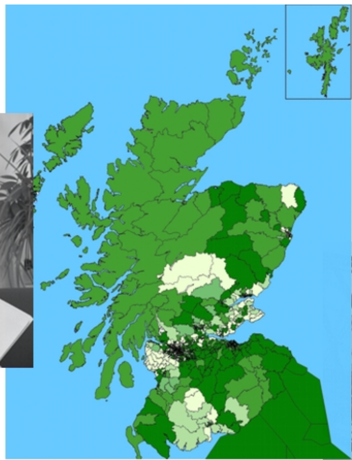
Transport Model for Scotland 05A Highways Calibration and Validation Report

Report for Transport Scotland

July 2008



Transport Model for Scotland

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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. The development of TMfS was completed in August 2004.

1.1.2 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. The model has a Base Year of 2005 and since completion has been used for a range of infrastructure and policy assessments by MVA, other consultants, Local Authorities and Transport Scotland.

1.2 Development of TMfS:05A

1.2.1 During 2007, MVA was instructed by Transport Scotland to produce an updated version of TMfS:05, known as TMfS:05A. This model forms the latest version of the model for general release. The main aims of TMfS:05A were twofold.

1.2.2 The first was to improve spatial detail and the representation of the supply side of the model in 'external' areas of the highway and public transport models, mainly the Highlands. The purpose of this enhancement was to feed a new accessibility analysis module to allow nationwide accessibility analysis to be undertaken on a consistent basis. It also provides more accurate travel time / cost information in these areas, building on new journey time surveys also undertaken in 2007.

1.2.3 The second aim was to incorporate new demand data from recent roadside interviews in the highway model in areas where the model was previously perceived to be weak, namely the Ayrshire and Dundee areas.

1.2.4 This report describes the development of the TMfS 2005A Highway Assignment Model (HAM). Separate reports detail the other aspects of the TMfS 2005A development:

- TMfS:05A PTAM Cal Val Draft Report, MVA October 2007; and
- TMfS:05A Park and Ride Model Development Report, MVA October 2007.

1.2.5 The TMfS:05A HAM was developed by drawing upon a variety of sources for network information and by incorporating roadside interview survey data and associated traffic count data.

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

1.2.7 Throughout this report, the original 2005 TMfS model will be referred to TMfS:05 and the new extended TMfS 2005 model as TMfS:05A.

1.2.8 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 Structure of this report

1.3.1 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 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:05A 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.

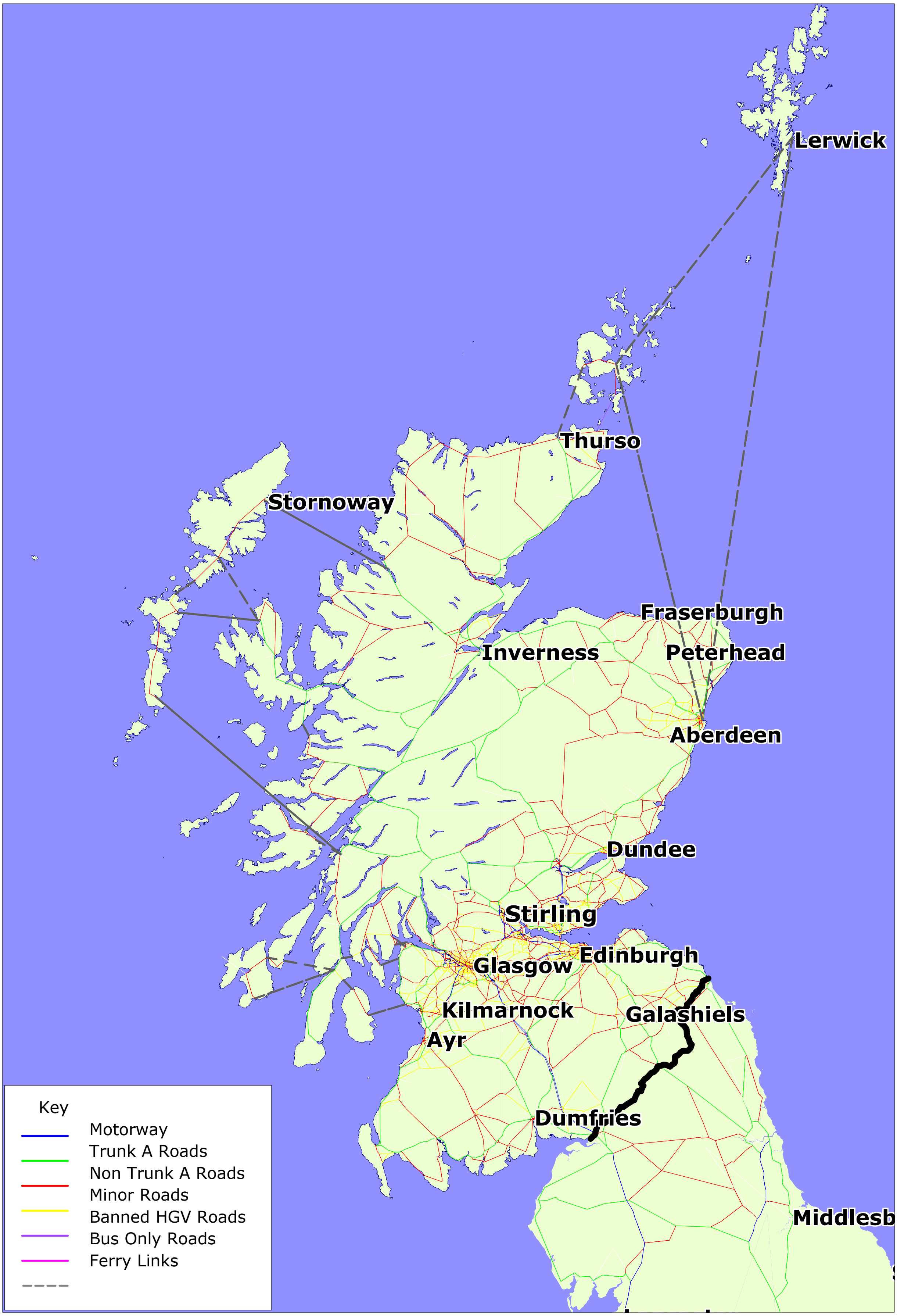

Figure 1.1 TMfS:05A Modelled Area

2 Network Development

2.1 Introduction

2.1.1 This chapter considers the network developments that have been incorporated into the TMfS:05A model.

2.1.2 The principal developments of the TMfS:05A Highway network are as follows:

- refinement of modelled road network following the Audit of TMfS:05 and application of model to improve network representation;
- review and refinement of road links in the Highlands and Argyll and Bute areas based on journey time data collected as part of the Strategic Transport Projects Review commission; and
- addition of ferry links and connecting roads infrastructure to represent the Scottish Islands including the Clyde estuary, Argyll and Bute, the western isles, Orkney and Shetland.

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

- link types;
- link capacities;
- speed/flow curve definition;
- link distance checks;
- modelled junction data; and
- representation of ferry fares.

2.2 Link types

2.2.1 The link types used in the TMfS:05A are in line with those used in the Scottish Transport Statistics Note 24 (see Table 2.1), these remain consistent with TMfS.05. 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, three additional link types have been used in the network:

- 9 – Banned HGV;
- 10 – Bus Only; and
- 14 – Ferry Links (new link type within TMfS:05A).

2.3 Link capacities

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

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 existing speed flow definitions for the updated TMfS:05A from those used in TMfS.05.

2.4.2 Additional speed/flow curves have, however, been added within TMfS:05A to represent speeds on the journey time routes surveyed as part of the Strategic Transport Projects Review commission. The new capacity indices were based on the current TMfS capacity index 16 (rural routes) with the same profile applied to derive the speed at 80% capacity, and 100% capacity. The new curves maintain freeflow speed up to 50% capacity whereas the speed for capacity index 16 starts to reduce above 0% capacity. Starting from 26mph and increasing in steps of 3 mph until 68mph resulted in new capacity indices 26 to 40 inclusive.

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

TMfS CI	Description
22	Rural all purpose three or more lanes
23	Rural all purpose two lanes
	Other Capacity Indices
24	Traffic calming
25	50mph expressway
	STPR Journey Time Survey Routes
26	26 mph freeflow speed
27	29 mph freeflow speed
28	32 mph freeflow speed
29	35 mph freeflow speed
30	38 mph freeflow speed
31	41 mph freeflow speed
32	44 mph freeflow speed
33	47 mph freeflow speed
34	50 mph freeflow speed
35	53 mph freeflow speed
36	56 mph freeflow speed
37	59 mph freeflow speed
38	62 mph freeflow speed
39	65 mph freeflow speed
40	68 mph freeflow speed

2.4.3 There are three types of curves are used in the model (see Figure 2.1), which are the same as TMfS.05:

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.

2.4.4 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.

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

2.4.6 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
Type 1	1, 3, 5-7, 10-11, 13, 16-19, 21-40
Type 2	2, 4, 12
Type 3	8-9, 14-15, 20

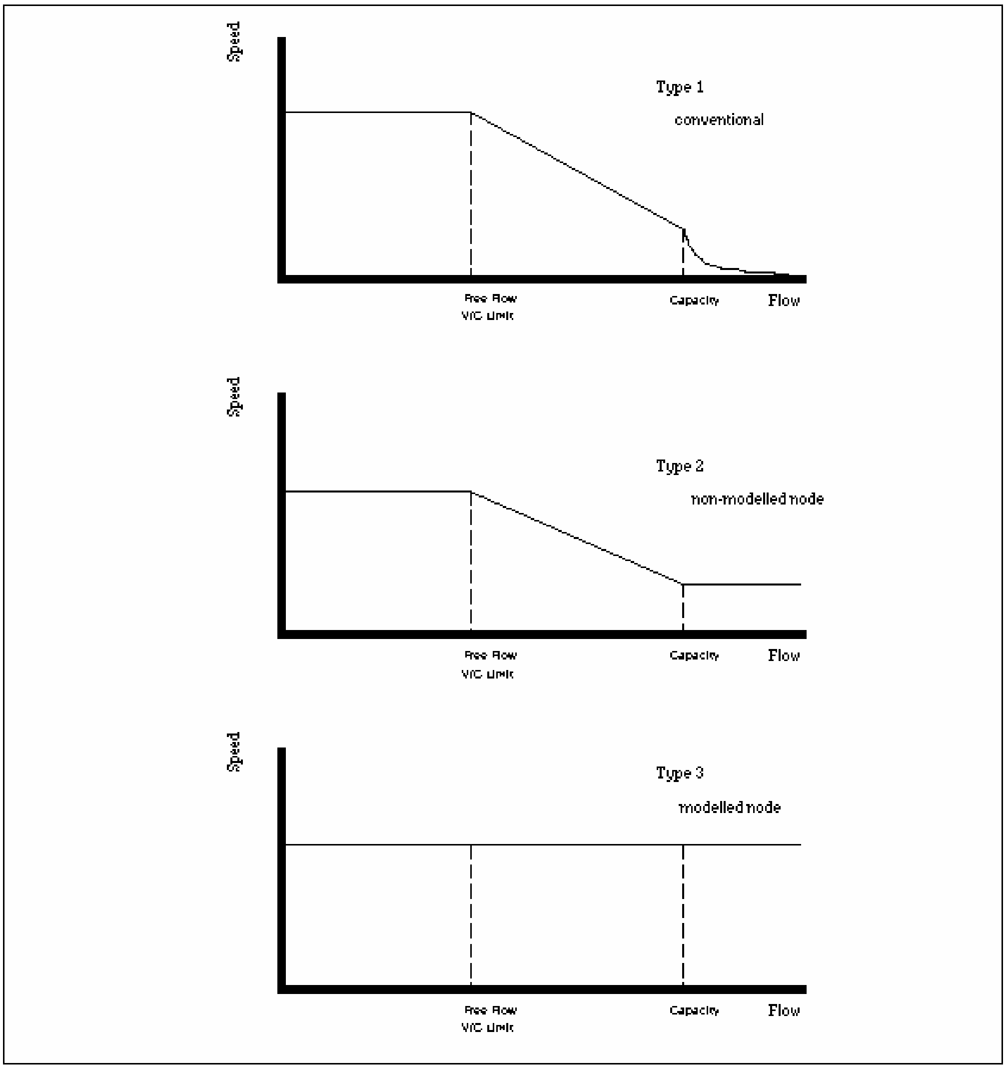

Figure 2.1 Speed Flow Curve Types

2.5 Link distance checks

2.5.1 The link distances for TMfS:05A 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:05A 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.

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

Road Type	STS (S)	TMfS (T)
Motorway	383	379
Trunk A	2893	2910
Grand Total	**3276**	**3289**

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

2.6 Modelled junction data

2.6.1 The modelled junctions within the TMfS:05A Base Highway model are the same as TMfS.05, with the exception of a number of junctions that were updated as part of the network refinement following the TMfS:05 Audit and application of the model.

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

2.7 Representation of Ferry Fares

2.7.1 Ferry fares for vehicles have been incorporated within the model through the use of toll files. Vehicle fares were obtained from the ferry operators and the following assumptions were made in order to derive a representation of ferry fares within the model:

- for Caledonian MacBrayne services where multiple ticket types for cars were available an assumed split was derived based on trip purposes extracted from the *Origin and Destination of Passengers and Freight on Strategic Sea Crossings Report* prepared for HITRANS, Shetland Transport Partnership and Strathclyde Partnership For Transport (March 2007);
- the majority of goods vehicle fares were provided by the ferry operators and an assumed vehicle length of 9 metres was used to represent and average fare;
- modelled car and goods vehicle fares include passenger fares with an assumed vehicle occupancy of 1.5 persons made up of 80% adults and 20% children; and
- Orkney and Shetland services from Aberdeen include cabin fares with an assumed split of cabin types being taken.

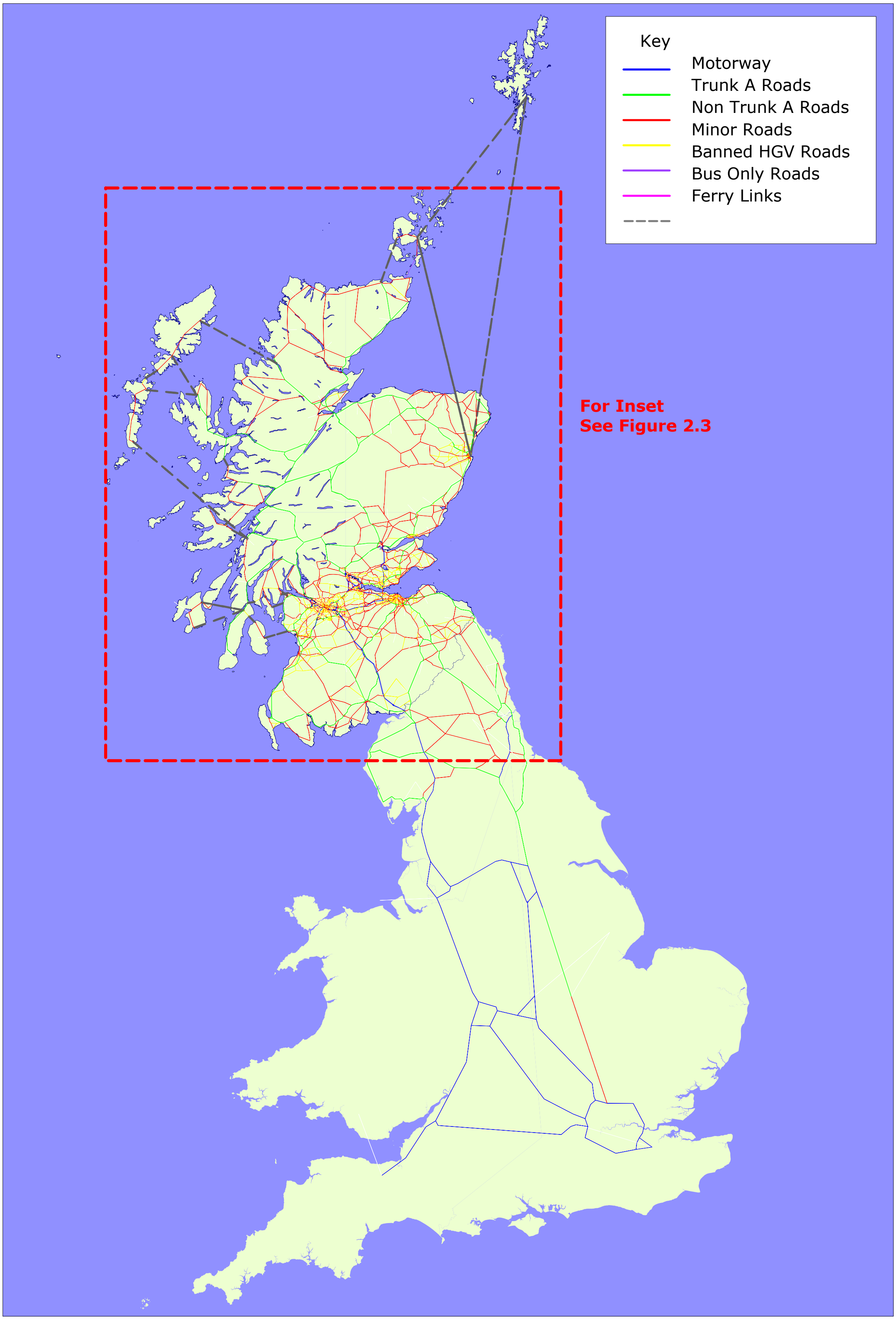

Figure 2.2 HAM Network Coverage

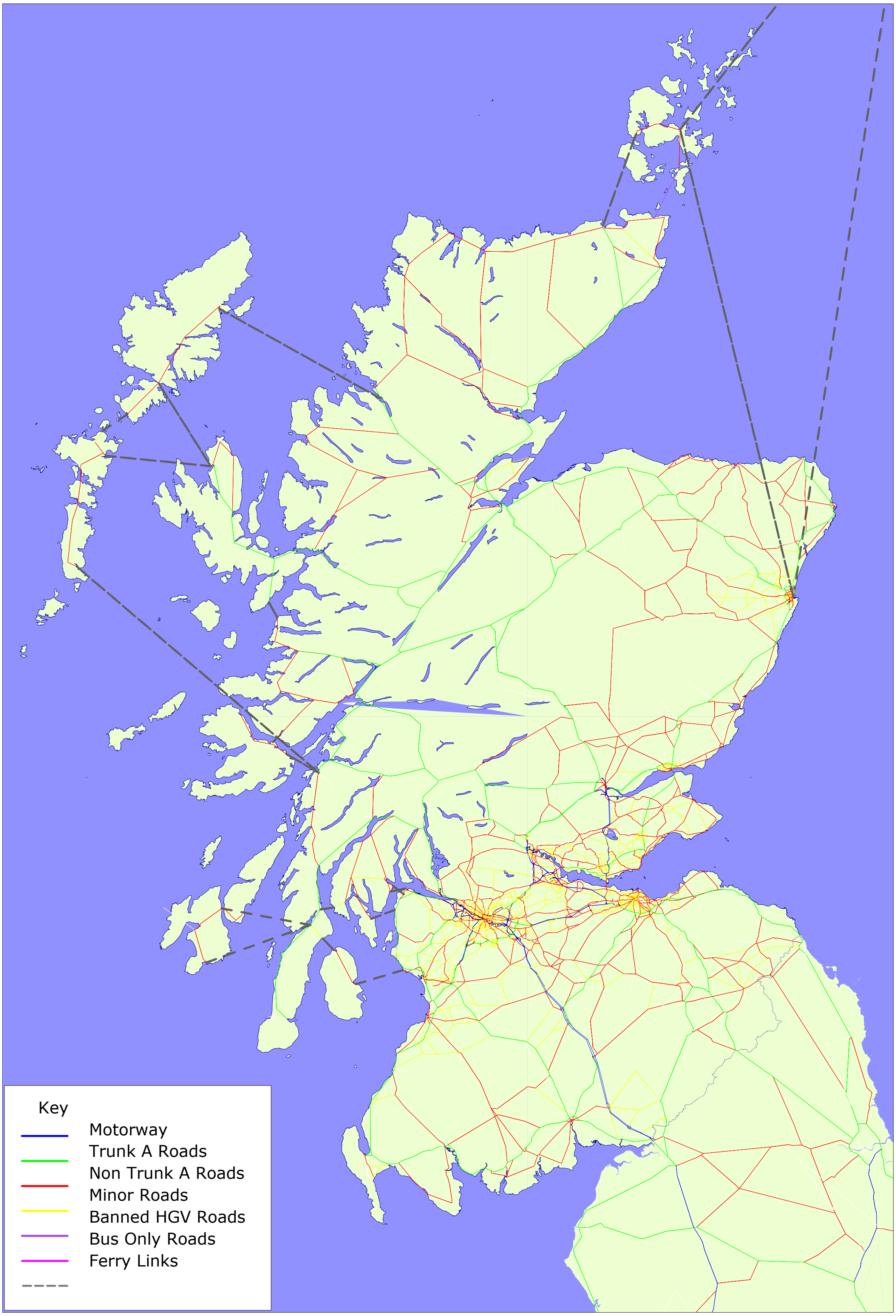

Figure 2.3 HAM Network (Insert from Figure 2.2)

3 Matrix Development

3.1 Introduction

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

- conversion to the new TMfS:05A zone structure;
- incorporation of Dundee and Ayrshire road side interview (RSI) data; 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 RSI 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 zoning system is based on amalgamations of 2001 Census Output Area Boundaries with the exception of airport zones which are disaggregated further. One of the principal aims in developing TMfS:05A was to improve spatial detail in 'external' areas of model in the Highlands, Argyll and Bute and Islands.

3.2.2 Therefore, zones in these areas have been disaggregated. The main purpose of the zonal disaggregation is to allow a more accurate representation of the costs and times of travel throughout the whole of Scotland, which can be combined with planning data. Zones have been split consistent with census output areas to allow planning data to be built up from census data. The zone disaggregation has been based on a review of significant settlements with all the islands represented individually. Figure 3.2 illustrates the new zones created in TMfS:05A

3.2.3 Figure 3.3 shows the final network wide zoning system. Further details of the model zoning system can be found on the TMfS website (www.tmfs.org.uk).

3.3 RSI Data

3.3.1 Three sources of RSI data were used for the development of the TMfS:05A demand matrices as described in Table 3.1 and shown in Figure 3.4. RSI data was also made available by Borders Council, however, this data was not used in the TMfS:05A model development as it was primarily local data and not strategic.

Table 3.1 TMfS:05A New RSI Data

Dataset	Supplier	Date of Data Collection
TACTRAN (Dundee and Surrounds) – 16 sites	TACTRAN	March/April 2007
Ayrshire SITM4 – 18 sites	SPT/Colin Buchanan	April 2007
Kilmarnock – 8 sites	East Ayrshire Council	October/November 2006

Note – Kilmarnock data is for morning and evening time periods only.

3.3.2 It should be noted that a further three RSI sites were available within the TACTRAN dataset but these were not used within the TMfS:05A matrix development. The three sites were:

- T14 A85 Riverside Avenue prior to Apollo Way Junction;
- T15 A90 Dundee Kingsway at Gourdy Croft; and
- T17 A90 South of Forfar at Gallowfauld.

3.3.3 At all these sites, recent RSI data had been incorporated in TMfS. A select link analysis was undertaken at the site locations. This was compared with the new RSI site data, which showed very similar travel patterns. Therefore, it was not considered that new RSI data would benefit the TMfS:05A matrix. Count information for these three sites was, however, used in the matrix estimation and calibration of the model as described later in this report.

RSI Data Processing

3.3.4 The processing of the RSI data included a number of data checking and cleaning tasks. Initial mapping of the origin and destination points for the records at the TACTRAN and Kilmarnock RSI sites indicated a significant number of illogical movements – typically between 5% and 30% for TACTRAN sites and around 10% for Kilmarnock sites. Therefore, given the volume of illogical records, it was necessary to undertake data cleaning in a database. Sectors were defined and allocated to each origin and destination for each record using GIS. Illogical sector movements were then identified for each site. The data was then processed using a database and illogical movements were discarded prior to calculating expansion factors for each site. The SITM4 Ayrshire RSI data did not contain the same volume of illogical movements (typically less than 5%) and data cleaning was undertaken manually through visual inspection of the records.

3.3.5 Following the data cleaning, vehicle matrices were prepared for each individual RSI site as follows:

- append TMfS:05A origin zone and destination zone attributes to each RSI record;
- aggregate the RSI records to form interview direction record matrices for each time period and user class – AM includes records between 0700-1000 hours, IP 1000-1600 hours, PM 1600-1900 hours;
- transpose the interview direction record matrices to create reverse direction matrices - AM interview matrices transposed to represent the PM reverse, IP interview matrices transposed to represent the IP reverse, PM interview matrices transposed to represent the AM reverse;

- calculate matrix expansion factors for each time period and vehicle type based on the record matrix totals and the corresponding count data;
- expand each time period / user class / direction matrix to the observed count, using the calculated expansion.

3.3.6 The 2006/2007 counts were scaled back to 2005 estimated counts using factors derived from Scottish Transport Statistics.

3.3.7 Two TACTRAN sites in central Dundee had no interpeak count data and factors derived from neighbouring sites were applied to equivalent AM peak counts at the sites.

3.3.8 The RSI site on the A78 (T) south of Pennyburn had missing data in the evening peak and, therefore, the interpeak and evening records where combined before calculating the expansion factors.

3.3.9 At a number of sites the expansion factors for heavy goods vehicles and to a lesser extent light goods vehicles were very high as few RSI records were available. In these instances data patching was undertaken and records from neighbouring sites were copied to obtain a better representation of the travel pattern.

3.4 Prior Matrix Development

3.4.1 The prior matrix for TMfS:05A was developed by combining the TMfS:05 matrix with the new RSI data.

3.4.2 TMfS:05 matrices were first converted to the new zoning system as described in section 3.2. This was undertaken using population data for the new zones where the travel pattern was retained from the TMfS:05 demand matrix and the volume of trips was split proportionate to the population totals.

3.4.3 The RSI matrices were combined with TMfS:05 matrices as follows.

- For the TACTRAN RSI sites on the A93 south of Blairgowrie and on the A94 north of Scone Airport, select link matrices were derived from TMfS:05 and these trips were removed in the TMfS:05 matrix and replaced with the RSI data;
- For the TACTRAN RSI site on the A90 North of Forfar, trips between Forfar and zones south of Aberdeen were selected for the RSI matrix and replaced the equivalent movements in the TMfS:05 matrix;
- The 13 RSI sites in Dundee formed a fully observed cordon, which replaced the equivalent movements in the TMfS:05 matrix;
- The 18 RSI sites in Ayrshire were combined into five screenlines and fully observed movements were identified for each. The screenlines were then combined to form a complete observed Ayrshire RSI matrix and potential multiple observed movements were factored to obtain the average number of trips across the screenlines. The TMfS:05 matrix was then replaced with the Ayrshire RSI matrix for fully observed movements; and
- The 8 RSI sites in Kilmarnock formed a fully observed cordon, which replaced the equivalent movements in the TMfS:05 matrix.

3.4.4 The above procedures were carried out in five discrete stages where the matrix output from Stage 1 was the input matrix to Stage 2 and so on. This avoided potential double counting of RSI data.

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 100 for TMfS:05 movements and 75 for TMfS:05A RSI movements);
- trip end data (with a confidence of 40);
- paths; and
- traffic counts (with an initial confidence of 100 for counts used to develop TMfS:05 and 75 for new TMfS:05A RSI counts).

3.5.3 It should be noted that TMfS.05A has been developed to a 2005 base year, however, the new RSI data and associated count data is from 2006 and 2007, albeit scaled back to 2005 traffic levels. In order to retain the existing travel pattern in areas away from the new RSI sites a higher confidence interval was associated with the old matrix and count data.

3.5.4 MVESTM 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.

3.5.5 The count data used for the estimation process was as per that used to develop TMfS:05 with the addition of the TMfS:05A RSI counts. 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.

3.6 Matrix Development Comparisons

3.6.1 Tables 3.2 to 3.13 detail the peak hour matrix totals for the TMfS.05, TMfS.05A Prior Incorporating RSIs (Prior meaning before MVESTM) and Final Highway matrix totals. For all analysis, the matrix values are in PCUs x 10.

3.6.2 Inspection of the sector matrices indicates the following points of interest:

- inclusion of the RSI data in the prior matrix increases the volume of trips within Ayrshire in all three time periods with a reduction in trips to external sectors and a net increase overall;
- inclusion of the RSI data in the prior matrix increases the volume of trips to/from Dundee in the morning and inter peak periods with a reduction in the evening peak; and
- overall, the change in the matrix from the prior matrices to the final post-MVESTM matrices in absolute terms is small.

Table 3.2 AM Peak Hour TMfS:05 Matrix (PCUs x 10)

OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	452336	71949	10736	8101	4155	7384	1078	1180	2751	3143	210	1641	1243	1891	567798
2	86997	84014	6575	13164	5273	12619	1582	1105	2768	1814	161	1674	386	3170	221303
3	12943	9624	229717	11239	1376	2707	282	50	188	15202	13023	5307	3749	591	305997
4	14417	19347	9616	196687	18471	28423	1896	212	244	4388	556	3085	849	830	299020
5	6141	6699	1067	11819	682497	159648	9726	1042	1292	550	359	390	1710	1606	884546
6	12201	17424	3152	22295	251642	503457	24299	3258	450	1392	1048	1105	4056	3809	849588
7	1208	2052	149	2109	13088	30240	105759	1300	446	240	13	223	11656	1956	170439
8	2675	1253	69	657	901	2926	2810	82541	1823	32	0	15	1925	2206	99835
9	8943	4253	179	219	3698	485	362	1292	10494	40	0	46	28	6114	36154
10	1812	2351	10716	7393	1482	1999	291	164	40	22854	10201	4392	4622	1361	69678
11	683	283	4710	398	238	248	1	221	0	8289	35552	12022	111	647	63405
12	587	1059	3651	711	692	1026	236	45	51	5315	21338	364563	2636	2876	404786
13	139	225	594	159	4834	2018	4301	1	293	3691	613	591	502	295	18256
14	1827	2099	643	271	2187	1212	2422	756	2609	140	82	562	164	0	14975
Total	602909	222631	281574	275224	990535	754393	155046	93166	23449	67091	83157	395614	33635	27354	4005779

Table 3.3 AM Peak Hour Prior Matrix Before MVESTM (PCUs x 10)

OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	452302	71949	10736	8101	4155	7384	410	1180	2751	3142	390	1393	1136	1891	566919
2	86997	83747	6575	13164	5273	12619	695	1105	2768	1779	335	1761	406	3170	220394
3	12943	9624	229328	11239	1376	2707	387	50	188	15790	15506	5394	3691	591	308814
4	14417	19347	9616	196271	18471	28423	1159	212	244	4397	410	3031	915	830	297743
5	6141	6699	1067	11819	682340	159648	10912	1042	1292	549	299	270	1672	1606	885358
6	12201	17424	3152	22295	251642	502899	18899	3191	450	1450	707	621	4015	3809	842755
7	1038	1161	345	1045	14914	19308	153514	1195	389	231	22	244	4180	1097	198682
8	2675	1253	69	657	901	2915	1996	82541	1823	25	0	20	1904	2206	98986
9	8943	4253	179	219	3698	485	69	1292	10494	40	22	46	34	6114	35888
10	1827	2273	10618	7374	1517	1987	379	164	40	24950	10738	2740	5550	1415	71572
11	765	255	4784	345	214	426	25	221	0	5732	44419	12844	146	684	70859
12	593	1062	3669	645	658	714	31	45	51	3810	23265	365489	2634	2914	405581
13	199	284	735	246	4798	1997	1918	24	187	5863	758	588	98	300	17997
14	1827	2099	643	271	2187	1212	1514	756	2609	207	104	657	96	0	14181
Total	602869	221428	281516	273693	992145	742725	191907	93016	23286	67964	96975	395098	26478	26629	4035730

Table 3.4 AM Peak Hour TMfS:05A Final Matrix (PCUs x 10)

OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	453382	66495	10483	7788	3986	7117	373	1172	2470	3367	321	947	943	1613	560457
2	86317	80187	6440	13118	5180	12776	619	1085	2500	1909	279	1389	232	2781	214813
3	11462	6852	229096	10852	943	2127	216	31	129	15610	14817	5067	4160	366	301727
4	12732	16318	9366	197292	17043	27641	872	193	199	4658	330	2799	709	685	290837
5	5019	5813	933	12187	690674	160205	9763	974	1255	581	278	218	1494	1318	890710
6	10793	16233	2912	22476	240423	502867	21827	3129	435	1582	672	548	3743	3223	830864
7	850	1081	262	972	12225	21619	161519	1290	613	180	17	159	3987	1061	205834
8	2643	1105	61	622	708	2645	2219	82863	1933	23	0	16	1706	2379	98921
9	8892	3823	154	218	3121	507	87	1319	12339	36	22	35	20	6146	36718
10	1602	1571	11264	7225	1236	1730	262	131	27	25058	11343	3247	5102	966	70764
11	692	153	4559	431	193	414	14	151	0	6858	44671	13249	191	519	72094
12	435	550	3310	675	468	510	17	33	29	4305	22832	340132	2909	1960	378166
13	140	164	792	262	4144	3050	3105	45	129	5762	1239	574	74	236	19718
14	1902	2180	650	278	2093	1396	1361	781	2789	228	87	552	89	0	14387
Total	596859	202524	280283	274394	982436	744604	202253	93196	24848	70159	96908	368931	25360	23254	3986009

Table 3.5 Inter Peak Hour TMfS:05 Matrix (PCUs x 10)

OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	352047	55662	5830	6512	4442	6267	614	1689	3247	1156	303	1036	986	2278	442070
2	42695	57806	6647	9527	3539	11013	1246	624	2584	1818	808	1671	661	3529	144169
3	6995	7162	173793	7241	1220	2497	223	42	225	8393	4484	2230	1183	1009	216699
4	5375	11645	7318	133562	8894	18572	1713	276	238	2220	608	1687	1139	1322	194570
5	4783	5366	970	9034	540381	139434	6839	845	919	371	267	597	3683	3487	716977
6	6988	11317	2043	18727	135542	386077	18021	2526	766	830	1792	1129	4253	4979	594990
7	903	1678	284	1771	6407	15266	75801	1951	2087	116	12	217	4589	2767	113851
8	1992	684	74	560	1057	2797	2313	70905	1517	45	22	95	1026	1714	84801
9	2654	2621	132	239	718	656	821	1632	9580	129	12	295	507	5731	25727
10	1126	1829	7044	3550	561	1153	142	32	118	25755	7323	3537	5799	615	58584
11	400	897	4623	611	284	2623	12	34	19	6070	45126	13951	297	461	75409
12	646	789	2199	1184	373	915	174	61	204	3239	13028	248802	943	1573	274130
13	259	174	546	417	1830	2126	3104	638	341	3110	153	758	447	1575	15478
14	1245	3122	641	862	2091	2150	1935	1321	3731	202	309	964	1557	0	20130
Total	428108	160752	212145	193796	707340	591545	112959	82577	25577	53455	74250	276970	27071	31041	2977584

Table 3.6 Inter Peak Hour Prior Matrix Before MVESTM (PCUs x 10)

OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	352042	55662	5830	6513	4442	6267	447	1689	3247	1113	425	988	936	2278	441878
2	42695	57747	6647	9527	3539	11013	687	624	2584	1702	882	1518	699	3529	143394
3	6995	7162	173661	7241	1220	2497	185	42	225	8322	5104	2228	1136	1009	217028
4	5375	11645	7318	133431	8894	18572	861	276	238	2188	562	1464	1187	1322	193334
5	4783	5366	970	9034	540362	139434	7699	845	919	371	298	480	3629	3487	717678
6	6988	11317	2043	18727	135542	386033	13166	2303	766	812	1804	865	4269	4979	589614
7	527	793	228	1053	7826	12547	94003	1364	168	164	49	263	1138	1635	121757
8	1992	684	74	560	1057	2324	1475	70905	1517	49	0	76	998	1714	83424
9	2654	2621	132	239	718	656	147	1632	9580	119	23	297	274	5731	24821
10	1103	1757	6782	3515	565	1144	166	41	111	26553	5565	2615	6708	636	57261
11	414	852	5128	540	321	2656	48	0	27	5141	48761	15307	371	468	80033
12	640	741	2163	1148	269	647	231	56	203	2704	14590	249479	942	1475	275287
13	283	246	595	428	1820	2155	984	631	200	4328	285	758	422	1528	14663
14	1245	3122	641	862	2091	2150	1455	1321	3731	233	351	899	1556	0	19657
Total	427734	159715	212211	192818	708667	588094	121555	81728	23516	53800	78699	277237	24263	29792	2979829

Table 3.7 Inter Peak Hour TMfS:05A Final Matrix (PCUs x 10)

OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	354669	51508	5184	5935	3995	5410	381	1651	2935	967	328	791	622	2097	436472
2	42440	56323	6492	9379	3459	10327	587	602	2493	1616	779	1271	523	3173	139464
3	6314	5472	174605	7346	981	2085	121	25	184	8303	4899	2056	1265	675	214332
4	4663	9615	7156	134379	8614	18225	755	206	192	2206	577	1292	903	1101	189884
5	4499	5079	855	8687	545826	139313	6955	631	864	324	251	295	3012	2728	719320
6	6536	10615	1819	18175	134993	387874	14571	1906	764	734	1627	668	4803	4359	589443
7	513	778	182	966	7129	14368	100259	1392	189	139	39	187	1298	1608	129045
8	2032	616	66	507	987	2282	1644	71088	1648	40	0	52	1061	1836	83858
9	2506	2620	118	235	722	649	147	1545	10946	107	19	184	156	5829	25782
10	1054	1277	6883	3336	528	1008	127	27	90	26454	6894	2739	5839	481	56738
11	321	500	4955	474	238	2001	33	0	21	5643	49514	15115	396	317	79528
12	544	483	2176	941	205	567	172	37	144	2744	14536	242895	1039	1033	267515
13	216	183	572	330	1791	2803	1689	1113	136	3913	303	821	353	1660	15882
14	1207	2946	579	785	2110	2626	1553	1402	3858	201	292	632	1577	0	19769
Total	427515	148016	211641	191473	711578	589537	128993	81624	24465	53391	80058	268997	22848	26895	2967033

Table 3.8 PM Peak Hour TMfS:05 Matrix (PCUs x 10)

OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	479404	93335	16948	13539	3324	10436	1584	2790	11309	5828	1082	736	679	2335	643328
2	55807	90946	10328	18505	5267	17966	1099	576	2960	2670	388	1096	338	6118	214064
3	9597	6613	249767	8469	1380	3232	96	31	192	12934	5702	4195	1375	497	304080
4	6877	16337	9095	204540	13274	28735	2859	185	369	4627	316	1205	1291	1505	291215
5	6049	7781	1038	18815	687643	235468	16525	1084	3396	1428	333	1377	9299	4397	994633
6	7896	17985	1379	25376	168409	532535	36096	3811	1041	1036	236	563	5212	3577	805152
7	450	1105	93	1933	10048	25861	94425	2457	545	150	2	197	8593	2481	148340
8	727	1394	56	250	1757	3234	2274	82347	1284	25	116	46	529	3103	97143
9	2964	3405	143	159	2656	631	3095	1785	12429	36	1	8	125	5992	33428
10	5088	2123	12391	4485	652	1549	214	13	231	14408	8803	5070	6266	1104	62398
11	246	272	10223	641	518	1155	9	1	2	9235	68029	23983	976	47	115337
12	595	1248	2485	3316	241	1188	291	18	316	5575	14281	356871	1707	850	388981
13	163	94	1113	483	2322	2716	4589	290	19	3306	95	1339	695	768	17992
14	1382	2730	306	755	2681	2348	2040	1313	4246	817	474	1421	651	0	21164
Total	577245	245368	315366	301263	900171	867054	165196	96701	38339	62075	99859	398108	37735	32776	4137256

Table 3.9 PM Peak Hour Prior Matrix Before MVESTM (PCUs x 10)

OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	479370	93335	16948	13539	3324	10436	996	2790	11309	5790	1121	686	664	2335	642642
2	55807	90678	10328	18505	5267	17966	1002	576	2960	2495	341	1075	360	6118	213476
3	9597	6613	249377	8469	1380	3232	311	31	192	12895	5521	4242	1282	497	303640
4	6877	16337	9095	204123	13274	28735	1490	185	369	4551	235	1117	1344	1505	289239
5	6049	7781	1038	18815	687486	235468	17921	1084	3396	1428	153	938	9233	4397	995186
6	7896	17985	1379	25376	168409	531977	22567	3764	1041	1014	205	316	5204	3577	790710
7	362	795	315	1087	10560	17904	159432	1793	115	239	26	41	1575	972	195216
8	727	1394	56	250	1757	3197	1509	82347	1284	24	116	31	420	3103	96217
9	2964	3405	143	159	2656	631	423	1785	12429	36	1	5	110	5992	30737
10	5094	2095	12564	4512	642	1587	182	13	231	16656	5529	3614	8767	1152	62638
11	368	368	11682	477	398	983	23	0	23	8877	58205	24678	1143	69	107294
12	409	1242	2577	3383	250	810	269	15	308	4958	13829	357824	1705	750	388329
13	169	101	1193	528	2318	2698	1717	229	28	4428	148	1213	429	773	15972
14	1382	2730	306	755	2681	2348	1086	1313	4246	852	507	1388	401	0	19997
Total	577070	244860	317002	299977	900400	857974	208929	95926	37931	64242	85937	397167	32637	31241	4151294

Table 3.10 PM Peak Hour TMfS:05A Final Matrix (PCUs x 10)

OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	481603	89692	15729	11546	2842	9179	909	2604	10747	5611	1035	611	489	2200	634795
2	54182	89189	9242	18503	4361	16496	835	509	2760	2441	316	805	239	5320	205197
3	8447	5845	249440	8932	1085	3055	197	23	164	12963	5341	4247	1462	397	301598
4	6057	14830	8752	206736	12236	28095	1482	165	330	4658	295	1197	1952	1319	288104
5	6065	8083	775	17276	700720	231342	14928	807	3236	1271	184	756	8232	3423	997098
6	7858	18655	1042	23959	164865	533977	23624	3100	1059	968	233	287	5297	3529	788454
7	342	859	190	934	9224	24930	157548	1971	122	185	22	30	3049	868	200275
8	698	1469	47	232	1495	3213	1603	82069	1235	20	75	28	476	3342	96001
9	2999	2975	93	124	2650	641	444	1606	13447	22	0	4	48	6336	31389
10	5096	1852	13091	4636	597	1599	175	10	214	15844	7503	3777	7995	951	63341
11	294	259	10220	430	357	900	34	0	17	9446	63230	24519	1268	47	111020
12	283	742	2207	2888	199	644	156	9	187	4366	14530	342220	1716	498	370645
13	113	79	1336	412	1982	3328	2336	257	19	3969	213	1507	403	873	16827
14	1457	2576	247	717	2648	2402	1474	1428	4423	756	625	1279	693	0	20725
Total	575495	237106	312413	297325	905261	859801	205746	94558	37961	62520	93602	381264	33318	29101	4125471

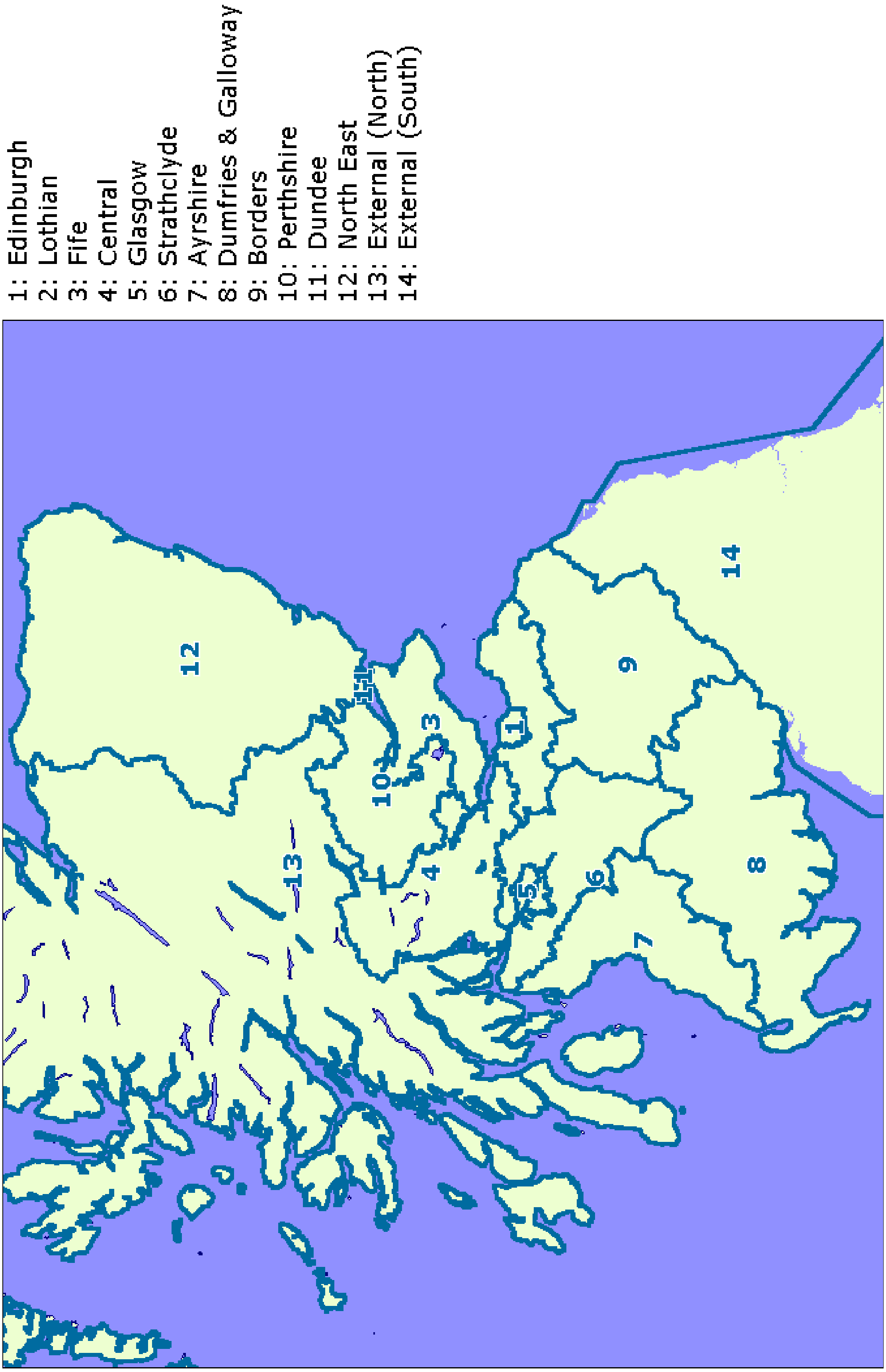

Figure 3.1 14 Sector Definition

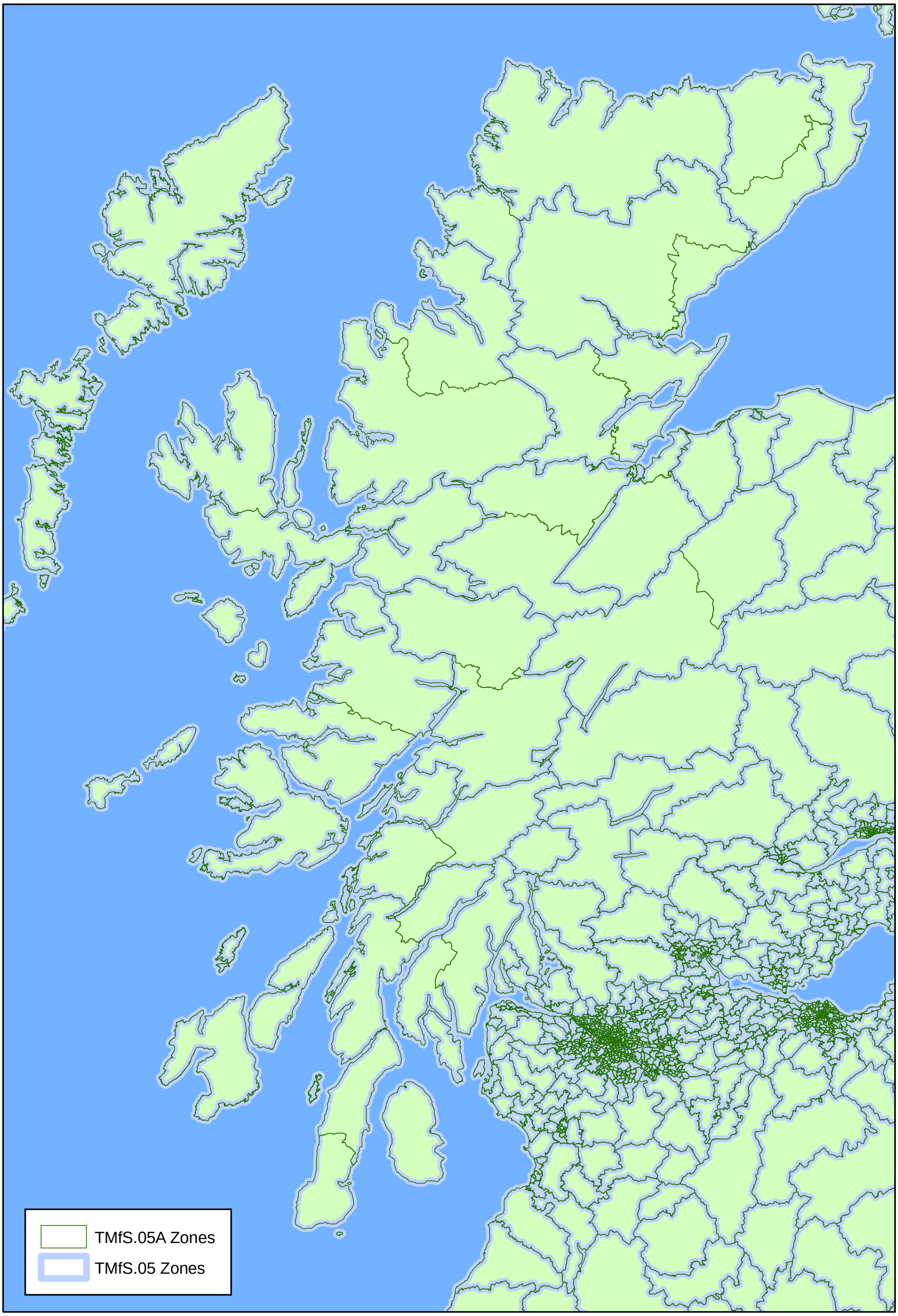

Figure 3.2 Zone Split

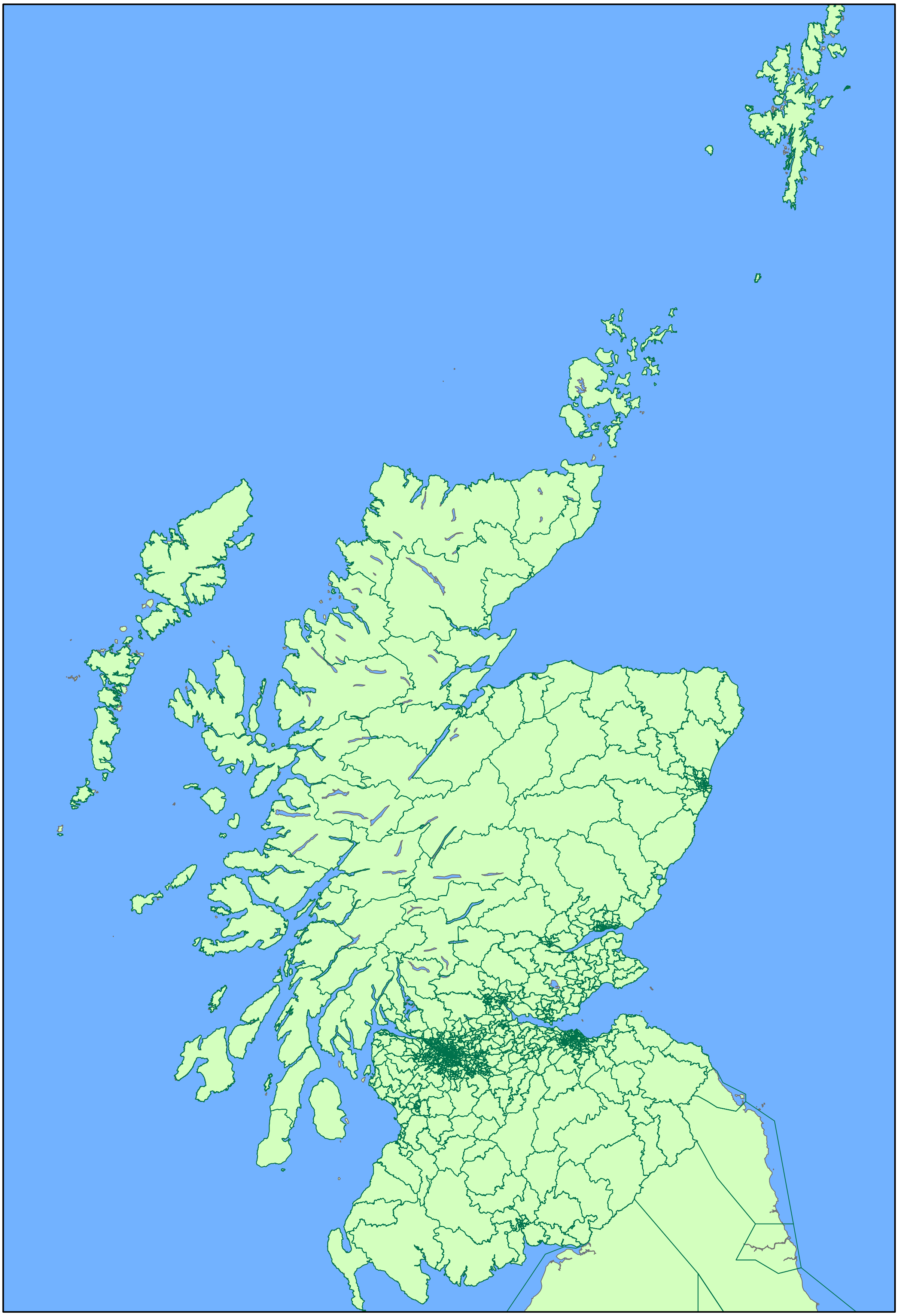

Figure 3.3 TMfS:05A Zoning System

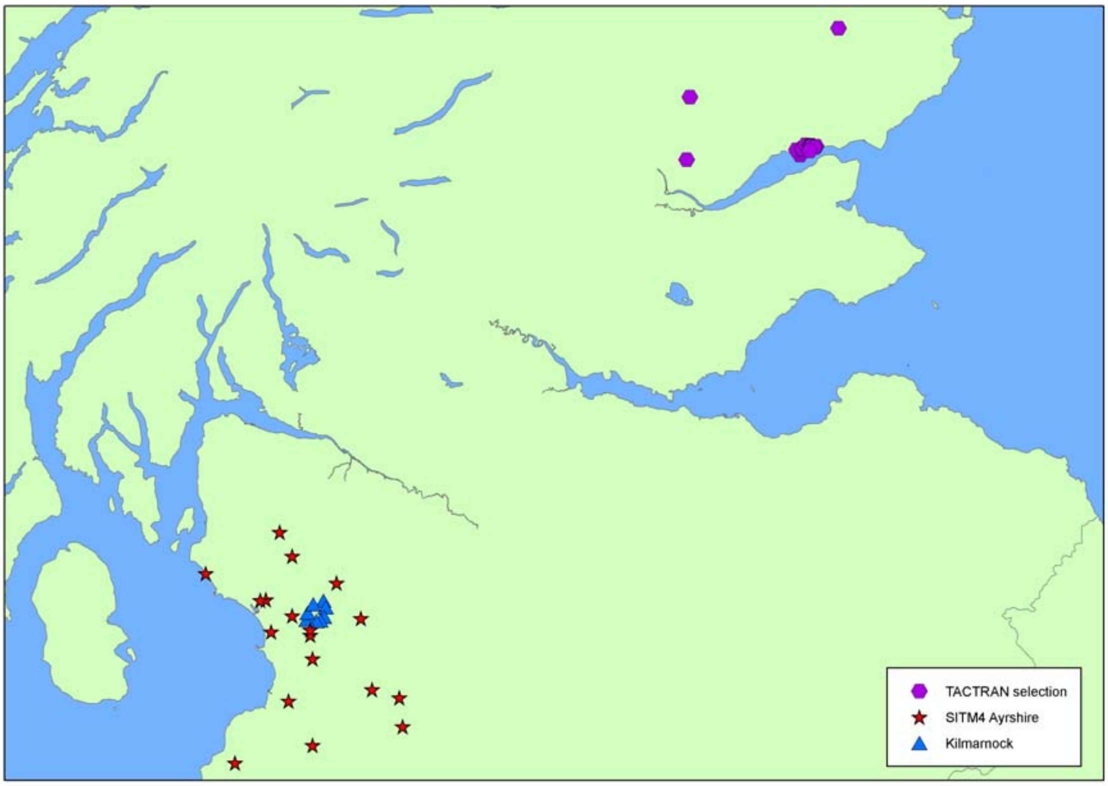

Figure 3.4 TMfS:05A RSI Sites

4 Assignment Model Development

4.1 Introduction

4.1.1 The assignment procedure adopted for TMfS:05A HAM is the same as that used in TMfS.05, 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:05A 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 describes assignment procedure used for TMfS:05A 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 previous versions of the TMfS 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:05A.

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 in TMfS:05A.

4.4 Model Convergence

4.4.1 The methodology for calculating model convergence in the TMfS:05A HAM is the same as that for TMfS.05.

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 (TMfS:05 values in brackets):

- AM Peak – 68 iterations (77);
- Inter-Peak – 30 iterations (36); and
- PM Peak – 67 iterations (68).

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 vehicles.

5.1.2 The screenline locations and traffic count data used for calibration purposes are those used in the MVESTM process. In total, 739 sites have been used in the MVESTM procedure in the morning and evening peaks and 723 in the inter peak (when the Kilmarnock RSIs were not undertaken). Of these 739/723 sites, 104 formed part of multi-point screenlines and, as such, are duplicates. Therefore, the number of unique screenlines is 635 in the morning and evening peaks and 619 in the inter peak.

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:

$$GEH = \left(\frac{(observed - \mathrm{mod}\,elled)^2}{(0.5 \times (observed + \mathrm{mod}\,elled)} \right)^{0.5}$$

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:05A are presented in Table 5.1 and the results for TMfS:05 are detailed in Table 5.2 for comparison purposes.

Table 5.1 TMfS:05A Forth Estuary Strategic Screenline

Direction	Time Period	Observed	Modelled	Dif	%Dif	GEH
Northbound	AM	4696	4715	19	0.4	0.3
	IP	3446	3442	-4	-0.1	0.1
	PM	6096	5759	-337	-5.5	4.4
Southbound	AM	5072	5030	-42	-0.8	0.6
	IP	3312	3535	223	6.7	3.8
	PM	4387	4462	75	1.7	1.1

Table 5.2 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

5.2.2 TMfS:05A Northbound screenlines show that observed and modelled flows differ by between a GEH of 0.1 and 4.4 and the Southbound screenline differs by between a GEH of 0.6 and 3.8. Comparing TMfS:05A GEHs with those of TMfS:05 GEHs, both the Northbound and Southbound directions demonstrate an improvement in all time periods.

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:05A observed versus modelled flows for this screenline while Table 5.4 presents TMfS:05 screenline data.

Table 5.3 TMfS:05A Clyde Strategic Screenline

Direction	Time Period	Observed	Modelled	Dif	%Dif	GEH
Northbound	AM	15426	14954	-472	-3.1	3.8
	IP	9807	10039	232	2.4	2.3
	PM	11208	10898	-310	-2.8	3.0
Southbound	AM	12386	13721	1335	10.8	11.7
	IP	10183	10918	735	7.2	7.2
	PM	15848	16941	1093	6.9	8.5

Table 5.4 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

5.2.4 TMfS:05A Northbound screenlines show that observed and modelled flows differ by between a GEH of 2.3 and 3.8 and the Southbound screenline differs by between a GEH of 7.2 and 11.7. Comparison of the tables shows some changes in the level of calibration and this is principally due to the update of demand matrices, and particularly the matrix estimation process.

5.2.5 Table 5.5 presents TMfS:05A 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:05 for comparison.

Table 5.5 TMfS:05A Tay Strategic Screenline

Direction	Time Period	Observed	Modelled	Dif	%Dif	GEH
Northbound	AM	1957	2117	160	8.2	3.6
	IP	725	811	86	11.8	3.1
	PM	909	980	71	7.9	2.3
Southbound	AM	718	866	148	20.6	5.3
	IP	722	767	45	6.2	1.6
	PM	1442	1376	-66	-4.6	1.8

Table 5.6 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

5.2.6 TMfS:05A Northbound screenlines show that observed and modelled flows differ by between a GEH of 2.3 and 3.6 and the Southbound screenlines differ between a GEH of 1.6 and 5.3. Comparison of the tables shows some changes in the level of calibration and this is principally due to the update of demand matrices, and particularly the matrix estimation process. In general the level of calibration is considered to be broadly similar and of a good standard. It should be noted that the observed counts shown in the tables are the same data as that used for TMfS:05 and not the new RSI count used during matrix estimation, which are included in Appendix D.

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.

5.4 Key Links

5.4.1 The same key links as TMfS:05 have been used when calibrating TMfS:05A. 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. 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:05 and the TMfS:05A results, the TMfS:05 results are contained in brackets in all tables.

5.4.2 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:05 values in brackets)					
Time Period	**≤5**	**≤7**	**≤10**	**≤12**	**≤15**
AM	68 (62)	81 (78)	93 (89)	97 (95)	100 (100)
IP	80 (79)	91 (90)	98 (96)	99 (99)	100 (100)
PM	66 (66)	83 (79)	94 (91)	100 (95)	100 (99)
Target	60%	80%	95%	100%	

5.4.3 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:05 results. In this instance, the number of sites that have GEH values of ≤5, ≤7, and ≤10 for all time periods are greater than or equal to the TMfS:05 values.

5.4.4 The highest GEH statistics are 16.14 in the AM Peak; 13.91 in the Inter-Peak; and 16.04 in the PM Peak.

5.5 Multi-Point Screenlines

5.5.1 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. The same screenlines as TMfS:05 have been used when calibrating TMfS:05A with addition of new RSI count data. Appendix D provides a detailed analysis of these multi-point screenline flows.

5.5.2 Table 5.8 summarises the screenline GEH analysis for each time period for the multi-point screenlines used in the calibration of the model. 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:05 values in brackets)					
Time Period	**≤5**	**≤7**	**≤10**	**≤12**	**≤15**
AM	60 (62)	74 (77)	87 (91)	93 (97)	97 (100)
IP	67 (67)	83 (71)	95 (94)	98 (99)	100 (100)
PM	60 (62)	75 (75)	88 (90)	94 (96)	97 (99)
Target	60%	80%	95%	100%	

5.5.3 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 635/619 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:05 values in brackets)					
Time Period	**≤5**	**≤7**	**≤10**	**≤12**	**≤15**
AM	62 (60)	74 (74)	88 (88)	94 (94)	98 (99)
IP	73 (72)	86 (84)	96 (95)	98 (99)	100 (100)
PM	61 (62)	76 (76)	88 (89)	95 (93)	98 (98)
Target	60%	80%	95%	100%	

5.5.4 A large number of the links in the TMfS:05A 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 21.64 in the AM peak, 15.91 in the Inter-Peak and 26.74 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. Of all the Key Links with a GEH value greater than 15, 12 are in the AM peak, 1 in the Inter-Peak and 14 in the PM peak.

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

5.5.6 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 vehicles only.

6.2 STPR Journey Time Survey Routes

6.2.1 As part of the validation process, observed and modelled journey times have been compared across twenty routes. This journey time data was collected as part of the Strategic Transport Projects Review (STPR) and was also used to determine the capacity indices and link speeds as described in Chapter 2 of this report. Table 6.1 illustrates the journey time comparisons.

Table 6.1 STPR Journey Time Routes

Route	Dir	Obs (mins)	Mod (mins)	Within DMRB Criteria
Route 1 Inverness To Elgin	WB	47.7	46.7	Yes
	EB	48.4	47.6	Yes
Route 2 Elgin to Aberdeen	EB	79.2	79.8	Yes
	WB	82.2	80.8	Yes
Route 3 Inverness to Aviemore	NB	29.9	30.0	Yes
	SB	39.5	39.2	Yes
Route 4 Ullapool to Inverness	NB	65.3	65.7	Yes
	SB	70.8	70.0	Yes
Route 5 Inverness to Dornoch	NB	48.4	47.5	Yes
	SB	50.4	50.2	Yes
Route 6 Dornoch to Helmsdale	NB	35.0	34.9	Yes
	SB	33.6	33.3	Yes
Route 7 Helmsdale to Thurso	NB	47.3	48.1	Yes
	SB	61.4	61.0	Yes
Route 8 Thurso to Latheron	NB	44.6	44.0	Yes
	SB	49.6	48.7	Yes

Route	Dir	Obs (mins)	Mod (mins)	Within DMRB Criteria
Route 10 Invergarry to Kyle of Lochalsh	WB	63.3	62.3	Yes
	EB	62.9	61.9	Yes
Route 15 Inverness to Fort William	NB	92.7	93.1	Yes
	SB	96.3	96.2	Yes
Route 16 Crianlarich to Oban	WB	47.0	46.7	Yes
	EB	47.7	47.2	Yes
Route 17 Crainlarich to Fort William	NB	65.8	65.8	Yes
	SB	70.2	68.8	Yes
Route 18 Fort William to Mallaig	WB	54.9	54.2	Yes
	EB	53.7	52.0	Yes
Route 20 Dunkeld to Aviemore	NB	70.2	70.6	Yes
	SB	74.1	73.7	Yes
Route 23 Tarbet to Cambeltown	SB	129.8	129.6	Yes
	NB	128.1	126.8	Yes
Route 26 Aviemore to Keith	WB	64.0	63.2	Yes
	EB	82.6	78.9	Yes
Route A Perth to Dunkeld	NB	11.0	11.1	Yes
	SB	12.1	12.2	Yes
Route B - Alexandra to Crianlarich	NB	50.9	49.6	Yes
	SB	50.3	49.1	Yes
Route C Invermoriston to A887-A87 junction	WB	17.5	17.3	Yes
	EB	17.5	17.3	Yes
Route D Oban to Ballachulish	NB	33.2	32.8	Yes
	SB	38.9	39.8	Yes

6.2.2 Table 6.1 shows that all the modelled journey times fall within the DMRB criteria, ie they are within 15% of the mean observed journey or one minute if higher.

6.2.3 Table 6.1 shows that the nearly all the modelled journey times fall within the confidence level, ie within upper and lower 95% confidence intervals. Only one route (Route 8 northbound) is outwith these confidence intervals, however, the GEH indicator is less than 1. Closer inspection of the journey time route indicates that the confidence intervals are very small at +/-17 seconds for a total average journey time in excess of 44 minutes. The modelled journey is only 33 seconds below the observed value and, therefore, is considered to be a good match.

6.3 Journey Time Validation

6.3.1 As part of the validation process, observed and modelled journey times have been compared across 59 routes throughout the modelled area. These are the same routes used to validate TMfS.05.

6.3.2 Table 6.2 and Figure 6.2 (at the end of this chapter) detail the 'Edinburgh 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 Edinburgh Area Urban Journey Routes

Route	Dir	Description	AM			IP			PM		
			Obs	Mod	Within DMRB Criteria	Obs	Mod	Within DMRB Criteria	Obs	Mod	Within DMRB Criteria
B1	1	A720 Lothianburn Junction to B701 Wester Hailes Road / Harvesters Way	34.6	43.5	No	30.3	35.7	No	38.2	42.8	Yes
	2	B701 Wester Hailes Road / Harvesters Way to A720 Lothianburn Junction	35.3	46.3	No	41.2	33.4	No	30.1	46.2	No
B2	1	A989 Tay St / A85 West of Bridge to A90 / A929 / A972 Dumbbell Roundabout	33.9	27.1	No	30.0	26.9	Yes	37.3	27.5	No
	2	A90 / A929 / A972 Dumbbell Roundabout to A989 Tay St / A85 West of Bridge	25.8	27.3	Yes	25.9	26.4	Yes	26.5	26.9	Yes
B8	1	M9 J3 Off Slip / A803 to A6095 Dumbbell Roundabout A1 Slips	58.5	53.5	Yes	45.2	44.9	Yes	49.5	52.6	Yes
	2	A6095 Dumbbell Roundabout A1 Slips to M9 J3 On Slip / A803	57.2	53.1	Yes	41.1	43.9	Yes	79.2	58.1	No
B11	1	A8 Glasgow Rd / Maybury Rd to A71 / A720 City Bypass	31.3	41.4	No	25.0	27.6	Yes	34.0	36.1	Yes
	2	A71 / A720 City Bypass to A8 Glasgow Rd / Maybury Rd	27.9	27.9	Yes	25.7	21.9	Yes	31.9	27.1	Yes
B12	1	A901 / A199 Commercial St to A902 / A90 Roundabout	31.8	34.6	Yes	31.7	29.0	Yes	38.4	40.0	Yes
	2	A902 / A90 Roundabout to A901 / A199 Commercial St	32.0	40.2	No	31.0	26.6	Yes	32.7	26.9	No
B13	1	A720 / A701 Burdiehouse Road to A1 West Slips / Newcraighall Roundabout	29.5	39.9	No	26.9	29.4	Yes	35.7	35.9	Yes

Route	Dir	Description	AM Obs	AM Mod	AM Within DMRB Criteria	IP Obs	IP Mod	IP Within DMRB Criteria	PM Obs	PM Mod	PM Within DMRB Criteria
	2	A1 West Slips / Newcraighall Roundabout to A720 / A701 Burdiehouse Road	42.4	32.9	No	30.4	28.9	Yes	34.1	37.5	Yes
B14	1	A720 / A772 Gilmerton Rd to A720 Sheriffhall Roundabout	21.2	23.2	Yes	18.4	18.0	Yes	23.5	20.3	Yes
	2	A720 Sheriffhall Roundabout to A720 / A772 Gilmerton Rd	20.5	20.9	Yes	16.8	18.1	Yes	20.4	20.1	Yes

6.3.3 Table 6.3 and Figure 6.3 (at the end of this chapter) detail the 'Glasgow 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 Glasgow Area Urban Journey Routes

Route	Dir	Description	AM Obs	AM Mod	AM Within DMRB Criteria	IP Obs	IP Mod	IP Within DMRB Criteria	PM Obs	PM Mod	PM Within DMRB Criteria
C1	1	Port Glasgow - Hillington	16.9	15.0	Yes	16.6	14.9	Yes	17.9	15.0	No
	2	Hillington - Port Glasgow	16.1	15.4	Yes	14.9	15.2	Yes	18.5	15.4	No
C2	1	Carmyle - Motherwell	7.5	6.4	Yes	7.6	6.4	No	7.7	6.4	No
	2	Motherwell – Carmyle	8.2	6.3	No	8.2	6.3	No	8.4	6.3	No
C3	1	Irvine - Barrhead	30.3	29.7	Yes	28.0	28.9	Yes	30.1	29.2	Yes
	2	Barrhead – Irvine	28.2	29.5	Yes	26.1	29.2	Yes	28.3	30.6	Yes
C4	1	East Kilbride Circular (Anti-Clockwise)	19.3	16.1	No	14.8	16.1	Yes	20.0	17.2	Yes
	2	East Kilbride Circular (Clockwise)	17.1	16.3	Yes	14.6	15.6	Yes	16.9	15.7	Yes
C5	1	A77 Loganswell Farm – Central	55.2	35.8	No	36.7	30.3	No	33.3	30.9	Yes
	2	Central - A77 Loganswell Farm	30.5	28.5	Yes	31.0	29.9	Yes	50.7	37.8	No
C6	1	M77 J2 – Junction with A77	5.8	6.2	Yes	5.9	6.2	Yes	5.8	6.3	Yes
	2	Junction with A77 - M77 J2	11.6	6.3	No	5.0	6.3	No	6.4	6.3	Yes
C7	1	A726 Nitshill – A73 Newhouse	48.3	50.4	Yes	45.3	50.2	Yes	49.0	52.3	Yes
	2	A73 Newhouse - A726 Nitshill	58.9	52.4	Yes	50.4	48.3	Yes	56.9	53.3	Yes
C8	1	Govan – Kingston Bridge	14.8	11.3	No	13.5	11.2	No	17.3	11.3	No
	2	Kingston Bridge – Govan	12.0	10.8	Yes	13.0	10.5	No	14.3	11.3	No

Route	Dir	Description	AM Obs	AM Mod	AM Within DMRB Criteria	IP Obs	IP Mod	IP Within DMRB Criteria	PM Obs	PM Mod	PM Within DMRB Criteria
C9	1	A814 Kilpatrick – Hope Street	25.2	22.7	Yes	22.5	20.9	Yes	23.7	22.6	Yes
	2	Hope Street - A814 Kilpatrick	23.7	22.6	Yes	22.4	22.5	Yes	24.1	28.5	No
C10	1	Dumbarton Road – Great Western Road	3.8	3.2	Yes	3.5	3.7	Yes	3.8	3.2	Yes
	2	Great Western Road - Dumbarton Road	3.5	3.0	Yes	3.3	3.5	Yes	3.4	3.0	Yes
C11	1	Johnstone - Bellahouston	27.9	25.5	Yes	26.1	24.4	Yes	28.4	24.6	Yes
	2	Bellahouston – Johnstone	32.4	27.1	No	27.2	26.2	Yes	31.3	28.6	Yes
C12	1	A80 Cumbernauld – M8	19.8	15.1	No	14.5	13.8	Yes	14.2	13.9	Yes
	2	M8 - A80 Cumbernauld	18.5	15.3	No	13.9	14.8	Yes	16.6	15.4	Yes
C14	1	A77 – East Kilbride	12.3	3.2	No	11.6	3.2	No	13.7	3.2	No
	2	East Kilbride – A77	13.0	10.6	No	12.3	10.4	No	14.3	10.6	No
C15	1	A8 – A728 (Cathcart Road)	37.4	41.1	Yes	36.6	33.3	Yes	37.1	43.1	No
	2	A728 (Cathcart Road) – A8	38.2	36.9	Yes	35.6	33.0	Yes	44.6	37.2	No
C16	1	Kingsway – Anniesland Cross	4.7	3.6	No	4.3	3.6	Yes	4.4	3.8	Yes
	2	Anniesland Cross – Kingsway	4.0	3.8	Yes	3.7	3.7	Yes	3.9	3.8	Yes
C17	1	A803 Springburn Circular (Anti-Clockwise)	46.3	51.3	Yes	43.8	47.1	Yes	45.4	50.5	Yes
	2	A803 Springburn Circular (Clockwise)	54.7	53.6	Yes	48.9	47.0	Yes	50.1	50.9	Yes
C18	1	Partick - Hillfoot	14.3	15.1	Yes	11.8	15.0	No	14.3	18.1	No
	2	Hillfoot – Partick	16.9	15.7	Yes	12.4	12.9	Yes	14.5	14.2	Yes
C19	1	M77 J2 - A8 Bargeddie	26.3	14.7	No	16.9	14.6	Yes	33.0	16.6	No
	2	A8 Bargeddie - M77 J2	32.4	19.5	No	16.0	16.4	Yes	43.6	25.1	No
C20	1	Glasgow - Bearsden	13.3	13.1	Yes	14.8	12.5	No	18.6	20.1	Yes
	2	Bearsden – Glasgow	19.0	17.7	Yes	14.5	13.2	Yes	15.4	13.5	Yes
C21	1	A82 / A898 Junction Circular (Clockwise)	50.4	46.5	Yes	47.3	46.2	Yes	51.6	47.6	Yes
	2	A82 / A898 Junction Circular (Anti-Clockwise)	52.2	47.1	Yes	49.7	46.0	Yes	50.8	46.8	Yes
C22	1	Great Western Road (M8 to A8014)	22.6	25.7	Yes	27.7	21.0	No	28.6	32.5	Yes
	2	Great Western Road (A8014 to M8)	31.0	27.1	Yes	25.4	19.4	No	27.6	26.4	Yes
C23	1	A725 Blantyre - Coatbridge	14.7	15.2	Yes	10.8	12.0	Yes	25.7	12.7	No
	2	Coatbridge - A725 Blantyre	15.7	15.0	Yes	16.3	13.1	No	16.3	18.4	Yes
C24	1	Bearsden - Kilsyth	31.2	27.8	Yes	29.7	28.2	Yes	31.6	27.6	Yes
	2	Kilsyth – Bearsden	30.7	28.7	Yes	30.0	29.0	Yes	45.9	29.7	No

Route	Dir	Description	AM Obs	AM Mod	AM Within DMRB Criteria	IP Obs	IP Mod	IP Within DMRB Criteria	PM Obs	PM Mod	PM Within DMRB Criteria
C25	1	A807 - A814 Partick	19.4	24.1	No	20.5	16.8	No	27.0	27.4	Yes
	2	A814 Partick - A807	20.8	21.4	Yes	18.8	21.3	Yes	27.3	33.2	No
C27	1	A71/ A78 Irvine – A73 Newhouse	75.2	63.4	No	63.3	63.4	Yes	74.4	65.5	Yes
	2	A73 Newhouse - A71/ A78 Irvine	66.1	64.6	Yes	64.5	62.6	Yes	67.0	62.6	Yes
C28	1	Govan - Cambuslang	24.9	28.1	Yes	23.2	24.9	Yes	29.4	28.8	Yes
	2	Cambuslang – Govan	29.6	30.5	Yes	20.8	23.0	Yes	27.8	27.2	Yes
C29	1	George Square / Castle St (Anti-Clockwise)	8.8	15.2	No	10.4	13.0	No	12.0	12.5	Yes
C31	1	Kilsyth – Auchenkilns Roundabout	7.6	7.7	Yes	7.6	7.3	Yes	8.6	7.4	Yes
	2	Auchenkilns Roundabout – Kilsyth	8.0	7.7	Yes	8.4	7.4	Yes	8.3	8.8	Yes
C32	1	Bogton - Bishopbriggs	5.9	7.1	No	6.2	7.0	Yes	7.2	6.7	Yes
	2	Bishopbriggs – Bogton	7.9	6.7	Yes	6.3	6.9	Yes	8.0	6.5	No
C33	1	Mollinsburn – Coatbridge	4.3	3.6	Yes	4.1	3.6	Yes	4.2	3.6	Yes
	2	Coatbridge - Mollinsburn	6.5	4.9	No	4.6	4.8	Yes	4.9	4.9	Yes
D1	1	Bellgrove St to Main St	14.1	12.8	Yes	13.9	13.5	Yes	15.4	13.9	Yes
	2	Main St to Bellgrove St	14.8	14.7	Yes	15.2	12.9	No	15.6	12.7	No
D2	1	M80 M9 J9 Stirling to J1 Provan	32.5	24.7	No	23.2	24.0	Yes	23.2	25.1	Yes
	2	J1 Provan to M80 M9 J9 Stirling	27.0	25.1	Yes	23.5	23.6	Yes	23.6	23.8	Yes
D3	1	A803 A80 Haggs to Townhead	41.1	36.9	Yes	35.2	37.9	Yes	38.1	37.3	Yes
	2	Townhead to A803 A80 Haggs	38.0	38.9	Yes	36.4	37.4	Yes	41.9	36.9	Yes
D4	1	A89 Airdrie to Baillieston Lights	14.6	14.2	Yes	13.9	13.7	Yes	15.6	13.5	Yes
	2	Baillieston Lights to A89 Airdrie	15.8	12.2	No	14.5	12.0	No	15.7	12.2	No
D5	1	A775 Newhouse to Glasgow Zoo	15.7	15.8	Yes	14.7	15.4	Yes	17.5	16.0	Yes
	2	Glasgow Zoo to A775 Newhouse	18.3	14.9	No	15.2	14.3	Yes	16.8	14.9	Yes
D6	1	A725 Raith to A89 Coatbridge	13.1	9.1	No	9.9	8.9	Yes	14.2	11.4	No
	2	A89 Coatbridge to A725 Raith	13.4	10.4	No	7.9	9.0	Yes	13.1	8.6	No
D7	1	A8 Edinburgh Road to Alexander Park St	14.6	13.9	Yes	12.6	14.3	Yes	15.6	14.4	Yes
	2	A8 Alexander Park St to Edinburgh Road	13.8	13.1	Yes	12.0	12.4	Yes	13.2	12.0	Yes

Route	Dir	Description	AM Obs	AM Mod	AM Within DMRB Criteria	IP Obs	IP Mod	IP Within DMRB Criteria	PM Obs	PM Mod	PM Within DMRB Criteria
D8	1	A89 Baillieston Lights to Millerston Street	14.0	11.9	Yes	12.7	12.1	Yes	15.2	12.3	No
	2	A89 Millerston Street to Baillieston Lights	15.2	14.5	Yes	13.2	13.6	Yes	14.1	13.3	Yes
D9	1	A74 Glasgow Zoo to A74 Fielden Street	11.4	9.0	No	10.6	10.0	Yes	12.5	11.9	Yes
	2	A74 Fielden Street to Glasgow Zoo	12.0	14.5	No	10.5	9.3	Yes	11.2	8.6	No
D10	1	A724 East Kilbride Expressway to A724 Springfield Road	19.9	18.8	Yes	18.3	20.7	Yes	22.6	20.3	Yes
	2	A724 Springfield Road to A724 East Kilbride Expressway	21.3	18.4	Yes	18.0	18.0	Yes	19.7	16.6	No
D11	1	A8 M8 J6 Newhouse to M8 J13 Provan	12.9	13.1	Yes	12.0	12.7	Yes	13.1	14.2	Yes
	2	M8 J13 Provan to A8 M8 Newhouse	16.5	13.0	No	12.5	12.3	Yes	13.8	12.8	Yes
E1	1	M8 Junction 29 to M8 Junction 22	8.8	7.2	No	7.9	7.0	Yes	9.8	7.0	No
E2	1	M8 Junction 15 to M8 Junction 24	10.5	9.3	Yes	7.4	6.2	No	18.6	13.5	No

6.3.4 Table 6.4 and Figure 6.4 (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 6.4 Aberdeen Area Urban Journey Routes

Route	Dir	Description	AM Obs	AM Mod	AM Within DMRB Criteria	IP Obs	IP Mod	IP Within DMRB Criteria	PM Obs	PM Mod	PM Within DMRB Criteria
A1	1	A90 Slip road at Portlethen to Great Northern Road/B979	36.2	39.7	Yes	29.4	28.0	Yes	38.7	34.7	Yes
	2	Great Northern Road/B979 to A90 slip road at Portlethen	37.0	36.6	Yes	27.8	25.2	Yes	39.2	30.6	No
A2	1	A90 Blackdog Junction to A956.A90	33.6	32.4	Yes	22.9	20.4	Yes	23.0	23.8	Yes

Route	Dir	Description	AM Obs	AM Mod	AM Within DMRB Criteria	IP Obs	IP Mod	IP Within DMRB Criteria	PM Obs	PM Mod	PM Within DMRB Criteria
	2	A956/A90 to A90 Blackdog Junction	23.5	27.2	No	23.6	20.1	No	25.5	25.5	Yes

6.3.5 Table 6.5 and Figure 6.5 (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 6.5 Inter Urban Journey Routes

Route	Dir	Description	AM Obs	AM Mod	AM Within DMRB Criteria	IP Obs	IP Mod	IP Within DMRB Criteria	PM Obs	PM Mod	PM Within DMRB Criteria
B3	1	A912 / A989 to A9 / A811 Roundabout	43.6	48.7	Yes	43.4	46.3	Yes	46.9	42.8	Yes
	2	A9 / A811 Roundabout to A85 / A93	42.7	46.0	Yes	43.9	47.8	Yes	44.5	45.7	Yes
B4	1	M9 J10 / A84 to M9 J10	50.9	49.9	Yes	45.9	52.8	Yes	53.5	50.4	Yes
	2	M9 J10 to M9 J10 / A84	50.7	48.4	Yes	44.3	51.1	No	54.2	48.1	Yes
B5	1	M80 J5 / M876 to M8 Hermiston Gate Roundabout	29.4	30.1	Yes	29.2	29.4	Yes	29.2	29.6	Yes
	2	M8 Hermiston Gate Roundabout to M80 J5 / M876	29.9	28.9	Yes	29.8	28.7	Yes	30.4	29.4	Yes
B6	1	A985 / A876 to M90 / A9 / A93 Roundabout	48.0	49.3	Yes	46.7	49.2	Yes	49.2	49.2	Yes
	2	M90 / A9 / A93 Roundabout to A985 / A876	48.8	49.2	Yes	48.7	49.1	Yes	55.8	49.0	Yes
B7	1	M9 J1a NB Off Slip to A929 / A972 / A90 Dumbbell Roundabout (West Roundabout)	74.4	75.3	Yes	76.1	73.1	Yes	75.5	83.8	Yes
	2	A929 / A972 / A90 Dumbbell Roundabout (West Roundabout) to M9 J1a NB Off Slip	76.9	74.9	Yes	79.3	70.0	Yes	79.9	73.5	Yes
B9	1	Newbridge Interchange (A8 / M9 / M8) to M8 J6 / A73 Roundabout	22.5	22.4	Yes	22.3	22.1	Yes	22.7	22.3	Yes
	2	M8 J6 / A73 Roundabout to Newbridge Interchange (A8 / M9 / M8)	24.8	22.6	Yes	22.7	22.4	Yes	25.3	22.7	Yes

Route	Dir	Description	AM Obs	AM Mod	AM Within DMRB Criteria	IP Obs	IP Mod	IP Within DMRB Criteria	PM Obs	PM Mod	PM Within DMRB Criteria
B10	1	A713 Whitletts Road / B749 Craigie Road to A77 / B764	27.0	25.6	Yes	25.5	25.6	Yes	28.4	25.5	Yes
	2	A77 / B764 to A713 Whitletts Road / B749 Craigie Road	24.5	26.5	Yes	24.3	26.3	Yes	25.4	28.3	Yes

6.3.6 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.

6.3.7 The journey time routes all have sufficient surveyed data to provide a range of acceptable journey times assuming that a 95% confidence interval could be expected for each route and that the journey times would vary in the form of a normal distribution. It should be noted that the journey times are unlikely to form a normal distribution but this assumption provides a valuable means for comparing the modelled and observed data.

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

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

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

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.

6.3.9 It should be noted that lower confidence limits have been capped at zero, ie there are no negative journey times. Appendix H contains detailed journey time analysis for each route detailed in Tables 6.2 to 6.5, which shows the modelled times versus the observed data along with the confidence intervals.

6.3.10 Comparison between modelled and observed journey times has been carried out in line with DMRB validation acceptability guidelines (Volume 12, Section 2, Part 1, Table 4.2, Criteria 6). The modelled journey times have also been compared with the observed range of surveyed journey times. Table 6.6 below summarises the journey time validation for TMfS:05A.

Table 6.6 TMfS:05A Journey Time Validation

Area	Total No. of routes	AM No. of routes	AM % of routes	IP No. of routes	IP % of routes	PM No. of routes	PM % of routes
Number within DMRB criteria - modelled within 15% observed or 1 minute							
Edinburgh Urban	14	7	50%	12	86%	10	71%
Glasgow Urban	83	56	67%	65	78%	55	66%
Aberdeen Urban	4	3	75%	3	75%	3	75%
Inter Urban	14	14	100%	13	93%	14	100%
Number within range of observed values							
Edinburgh Urban	14	8	57%	7	50%	5	36%
Glasgow Urban	81	39	48%	29	36%	32	40%
Aberdeen Urban	4	3	75%	3	75%	3	75%
Inter Urban	14	6	43%	5	36%	4	29%
Number within 95% confidence interval of population							
Edinburgh Urban	14	12	86%	10	71%	11	79%
Glasgow Urban	83	67	81%	57	69%	60	72%
Aberdeen Urban	4	4	100%	4	100%	3	75%
Inter Urban	14	10	71%	9	64%	7	50%
Number within 95% confidence interval of mean							
Edinburgh Urban	14	4	29%	5	36%	5	36%
Glasgow Urban	83	51	61%	35	42%	37	45%
Aberdeen Urban	4	3	75%	1	25%	3	75%
Inter Urban	14	6	43%	4	29%	3	21%

6.3.11 Inspection of Table 6.6 and Appendix H shows that the journey time validation for TMfS:05A is broadly similar to TMfS:05 and demonstrates a reasonable level of validation.

6.3.12 As the Inter Urban Routes are surveyed over longer distances, additional analysis was undertaken where these routes were divided into segments. Table 6.7 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 6.7 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

6.4 Validation Count Sites

6.4.1 Traffic count data not used in calibration has been used for the purposes of the validation and the same data used in TMfS:05 has been used when validating TMfS:05A. 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.

6.4.2 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.

6.4.3 Table 6.8 presents a summary of the validation site analysis:

Table 6.8 Validation Site Analysis

% of sites with GEH value (TMfS:05 values in brackets)					
Time Period	**≤5**	**≤7**	**≤10**	**≤12**	**≤15**
AM	48 (48)	65 (65)	82 (84)	89 (92)	97 (98)
IP	60 (60)	75 (77)	90 (91)	95 (97)	99 (100)
PM	49 (50)	65 (65)	84 (84)	92 (93)	98 (99)
Target	60%	80%	95%	100%	

6.4.4 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 27.9 in the AM peak, 21.0 in the Inter-Peak and 29.5 in the PM peak respectively. Appendix L contains graphical representations of the screenline results. Of all the Key Links with a GEH in excess of 15, there are 39 in the AM peak, 13 in the Inter-Peak and 34 in the PM peak.

6.5 Trip Length Distribution Analysis

6.5.1 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.

6.5.2 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).

6.5.3 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.

6.6 HGV Screenline Analysis

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

6.6.2 Table 6.9 presents a summary of the HGV screenline analysis:

Table 6.9 HGV Screenline Analysis

% of sites with GEH value (TMfS:05 values in brackets)					
Time Period	**≤5**	**≤7**	**≤10**	**≤12**	**≤15**
AM	63 (54)	77 (68)	88 (82)	92 (92)	96 (93)
IP	66 (57)	79 (70)	90 (85)	93 (91)	96 (96)
PM	66 (59)	78 (73)	90 (88)	95 (94)	98 (97)
Target	60%	80%	95%	100%	

6.6.3 The majority of HGV screenlines exhibit a GEH statistic of less than 12. The highest GEH value in the AM peak is 26.0, with corresponding figures of 28.1 and 32.1 for the Inter-Peak and PM peak periods respectively. It should be stressed that no specific calibration work is carried out on HGVs, only on total vehicles and so *all* HGV data is used for validation. For all of the Key Links with a GEH statistic greater than 15, there are 46 in the AM peak, 44 in the Inter-Peak and 19 in the PM peak.

6.6.4 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.

6.6.5 Comparison of the TMfS:05 and TMfS:05A GEH statistics shows some changes in the level of calibration and this is principally due to the update of demand matrices, and particularly the matrix estimation process.

6.6.6 Appendix N contains graphical representations of TMfS:05A 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.

6.7 Car In Work, Car Non Work Analysis

6.7.1 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 6.10 and 6.11 show the screenline analysis for 'Car In Work' and 'Car Non Work' respectively.

Table 6.10 Car In Work Screenline Analysis

% of sites with GEH value (TMfS:05 values in brackets)					
Time Period	**≤5**	**≤7**	**≤10**	**≤12**	**≤15**
AM	72 (74)	83 (86)	93 (93)	97 (97)	98 (100)
IP	80 (78)	90 (91)	96 (98)	96 (98)	98 (100)
PM	74 (80)	86 (88)	94 (95)	97 (98)	98 (99)
Target	60%	80%	95%	100%	

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

Table 6.11 Car Non Work Screenline Analysis

% of sites with GEH value (TMfS:05 values in brackets)					
Time Period	**≤5**	**≤7**	**≤10**	**≤12**	**≤15**
AM	63 (61)	78 (74)	89 (86)	93 (91)	96 (95)
IP	67 (67)	85 (81)	94 (95)	96 (97)	98 (98)
PM	63 (53)	77 (66)	91 (83)	95 (88)	96 (93)
Target	60%	80%	95%	100%	

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

6.7.4 Both the 'Car In Work' and 'Car Non Work' screenline analysis compare favourably with TMfS:05 results.

6.7.5 In a similar comparison to the HGV validation, it should be noted that Total vehicles 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.

6.8 Census Travel to Work Data

6.8.1 The post MVESTM TMfS:05A AM peak hour matrix has been validated against 'Census Travel-to-Work' data. Table 6.12 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.

6.8.2 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.

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

Table 6.12 Production and Attraction patterns as a percentage of the total

Local Authority	Census productions	TMfS:05A productions	Census attractions	TMfS:05A attractions
Aberdeenshire	4%	2%	2%	1%
Angus	2%	1%	1%	1%
Argyll & Bute	0%	0%	0%	0%
City of Aberdeen	5%	7%	8%	8%
City of Dundee	3%	2%	4%	3%
City of Edinburgh	11%	13%	14%	15%
City of Glasgow	10%	17%	16%	22%
Clackmannanshire	1%	1%	1%	1%
Dumfries & Galloway	2%	2%	2%	2%
East Ayrshire	3%	2%	2%	2%
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%	8%	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%	2%	2%	2%
North Lanarkshire	7%	6%	6%	6%
Perthshire & Kinross	3%	2%	3%	2%
Renfrewshire	4%	5%	5%	5%
South Ayrshire	3%	2%	3%	2%
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%

6.8.4 Appendix P contains similar analysis to Table 6.12, 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.

6.8.5 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.

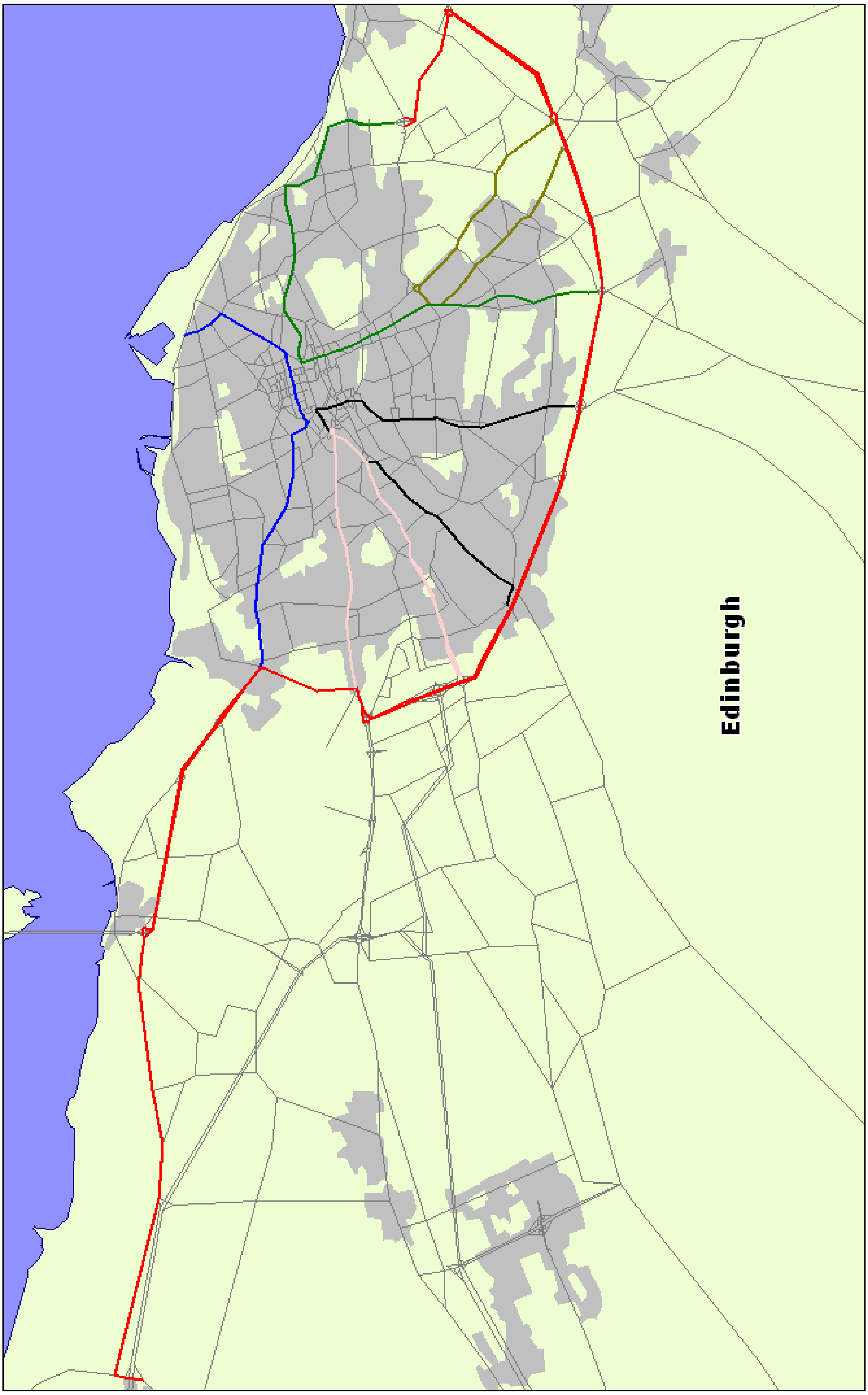

Figure 6.2 Edinburgh Area Urban Journey Routes
(see Appendix J for details of each route)

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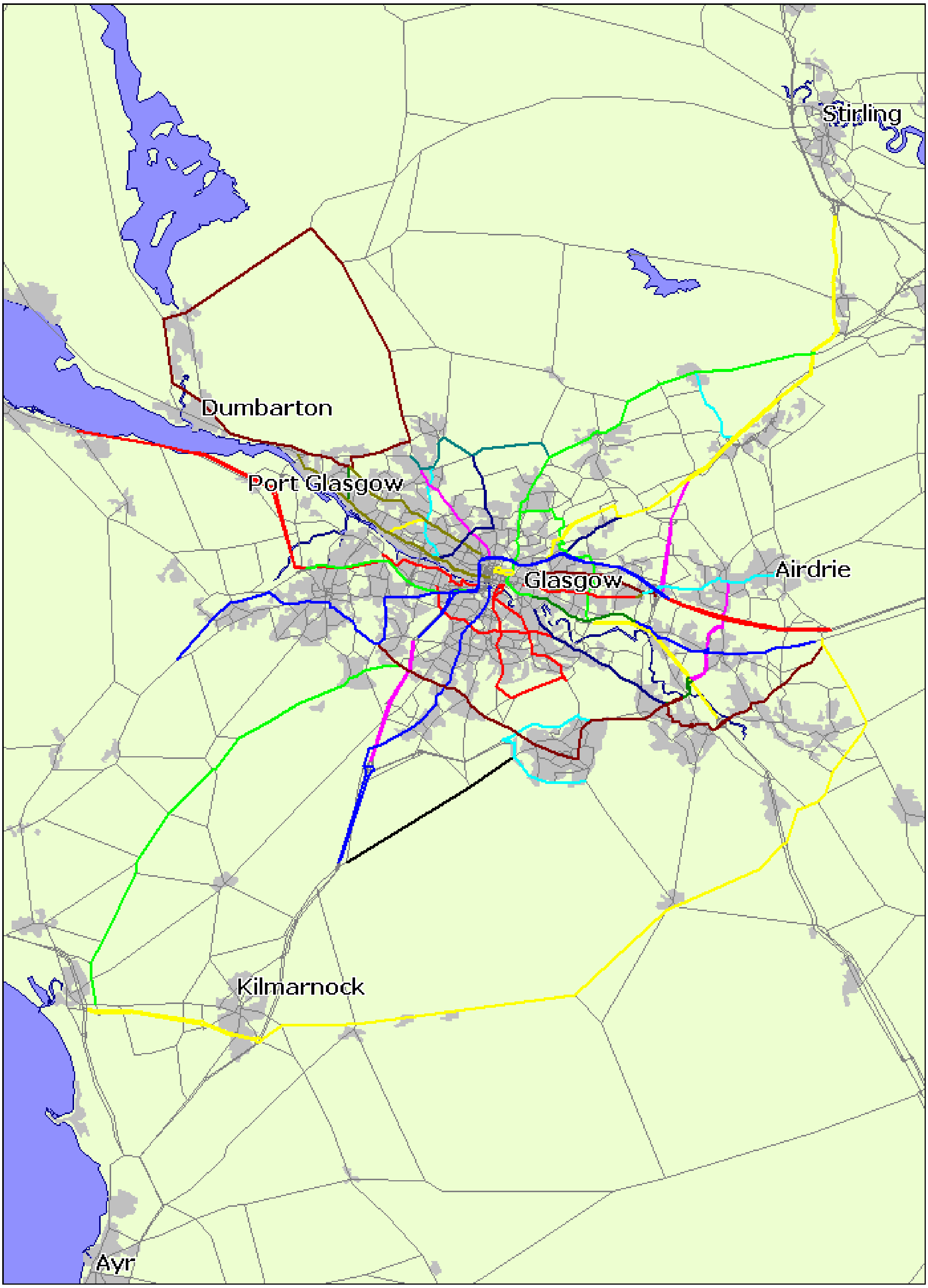

Figure 6.3 Glasgow Area Urban Journey Routes

(See Appendix G for details of each route)

Figure 6.4 Aberdeen Area Urban Journey Routes

(See Appendix G for details of each route)

Figure 6.5 Inter Urban Journey Routes

(See Appendix G for details of each route)

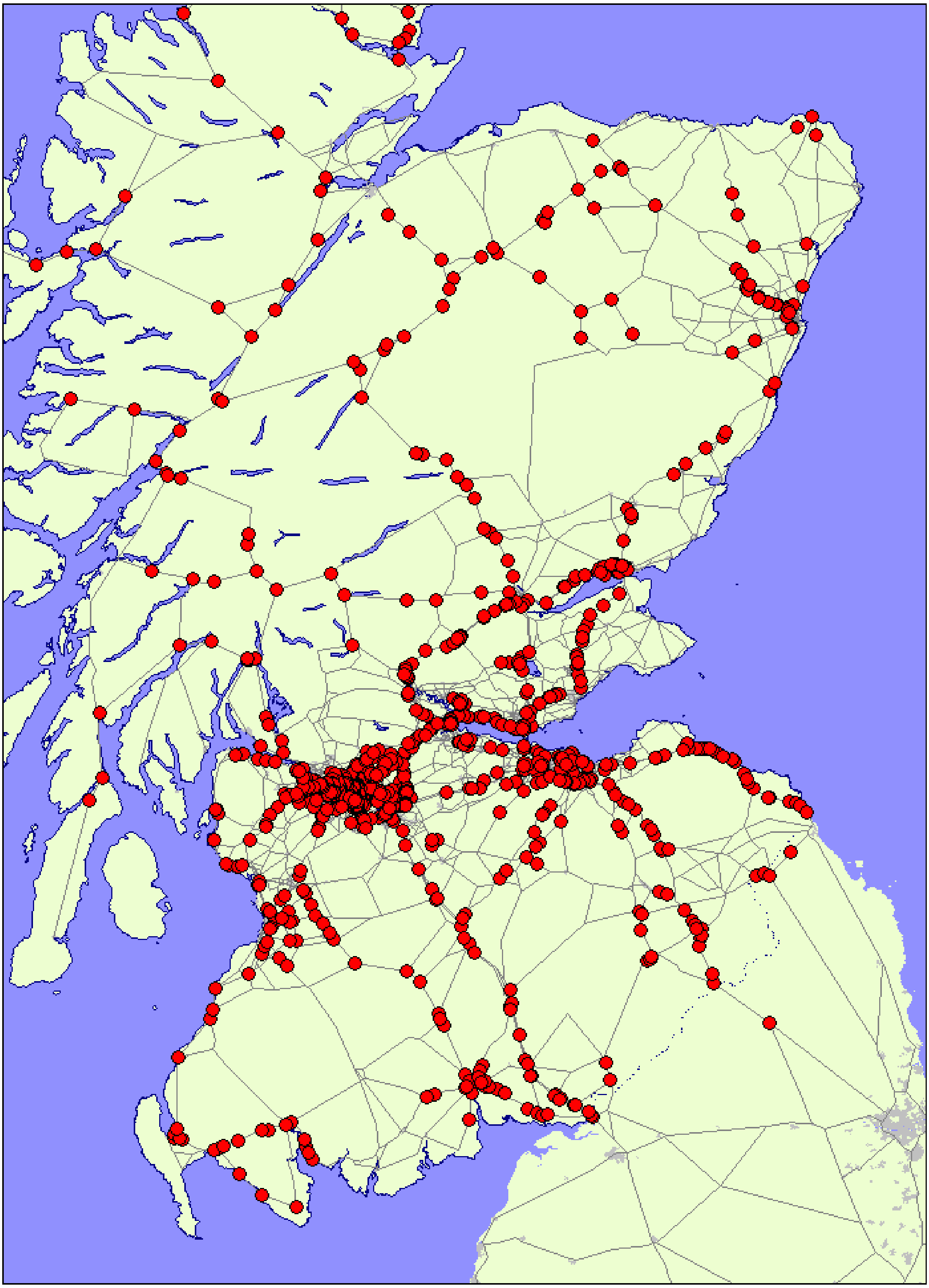

Figure 6.6 Validation Count Site Locations

7 Conclusions and Recommendations

7.1 Conclusions

7.1.1 This report has presented the calibration and validation of the TMfS:05A Rebase Highway Assignment Model.

7.1.2 The network was developed from the equivalent TMfS:05 network with the refinement of the road network and zone system in the Highlands and Argyll and Bute areas and the addition of ferry links and connecting roads infrastructure to represent the Scottish Islands.

7.1.3 New demand data from recent roadside interviews has been incorporated in the highway model in areas where the model was previously perceived to be weak, namely the Ayrshire and Dundee areas.

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.

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.

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:05A 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 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.

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