	0.3	64.5	62.5	0.3	67.0	62.8	0.5
C28	1	Govan - Cambuslang	24.9	28.5	0.7	23.2	24.1	0.2	29.4	28.0	0.3
	2	Cambuslang – Govan	29.6	30.0	0.1	20.8	22.8	0.4	27.8	27.1	0.1
C29	1	George Square / Castle St (Anti-Clockwise)	8.8	14.8	1.8	10.4	13.0	0.8	12.0	12.4	0.1
C31	1	Kilsyth – Auchenkilns Roundabout	7.6	7.8	0.1	7.6	7.4	0.1	8.6	7.5	0.4
	2	Auchenkilns Roundabout – Kilsyth	8.0	7.9	0.0	8.4	7.5	0.3	8.3	9.1	0.3
C32	1	Bogton - Bishopbriggs	5.9	7.1	0.4	6.2	7.0	0.3	7.2	6.8	0.2
	2	Bishopbriggs – Bogton	7.9	6.8	0.4	6.3	6.9	0.2	8.0	6.6	0.5
C33	1	Mollinsburn – Coatbridge	4.3	3.6	0.3	4.1	3.6	0.3	4.2	3.6	0.3
	2	Coatbridge - Mollinsburn	6.5	4.9	0.7	4.6	4.8	0.1	4.9	4.9	0.0
D1	1	Bellgrove St to Main St	14.1	12.8	0.3	13.9	13.4	0.1	15.4	13.9	0.4
	2	Main St to Bellgrove St	14.8	15.1	0.1	15.2	12.9	0.6	15.6	12.7	0.8
D2	1	M80 M9 J9 Stirling to J1 Provan	32.5	24.7	1.5	23.2	24.0	0.2	23.2	25.5	0.5
	2	J1 Provan to M80 M9 J9 Stirling	27.0	26.4	0.1	23.5	23.6	0.0	23.6	24.0	0.1
D3	1	A803 A80 Haggs to Townhead	41.1	37.0	0.6	35.2	37.9	0.4	38.1	37.8	0.0
	2	Townhead to A803 A80 Haggs	38.0	39.2	0.2	36.4	37.4	0.2	41.9	37.3	0.7
D4	1	A89 Airdrie to Baillieston Lights	14.6	14.4	0.1	13.9	13.7	0.1	15.6	13.6	0.5
	2	Baillieston Lights to A89 Airdrie	15.8	12.6	0.9	14.5	12.1	0.7	15.7	12.4	0.9
D5	1	A775 Newhouse to Glasgow Zoo	15.7	15.9	0.1	14.7	15.7	0.2	17.5	16.0	0.4

			AM			IP			PM		
Route	Direction	Description	Obs	Mod	GEH	Obs	Mod	GEH	Obs	Mod	GEH
	2	Glasgow Zoo to A775 Newhouse	18.3	15.2	0.8	15.2	14.3	0.2	16.8	15.0	0.5
D6	1	A725 Raith to A89 Coatbridge	13.1	9.3	1.1	9.9	9.0	0.3	14.2	11.3	0.8
	2	A89 Coatbridge to A725 Raith	13.4	10.5	0.8	7.9	9.0	0.4	13.1	8.5	1.4
D7	1	A8 Edinburgh Road to Alexander Park St	14.6	13.8	0.2	12.6	13.6	0.3	15.6	14.0	0.4
	2	A8 Alexander Park St to Edinburgh Road	13.8	13.2	0.1	12.0	12.3	0.1	13.2	12.0	0.3
D8	1	A89 Baillieston Lights to Millerston Street	14.0	11.9	0.6	12.7	12.1	0.2	15.2	12.3	0.8
	2	A89 Millerston Street to Baillieston Lights	15.2	14.8	0.1	13.2	13.6	0.1	14.1	13.3	0.2
D9	1	A74 Glasgow Zoo to A74 Fielden Street	11.4	9.0	0.7	10.6	10.2	0.1	12.5	11.8	0.2
	2	A74 Fielden Street to Glasgow Zoo	12.0	10.9	0.3	10.5	9.3	0.4	11.2	8.8	0.8
D10	1	A724 East Kilbride Expressway to A724 Springfield Road	19.9	18.8	0.2	18.3	20.7	0.5	22.6	20.6	0.4
	2	A724 Springfield Road to A724 East Kilbride Expressway	21.3	18.6	0.6	18.0	18.1	0.0	19.7	16.7	0.7
D11	1	A8 M8 J6 Newhouse to M8 J13 Provan	12.9	13.2	0.1	12.0	12.7	0.2	13.1	14.2	0.3
	2	M8 J13 Provan to A8 M8 Newhouse	16.5	13.4	0.8	12.5	12.3	0.0	13.8	13.2	0.1
E1	1	M8 Junction 29 to M8 Junction 22	8.8	7.3	0.5	7.9	7.1	0.3	9.8	7.1	1.0
E2	1	M8 Junction 15 to M8 Junction 24	10.5	10.1	0.1	7.4	6.3	0.4	18.6	13.5	1.3

6.2.3 Table 6.3 and Figure 6.3 (at the end of this chapter) detail the 'Aberdeen Area Urban Journey Routes'. Each individual route is illustrated in Appendix G. Table 6.3 also shows the mean observed and modelled journey times for each route in each time period.

Table 6.3 Aberdeen Area Urban Journey Routes

			AM			IP			PM		
Route	Direction	Description	Obs	Mod	GEH	Obs	Mod	GEH	Obs	Mod	GEH
A1	1	A90 Slip road at Portlethen to Great Northern Road/B979	36.2	37.4	0.2	29.4	26.2	0.6	38.7	35.8	0.5
	2	Great Northern Road/B979 to A90 slip road at Portlethen	37.0	36.6	0.1	27.8	25.8	0.4	39.2	31.6	1.3
A2	1	A90 Blackdog Junction to A956.A90	33.6	33.5	0.0	22.9	20.5	0.5	23.0	25.4	0.5
	2	A956/A90 to A90 Blackdog Junction	23.5	27.2	0.7	23.6	20.3	0.7	25.5	28.9	0.7

6.2.4 Table 6.4 and Figure 6.4 (at the end of this chapter) detail the 'Inter Urban Journey Routes'. Each individual route is illustrated in Appendix G. Table 6.4 also shows the mean observed and modelled journey times for each route in each time period.

Table 6.4 Inter Urban Journey Routes

			AM			IP			PM		
Route	**Direction**	**Description**	**Obs**	**Mod**	**GEH**	**Obs**	**Mod**	**GEH**	**Obs**	**Mod**	**GEH**
B3	1	A912 / A989 to A9 / A811 Roundabout	43.6	47.6	0.6	43.4	45.6	0.3	46.9	42.8	0.6
	2	A9 / A811 Roundabout to A85 / A93	42.7	45.9	0.5	43.9	47.7	0.6	44.5	45.8	0.2
B4	1	M9 J10 / A84 to M9 J10	50.9	50.8	0.0	45.9	53.0	1.0	53.5	51.0	0.3
	2	M9 J10 to M9 J10 / A84	50.7	49.1	0.2	44.3	51.7	1.1	54.2	49.0	0.7
B5	1	M80 J5 / M876 to M8 Hermiston Gate Roundabout	29.4	30.2	0.1	29.2	29.4	0.0	29.2	29.6	0.1
	2	M8 Hermiston Gate Roundabout to M80 J5 / M876	29.9	29.0	0.2	29.8	28.7	0.2	30.4	29.5	0.2
B6	1	A985 / A876 to M90 / A9 / A93 Roundabout	48.0	49.4	0.2	46.7	49.3	0.4	49.2	49.3	0.0
	2	M90 / A9 / A93 Roundabout to A985 / A876	48.8	49.1	0.0	48.7	49.2	0.1	55.8	49.0	0.9
B7	1	M9 J1a NB Off Slip to A929 / A972 / A90 Dumbbell Roundabout (West Roundabout)	74.4	76.4	0.2	76.1	73.2	0.3	75.5	87.6	1.3
	2	A929 / A972 / A90 Dumbbell Roundabout (West Roundabout) to M9 J1a NB Off Slip	76.9	78.2	0.1	79.3	71.1	1.0	79.9	76.0	0.4
B9	1	Newbridge Interchange (A8 / M9 / M8) to M8 J6 / A73 Roundabout	22.5	22.5	0.0	22.3	22.1	0.0	22.7	22.5	0.1
	2	M8 J6 / A73 Roundabout to Newbridge Interchange (A8 / M9 / M8)	24.8	22.8	0.4	22.7	22.4	0.1	25.3	22.7	0.5
B10	1	A713 Whitletts Road / B749 Craigie Road to A77 / B764	27.0	25.2	0.4	25.5	25.2	0.1	28.4	25.0	0.7
	2	A77 / B764 to A713 Whitletts Road / B749 Craigie Road	24.5	25.9	0.3	24.3	26.0	0.3	25.4	25.8	0.1

6.2.5 The 'A', 'B', and 'D' routes were surveyed at least six times in each direction in each modelled time period; the 'C' routes were surveyed at least four times. Two new routes, annotated as 'E' (in the tables above), have been added to the validation analysis procedure, since TMfS:02, and have been surveyed six times (in each direction). The resulting journey times were analysed to determine the mean journey time and standard error. This in turn led to a range of acceptable journey times given a 95% confidence interval that would be expected for each route, given that the journey times would vary in the form of a normal distribution.

6.2.6 The confidence intervals used were calculated using the following formula:

95% Confidence Interval for Population = Sample Mean +- t(0.025,n-1) * s

where:

n – sample size;

t – two tailed t-test with 5% level of significance and n-1 degrees of freedom; and

s – standard deviation of sample.

6.2.7 Appendix H contains detailed journey time analysis for each route detailed in Tables 6.1 to 6.4. These results are, shown graphically along with the confidence intervals and are discussed further in this chapter.

6.2.8 It should be taken into consideration that the journey time routes used in the validation process, except for route 'E', are from TMfS:02 and have not been factored to a 2005 base level. In addition, some of the journey time routes have been physically altered as a result of newly constructed Highway schemes, an example being Route B10 between the A713 Whitletts Road / B749 Craigie Road and A77 / B764. The M77 Extension between Fenwick and Malletsheugh has been completed and included in the network. This will therefore have an effect on the network flows and the journey time. A complete list of highway schemes that have been coded in the TMfS:05 network are located earlier in Chapter 2 of this report.

6.2.9 For the Edinburgh area journey times, there are eight instances where a journey time lies outwith its 95% confidence intervals (see Appendix H). Route B8_2 consistently lies outwith its respective confidence intervals over all three time periods. These routes are listed in Table 6.5 below:

Table 6.5 Edinburgh Urban Area Journey Routes

Time Period	Route ID	Description	Additional Time Periods
AM	B8_2	A6095 Dumbbell Roundabout A1 Slips to M9 J3 On Slip / A803	IP/PM
	B13_1	A720 / A701 Burdiehouse Road to A1 West Slips / Newcraighall Roundabout	
IP	B1_2	B701 Wester Hailes Road / Harvesters Way to A720 Lothianburn Junction	
	B13_2	Newcraighall Roundabout / A720 / A701 Burdiehouse Road to A1 West Slips	PM
PM	B2_1	A989 Tay St / A85 West of Bridge to A90 / A929 / A972 Dumbbell Roundabout	

6.2.10 The AM period has two journey time routes that lie outside their confidence intervals. The modelled journey time for Route B8_2 is faster than the observed time whereas, Route B13_1's modelled time is marginally longer.

6.2.11 The Inter-Peak contains three such routes; these are dealt with in turn. The model journey time for Route 1_2 is around 10 minutes quicker than the observed time. However, it must be noted that the Central Edinburgh Traffic Management scheme has been included in TMfS:05, it is anticipated that some routes that pass through the centre of Edinburgh would differ from their recorded journey time. Route B8_2, lies outwith its confidence interval, however, it must be noted that the confidence intervals for achieving validation of this journey are very small. Route 13_2 journey time is marginally slower that the observed time.

6.2.12 The PM Peak period contains three routes whish lie outwith their confidence intervals. Route B2_1's modelled journey time is around seven minutes faster than. The worst offender in this time period is Route B8_2, which is around 10 faster than the observed data.

6.2.13 In general, the Edinburgh Area Journey Times demonstrate a high level of validation.

6.2.14 For the Glasgow Area Journey Times there are 14 instances where a modelled journey time lies outwith with its 95% confidence intervals in the AM Peak period, 21 in the Inter-Peak and 19 in the PM Peak Period. These routes are listed in Table 6.6 below:

Table 6.6 Glasgow Area Urban Journey Times

Time Period	Route ID	Description	Additional Time Periods
AM	C2_2	Motherwell – Carmyle	
	C7_2	A73 Newhouse - A726 Nitshill	
	C14_1	A77 – East Kilbride	IP/PM
	C29_1	George Square / Castle St (Anti-Clockwise)	IP
	C33_1	Mollinsburn – Coatbridge	IP
	D2_1	M80 M9 J9 Stirling to J1 Provan	
	D3_1	A803 A80 Haggs to Townhead	IP
	D5_2	Glasgow Zoo to A775 Newhouse	IP/PM
	D6_1	A725 Raith to A89 Coatbridge	
	D7_1	A8 Edinburgh Road to Alexander Park St	
	D8_1	A89 Baillieston Lights to Millerston Street	IP/PM
	D9_1/2	A74 Glasgow Zoo to A74 Fielden Street	
	D10_2	A724 Springfield Road to A724 East Kilbride Expressway	
IP	C2_1/2	Motherwell – Carmyle	PM
	C3_2	Barrhead – Irvine	PM
	C4_1	East Kilbride Cirular (Anti-Clockwise)	
	C6_2	Junction with A77 - M77 J2	
	C18_1	Partick - Hillfoot	PM
	C19_1/2	M77 J2 - A8 Bargeddie	
	C20_1/2	Glasgow - Bearsden	
	C22_2	Great Western Road (A8014 to M8)	
	D4_2	Baillieston Lights to A89 Airdrie	
	D10_1	A724 East Kilbride Expressway to A724 Springfield Road	
	D11_1	A8 M8 J6 Newhouse to M8 J13 Provan	PM
	E2_1	M8 Junction 15 to M8 Junction 24	
PM	C1_1	Port Glasgow - Hillington	
	C16_1	Kingsway – Anniesland Cross	
	C21_1	A82 / A898 Junction Circular (Clockwise)	
	C27_2	A73 Newhouse - A71/ A78 Irvine	
	D3_2	Townhead to A803 A80 Haggs	
	D7_1/2	A8 Edinburgh Road to Alexander Park St	
	D8_2	A89 Millerston Street to Baillieston Lights	
	D9_2	A74 Fielden Street to Glasgow Zoo	
	D10_1/2	A724 East Kilbride Expressway to A724 Springfield Road	

AM Peak Period

6.2.15 Routes C2_2 and C33_1 both lie outwith their confidence interval, however, it must be noted that the confidence intervals for achieving validation of this journey time are only a minute either side of the average, and for a strategic model such as TMfS:05 is very difficult to match this journey time.

6.2.16 Routes D2_1, D3_1, D5_2, D6_1, D7_1, D8_1, D9_1, D9_2 and D10_2 all lie outwith their confidence interval, however the scale of which is minor, representing a few minutes. The modelled journey time is faster than the observed journey time data.

6.2.17 Route C14_1 along with C7_2 are examples of those journey time routes affected by additional schemes modelled in TMfS:05. The Glasgow Southern Orbital (GSO) removes traffic from the B764 on which Route C14 travels along. Route C7 travels along the A726 which may be affected by the addition of the GSO and associated traffic flows. As a result, it would be anticipated that the modelled journey time would be outside the recorded time.

6.2.18 The modelled time to travel Route C29_1 is slower that the observed data collected for this route, however the difference is journey times is not considered to have a major affect on the performance of TMfS:05.

Inter-Peak Period

6.2.19 Routes C2_1/2, C19_1, C20_1/2, C22_2, C33_1, D4_2, D5_2, D8_1 and E2_1 all lie outwith their confidence intervals, however the scale of which is minor, representing a few minutes. The modelled journey time is faster than the observed journey time data.

6.2.20 Routes C3_2, C4_1, C6_2, C18_1, C19_2, C29_1, D3_1 and E2_1 all lie outwith their confidence intervals, however the scale of which is minor, representing a few minutes. The modelled journey time is slower than the observed journey time data.

PM Peak Period

6.2.21 Routes C1_1, C2_1, C2_2, C16_1, C21_1, C27_2, D3_2, D5_2, D7_1/2, D8_1/2, D9_2 and D10_1/2 all lie outwith their confidence intervals, however the scale of which is minor, representing a few minutes. The modelled journey time is faster than the observed journey time data. In particular, Route D10_1/2 follows a very similar pattern to the TMfS:02 comparison between modelled and observed journey time. In any instance where the journey time is outwith its confidence levels, it differs by ±5 minutes.

6.2.22 Routes C3_2, C18_1 and D11_1 all lie outwith their confidence intervals, however the scale of which is minor, representing a few minutes. The modelled journey time is slower than the observed journey time data.

6.2.23 For the Aberdeen Area Journey Times, there are no instances where a modelled journey time lies outwith its 95% confidence intervals over all three time periods.

6.2.24 For the Inter Urban Journey Times there are a total of 14 instances where a modelled journey time falls out with its 95% confidence intervals. Table 6.7 highlights the routes in question.

Table 6.7 Inter Urban Journey Times

Time Period	Route ID	Description	Additional Time Periods
AM	B3_2	A9 / A811 Roundabout to A85 / A93	IP
	B9_2	M8 J6 / A73 Roundabout to Newbridge Interchange (A8 / M9 / M8)	PM
IP	B4_1	M9 J10 / A84 to M9 J10	PM
	B4_2	M9 J10 to M9 J10 / A84	
	B7_2	A929 / A972 / A90 Dumbbell Roundabout (West Roundabout) to M9 J1a NB Off Slip	PM
	B10_2	A77 / B764 to A713 Whitletts Road / B749 Craigie Road	
PM	B3_1	A85 / A93 to A9 / A811 Roundabout	
	B6_2	M90 / A9 / A93 Roundabout to A985 / A876	
	B7_1	M9 J1a NB Off Slip to A929 / A972 / A90 Dumbbell Roundabout (West Roundabout)	

6.2.25 The AM peak period has two journey time routes that lie outwith their confidence intervals. Route B3_2 is marginally outwith its confidence interval, represents a few minutes difference. The modelled journey time is slower than the observed journey time data, a similar pattern can be seen in the Inter-Peak period. Route B9_2, is faster that the observed journey time however, it must be noted that the confidence intervals for achieving validation of this journey time are very small and for a strategic model such as TMfS:05 it is very difficult to match this journey time.

6.2.26 The Inter-Peak's Route B4_1 and B4_2 both lie outwith their confidence intervals, with the modelled journey time being slower than the observed journey time. These routes are also outwith their confidence intervals in the PM Peak, in this instance the modelled journey time is marginally faster than observed data. It must be noted that Route B4_1 and its reverse B4_2, are affected by new schemes modelled in TMfS:05. The A876 Kincardine Bridge Eastern Link removes the need for traffic travelling through the village of Kincardine, therefore it can be anticipated that the modelled journey time will be different to the observed time.

6.2.27 Route 7_2 and 10_2 complete the list of journey time that are not within the confidence intervals. Route 7_2's modelled journey time is faster than observed timings, it must be noted that the observed data comes from the CSTCS model (circa 2000). Despite being outwith its confidence intervals, it is envisaged that this journey time will not have a detrimental effect on the validation of TMfS:05. Route 10_2 is slightly slower that the observed journey time however, it must be noted that the confidence intervals for achieving validation of this journey time is very small and for TMfS:05 this is very difficult to match and, given age of data, perhaps inappropriate to closely match.

6.2.28 Routes B3_1, B4_1/2, B6_2, B7_2 and B9_2 in the PM Peak Period all lie outwith their confidence intervals, however the scale of which is minor, representing a few minutes. The modelled journey time is faster than the observed journey time data. Route B7_1 remains virtually unchanged from TMfS:02 where it was marginally outside its 95% confidence intervals, its modelled journey time is slower than the observed data.

6.2.29 As the Inter Urban Routes are surveyed over longer distances, additional analysis was undertaken where these routes were divided into segments. Table 6.8 details these segments with the diagrams and results shown in Appendix I. Overall, the journey time segments show as good a level of validation as exhibited over the whole route.

Table 6.8 Inter Urban Route segments

Route	Segment	Description
B3	1	A912/A989 – A9/M90 Roundabout
	2	A9/M90 Roundabout – A9/B8033
	3	A9/B8033 – A9/A811 Roundabout
B4	1	M9 J10/A84 – A907/A977
	2	A907/A977 – M876/A905 Roundabout
	3	M876/A905 Roundabout – M9 J10
B5	1	M80 J5/M876 – M9 J7 NB On slip
	2	M9 J7 NB On slip – M9 J3 Slips
	3	M9 J3 Slips – M8 Hermiston Gate Roundabout
B6	1	A985/A876 Roundabout – M90 J2 NB Off slip
	2	M90 J2 NB Off slip – M90 J8 NB Off slip
	3	M90 J8 NB Off slip – M90/A9/A93 Roundabout
B7	1	M9 J1a NB Off Slip – A92/B9149 West Slips
	2	A92/B9149 West Slips – A91/A92
	3	A929 / A972 / A90 Dumbbell Roundabout (West Roundabout)
B9	1	A8/M9/M8 Newbridge GSJ – M8 J3 WB Off Slip
	2	M8 J3 WB Off Slip – M8 J4 East Slips
	3	M8 J4 East Slips – M8 J6/A73 Roundabout
B10	1	A713 Whitletts Road/B749 Craigie Road – A77/A78 Roundabout
	2	A77/A78 Roundabout – A77/B7038 NB On Slip
	3	A77/B7038 NB On Slip – A77/B764

6.3 Validation Count Sites

6.3.1 Traffic count data not used in calibration has been used for the purposes of the validation. In total, 1,372 one-way counts have been used to present the validation of the HAM. The locations of these sites are described in Appendix J along with the source, type and date of the associated count. Figure 6.5 provides an illustration of the independent validation counts within the TMfS study area.

6.3.2 Appendix K presents tables for the AM peak, Inter-Peak and PM peak observed and modelled flows. The GEH statistic has again been used to assess the overall acceptability of the results.

6.3.3 Table 6.9 presents a summary of the validation site analysis:

Table 6.9 Validation Site Analysis

	% of sites with GEH value (TMfS:02 Values in brackets)				
Time Period	≤5	≤7	≤10	≤12	≤15
AM	48 (55)	65 (70)	84 (87)	92 (94)	98 (98)
IP	60 (62)	77 (76)	91 (90)	97 (96)	100 (99)
PM	50 (52)	65 (68)	84 (83)	93 (92)	99 (98)
Target	60%	80%	95%	100%	

6.3.4 As with the link flow analysis performed on the calibration sites the majority of sites exhibit a GEH statistic less than 12. However, the highest GEH values are

15.9 in the AM peak, 15.7 in the Inter-Peak and 15.9 in the PM peak respectively. Appendix L contains graphical representations of the screenline results. Although the percentages are lower than TMfS:02 values, it must be remembered that there has been a significant increase in the number of screenlines used in the validation process. Many of these additional counts are in rural areas or on the periphery of the modelled area and can be affected by a lack of adequate travel pattern data, low levels of good quality calibration data and lack intra-zonal trips. Of all the Key Links with a GEH in excess of 15, there are 23 in the AM peak, 7 in the Inter-Peak and 21 in the PM peak.

6.4 Trip Length Distribution Analysis

6.4.1 Trip Length Distribution analysis has also been undertaken for each vehicle class. Appendix M contains the trip length distributions for ‘Car In Work’, ‘Car Non Work’, ‘LGV’ and ‘HGV’ for the AM peak, Inter-Peak and PM peak respectively.

6.4.2 For each graph there are two trip length distributions shown. The first is the TMfS Prior matrix (Prior). The second is the Final TMfS assignment matrix after matrix estimation (Estimated).

6.4.3 The matrix estimation process has produced a slight increase in short distance trips in comparison to the prior matrices. This can be expected from simple matrix estimation techniques, as MVESTM adds in a small number of short distance trips particularly to match calibration screenline counts, especially those with a higher assigned confidence level. This slight increase is not deemed to reduce the quality of the calibrated matrix.

6.5 HGV Screenline Analysis

6.5.1 HGV Screenline Analysis has also been undertaken for the screenlines used in the validation where suitable classified vehicle count data was available.

6.5.2 Table 6.10 presents a summary of the HGV screenline analysis:

Table 6.10 HGV Screenline Analysis

	% of sites with GEH value (TMfS:02 values in brackets)				
Time Period	≤5	≤7	≤10	≤12	≤15
AM	54 (62)	68 (77)	82 (88)	88 (92)	93 (96)
IP	57 (67)	70 (71)	85 (90)	91 (93)	96 (97)
PM	59 (67)	73 (80)	88 (90)	94 (95)	97 (97)
Target	60%	80%	95%	100%	

6.5.3 The majority of HGV screenlines exhibit a GEH statistic of less than 12. The highest GEH value in the AM peak is 25.9, with corresponding figures of 27.4 and 32.1 for the Inter-Peak and PM peak periods respectively. The TMfS:05 statistics are poorer than their TMfS:02 counterparts as a consequence of issues raised in section 6.3.4 above. It should also be stressed that no specific calibration work is carried out on HGVs, only on total PCUs and so *all* HGV data is used for validation. For all of the Key Links with a GEH statistic greater than 15, there are 91 in the AM peak, 59 in the Inter-Peak and 35 in the PM peak.

6.5.4 The majority of sites exhibit a GEH statistic of less than 12. As previously mentioned, the number of screenline sites used in the validation process has significantly increased with many of these additional counts being in rural areas or on the periphery of the modelled area, which can be affected by a lack of intra-zonal trips.

6.5.5 Appendix N contains graphical representations of TMfS:05 screenline results, showing counts versus modelled flow in vehicles. This shows that TMfS contains a good match for most HGV counts, however, the model underestimates some links with high HGV flows.

6.6 Car In Work, Car Non Work Analysis

6.6.1 Screenline analysis was also conducted for those sites where a count was available for both the 'Car In Work' and 'Car Non Work' journey purposes, these were from RSI sites where trip purpose had been one of the questions. Tables 6.11 and 6.12 show the screenline analysis for 'Car In Work' and 'Car Non Work' respectively.

Table 6.11 Car In Work Screenline Analysis

	% of sites with GEH value (TMfS:02 values in brackets)				
Time Period	≤5	≤7	≤10	≤12	≤15
AM	74 (76)	86 (90)	93 (98)	97 (100)	100 (100)
IP	78 (84)	91 (97)	98 (99)	98 (99)	100 (100)
PM	80 (80)	88 (93)	95 (98)	98 (100)	99 (100)
Target	60%	80%	95%	100%	

6.6.2 The majority of sites exhibit a GEH statistic less than 12.

Table 6.12 Car Non Work Screenline Analysis

	% of sites with GEH value (TMfS:02 values in brackets)				
Time Period	≤5	≤7	≤10	≤12	≤15
AM	61 (56)	74 (73)	86 (89)	91 (95)	95 (98)
IP	67 (66)	81 (84)	95 (94)	97 (97)	98 (100)
PM	53 (57)	66 (71)	83 (87)	88 (95)	93 (99)
Target	60%	80%	95%	100%	

6.6.3 The majority of sites exhibit a GEH statistic less than 12.

6.6.4 Both the 'Car In Work' and 'Car Non Work' screenline analysis compare favourably with TMfS:02 results.

6.6.5 In a similar comparison to the HGV validation, it should be noted that Total PCUs are used in calibration and therefore all data relating to the In Work and Non Work split is used in validation. The resulting analysis is not generally valid to compare to screenline based targets, but more so demonstrative of the validation a combination of matrix splitting (into In Work and Non Work) and the assignment methodology.

6.7 Census Travel to Work Data

6.7.1 The post MVESTM TMfS:05 AM peak hour matrix has been validated against 'Census Travel-to-Work' data. Table 6.13 shows the pattern, as a percentage of the total, of productions and attractions in both TMfS:05 and in the 'Census Travel-to-Work' AM peak hour matrices.

6.7.2 TMfS:05 tends to have slightly high proportions in the urban areas and much smaller proportions in the more rural areas. This is because within urban areas, TMfS has a fine zoning system, rural areas however, have a coarse zoning system. In these local authorities, the only trips in the model are long distance trips and intra zonal trips are not included.

6.7.3 The table shows that the pattern within the base AM peak TMfS:05 matrix demonstrates a good match with the Census Travel-to-Work matrix.

Table 6.13 Production and Attraction patterns as a percentage of the total

Local Authority	*census productions*	*TMfS:05 productions*	*census attractions*	*TMfS:05 attractions*
Aberdeenshire	4%	3%	2%	1%
Angus	2%	1%	1%	1%
Argyll & Bute	0%	0%	0%	0%
City of Aberdeen	5%	7%	8%	9%
City of Dundee	3%	2%	4%	2%
City of Edinburgh	11%	13%	14%	15%
City of Glasgow	10%	18%	16%	23%
Clackmannanshire	1%	1%	1%	1%
Dumfries & Galloway	2%	2%	2%	2%
East Ayrshire	3%	1%	2%	1%
East Dunbartonshire	4%	4%	2%	2%
East Lothian	2%	1%	1%	1%
East Renfrewshire	3%	4%	1%	2%
England & Wales	0%	0%	0%	0%
Falkirk	4%	3%	3%	2%
Fife	8%	9%	7%	8%
Highland	0%	0%	0%	0%
Inverclyde	2%	0%	2%	1%
Midlothian	2%	1%	1%	1%
Moray	0%	0%	0%	0%
North Ayrshire	3%	1%	2%	1%
North Lanarkshire	7%	7%	6%	6%
Perthshire & Kinross	3%	2%	3%	1%
Renfrewshire	4%	5%	5%	5%
South Ayrshire	3%	1%	3%	1%
South Lanarkshire	7%	6%	6%	5%
Stirling	2%	2%	2%	2%
The Borders	1%	1%	1%	1%
West Dunbartonshire	2%	1%	1%	1%
West Lothian	4%	2%	4%	2%

6.7.4 Appendix P contains similar analysis to Table 6.10, although the data in the appendix is presented in terms of the pattern of trips produced by each Local Authority. For each Local Authority, the AM peak trip pattern to each of the other Local Authorities demonstrates a good match to the Census Travel-to-Work data. This data is also shown with the exclusion of intra Local Authority Trips. This shows an even better match, for all local authorities except those, right on the model periphery.

6.7.5 It should be noted, however, that the TMfS commuter matrix was extracted from the Base Year Non-Work matrix using factors from the Scottish Household Survey. These factors are only at a three sector level (Edinburgh, Glasgow and elsewhere) and hence the analysis is very coarse.. It should, also be noted that the factors tend to be higher in the Glasgow and Strathclyde area.

6.7.6

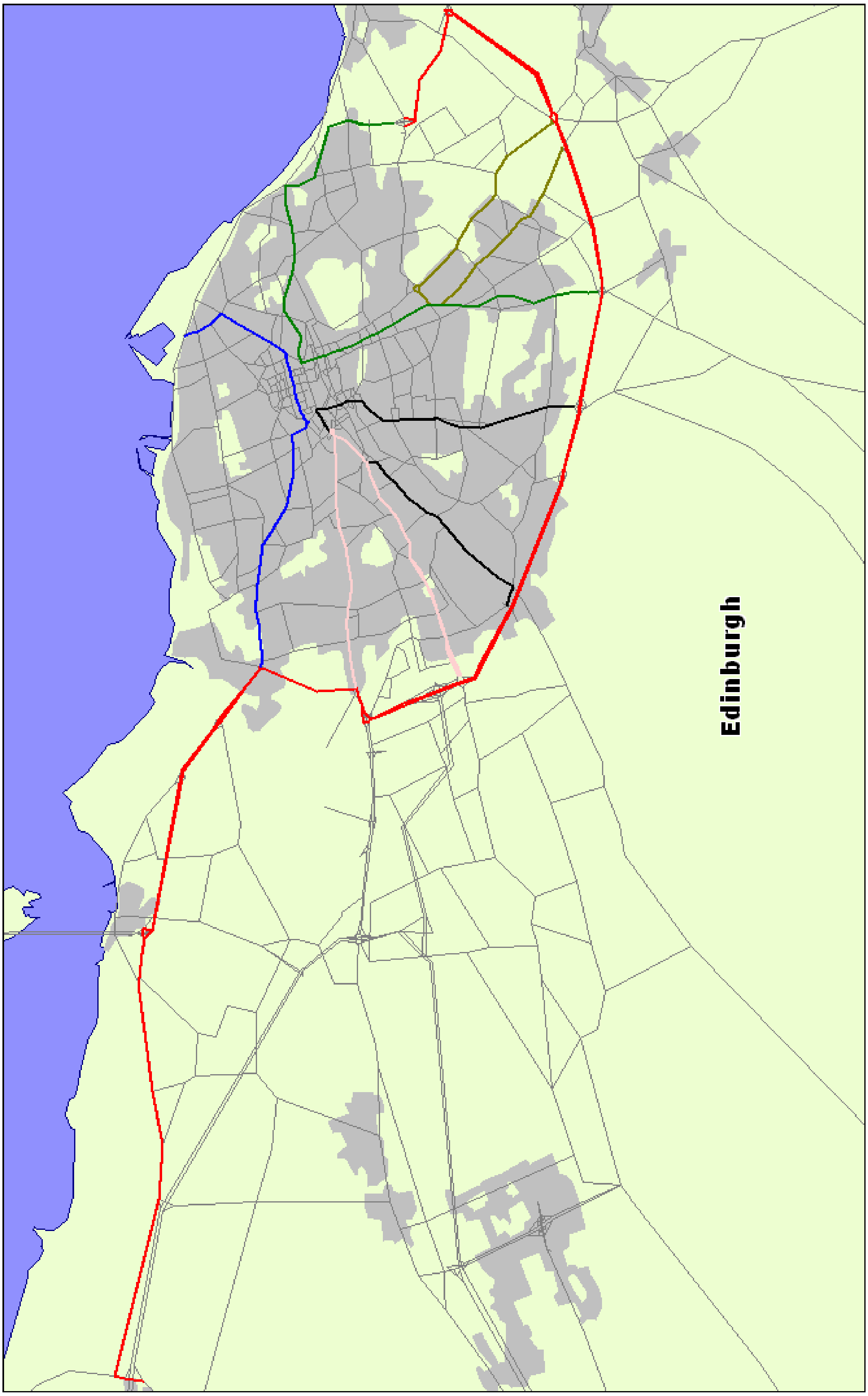

Figure 6.1 Edinburgh Area Urban Journey Routes (see Appendix J for details of each route)

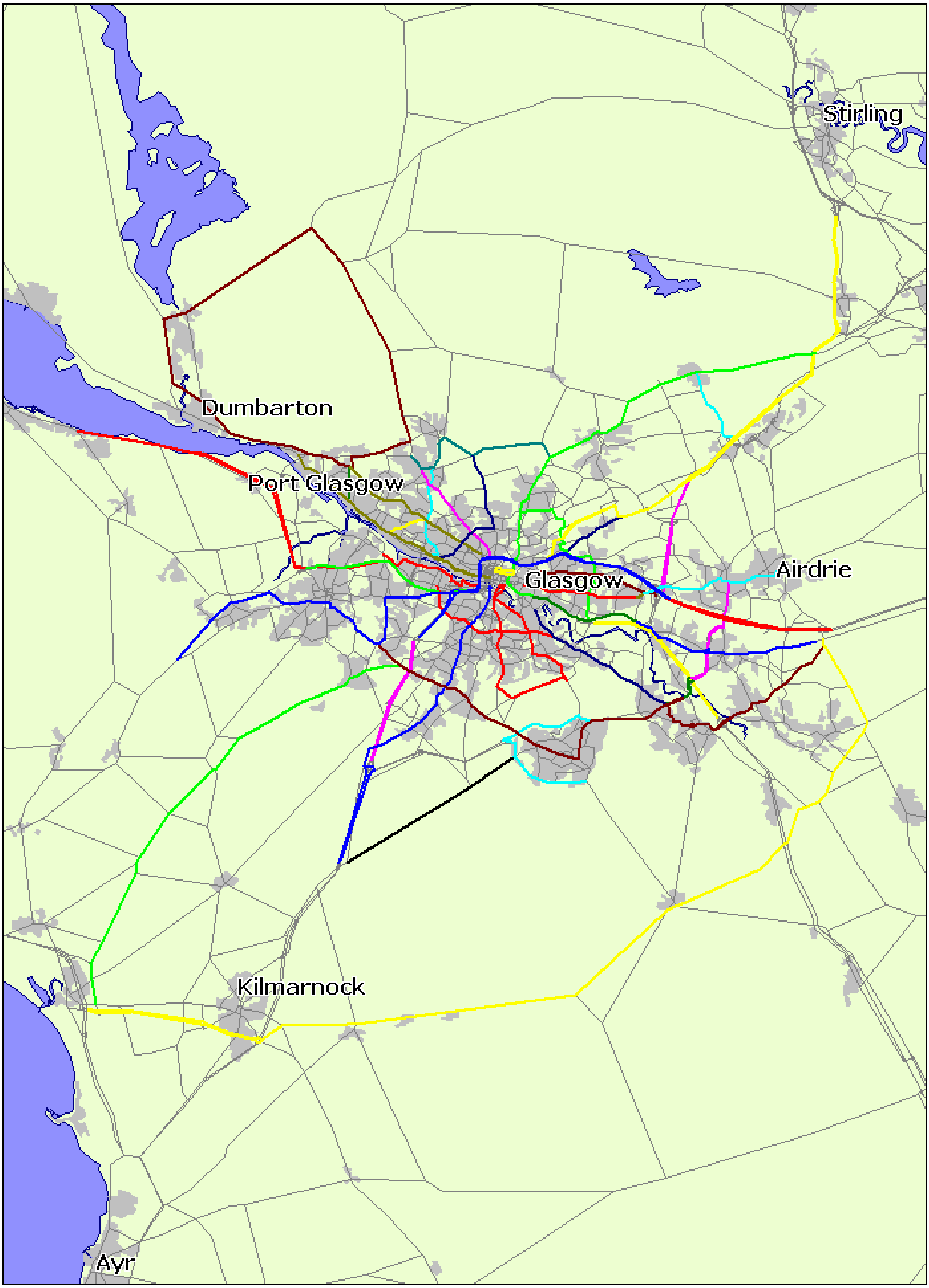

Figure 6.2 Glasgow Area Urban Journey Routes

(See Appendix G for details of each route)

Figure 6.3 Aberdeen Area Urban Journey Routes

(See Appendix G for details of each route)

Figure 6.4 Inter Urban Journey Routes

(See Appendix G for details of each route)

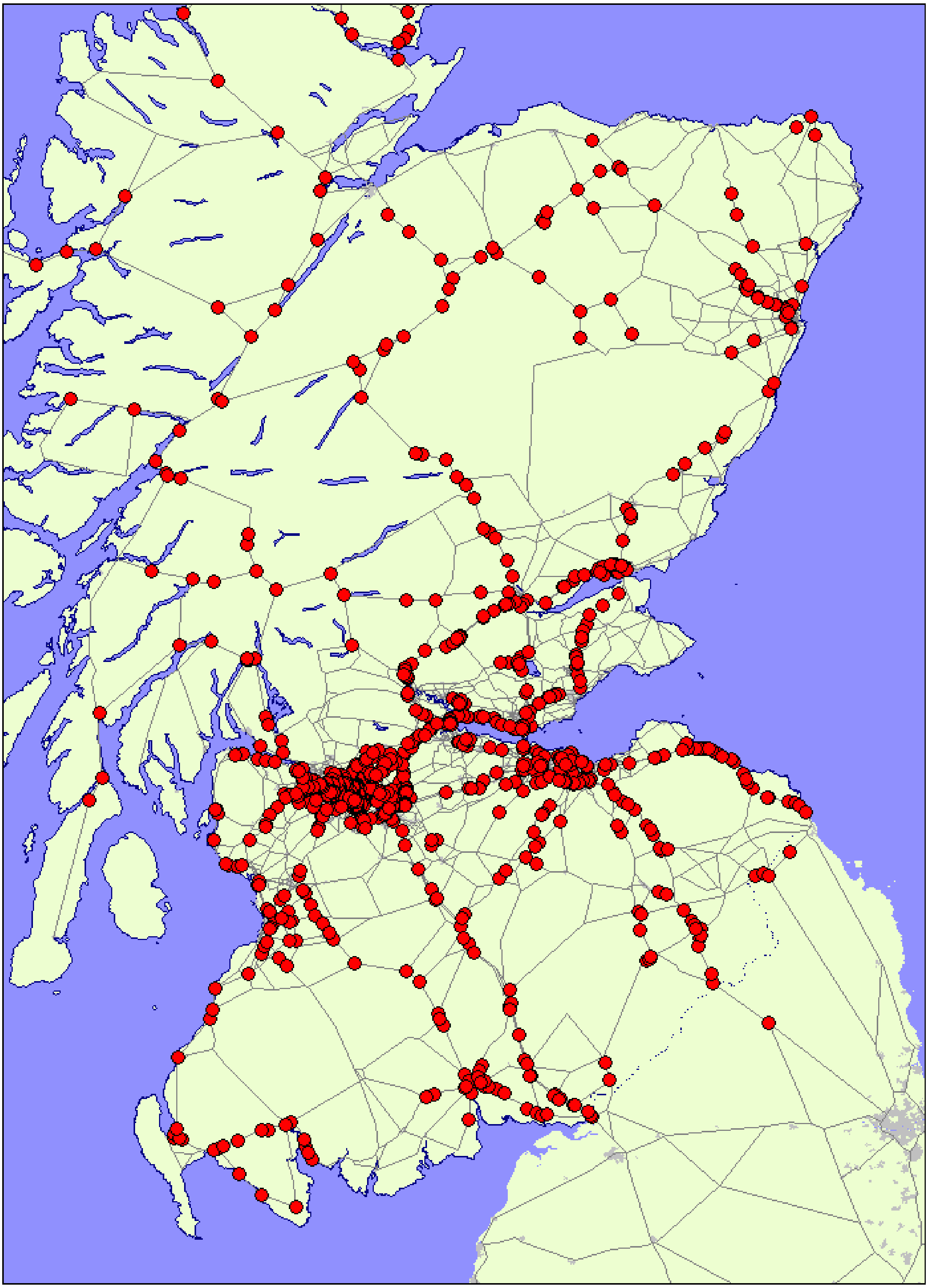

Figure 6.5 Validation Count Site Locations

6 Validation

7 Conclusions and Recommendations

7.1 Conclusions

7.1.1 This report has presented the calibration and validation of the 2005 TMfS Rebase Highway Assignment Model.

7.1.2 The network was developed from the TMfS:02 with numerous schemes added to the network. A checking procedure was undertaken on all approaches to modelled junctions in order to verify the link distances and capacity indices.

7.1.3 The zone system was altered to include the creation of new zones at Aberdeen, Prestwick and Edinburgh Airports as well as at the Royal Bank of Scotland (RBS) headquarters on the A8. Adjustments were also made to those zones that had irregular trip rates, based on the latest 2005 TELMoS planning data. Before applying MVESTM, the demand matrices were passed through the Park and Ride procedure.

7.1.4 An exacting calibration has been undertaken to link/screenline counts. The model is particularly well calibrated in the key areas (trunk roads/motorways), it validates well in the vast majority of the modelled area. Whilst it is less well calibrated in some rural areas, due to the large zones on the periphery of the modelled area and absence of quality observed data, the model still meets good standards of calibration. It should also be considered that TMfS:05 model incorporates a significantly higher number of screenlines and counts both in the calibration and validation process than that included in TMfS:02.

7.1.5 The model validates well in the key areas against journey times and against the very large number of counts not included in calibration. TMfS:05 also incorporates an increased number of journey times for the validation process over that used in TMfS:02.

7.1.6 Our view is that the HAM has been successfully developed and is fit for its intended purpose.

7.1.7 The TMfS:05 Highway Assignment Model can be used for the assessment of major strategic Highway schemes and policy decisions as part of the TMfS modelling suite. It is also fit for use as a source of travel demand and network structure for more localised models.

7.2 Recommendations

7.2.1 For future development, it is recommended that the highway matrices are enhanced using new RSI data. In particular, the collection of RSI data within Edinburgh is particularly dated and the model would benefit from inclusion of updated information.

7.2.2 We also recommend that the project of turning links which should be dualled from two-lane one-way links into fully dualled links is completed, this task will be specifically useful in any congestion/environmental mapping that may be undertaken as part of future work streams.

7.2.3 Each potential application of the model should be assessed in detail prior to ensure that the quality of the model is appropriate for the desired output as the quality of data input and consequently output differs across the entire modelled area.