Access to Bath from the East

Public Transport Model - Local Model Validation Report

July 2015

Bath and North East Somerset Council

Bath & North East Somerset Council

Mott MacDonald

Access to Bath from the East

Public Transport Model - Local Model Validation Report

July 2015

Bath and North East Somerset Council

Keynsham Civic Centre, Market Walk, Keynsham BS31 1FS

Mott MacDonald, Stoneham Place, Stoneham Lane, Southampton, SO50 9NW, United Kingdom
T +44 (0)23 8062 8800 **F** +44 (0)23 8064 7251 **W** www.mottmac.com

Issue and revision record

Revision	Date	Originator	Checker	Approver	Description
A	08/07/2015	J Zhu	S Sirivadidurage	C White	Draft

Information Class: Standard

Contents

Chapter	Title	Page
Executive Summary		i
1	Introduction	3
1.1	Background	3
1.2	Overall Modelling System	3
1.3	Purpose of Report	3
1.4	Structure of Report	3
2	Data Collection	5
2.1	Overview	5
2.2	P&R intercept surveys	5
2.3	Bus intercept surveys	7
2.4	Bus Occupancy Surveys	13
2.5	Rail intercept surveys	16
3	Network Development	18
3.1	Summary Approach	18
3.2	Zoning system	18
3.3	Extent of the Public Transport Network	18
3.4	Key Model Parameters	19
3.5	2006 – 2014 Service Update	19
3.6	Journey Times	21
3.7	Bus and Rail Fares	22
3.8	Assignment Parameters	22
4	Development of Demand	24
4.1	Travel Demand Data	24
4.2	Observed Bus Matrices	24
4.3	Observed P&R Matrices	26
4.4	Observed Rail Matrices	27
4.5	Journey to Work (JTW) Matrices	28
4.6	Matrix Merge	29
4.7	Creation of Time Period Matrices	30
5	Model Calibration	33
5.1	Overview	33
5.2	Matrix Adjustment	33
5.3	Impact of the matrix adjustment	40
6	Model Validation	52

6.1 Introduction 52
6.2 Validation of the trip matrix 52
6.3 Network and Service validation 53
6.4 Assignment validation 56
6.5 PT flow validation 56

7 Conclusions 57

Appendices 58
Appendix A. Passenger Interview forms 59

Executive Summary

This report describes the process of updating the existing 2006 G-BATH public transport model into a new base year of 2014. Rebased G-Bath PT model calibrate/validate well against observed data to provide a good representation of the public transport conditions in Bath.

Guidance set out in WebTAG unit M3.2 has been applied in developing the model.

The survey data were collected by NDC at the end of 2014 and provided comprehensive data on key bus routes into Bath city centre. In addition bus occupancy survey sites collectively form two cordons (Inner and Outer) that well capture Public Transport (PT) trips into and out of Bath. Rail passenger data were collected at Bath rail station and three other minor rail stations serving routes into Bath. In addition P&R passenger data were also collected at three P&R sites.

The bus network was developed to be consistent with the highway model while bus stops were added according to NaPTAN dataset. Bus routes coded into the model corresponds with Travel Line National Dataset. Rail network was retained from the previous 2006 model but 2014 timetable information being used to create new rail services.

The matrices were developed in a logical manner, with separate matrices built for bus, P&R and rail for the same set of purposes. Observed matrices derived from the surveys were combined with Journey To Work (JTW) matrices in order to derive final PT matrices.

The matrices calibrates/validates reasonably well against the count data. The assignment validation demonstrates that total screenline flows were fully satisfied with the validation criteria. Also majority of differences between modelled flows and counts on individual locations were also within validation criterion although 1 or 2 corridors per time period were outside of the 25% validation criteria.

All network and services were validated to ensure an appropriate representation of the service pattern and the model broadly reflects the timetabled journey times across the three time periods, with vast majority of routes being within 15% of the timetabled time.

In conclusion, it is considered that the base year PT assignment models developed for the 2014 G-Bath transport model demonstrate a good representation of passenger behaviour in the study area and form a robust basis from which future year forecasts can be developed

1 Introduction

1.1 Background

Mott MacDonald has been commissioned by Bath and North East Somerset (BANES) council to update its G-BATH model originally developed by Atkins to assist in the development of a demand forecast model for analysing the impacts of its strategies on

- Improving access from the east of Bath by improvement to public transport, both bus and rail, including a possible new railway station; and
- reducing impact of through traffic, particularly HGVs, on the city

The aim of the base model development process was to update the existing G-BATH model from their 2006 base to a 2014 base with all changes that have occurred in the intervening period being incorporated in the new model.

1.2 Overall Modelling System

The existing modelling system consists of two main elements

- A highway assignment model developed in SATURN software
- A public transport assignment model and a variable demand model (including P&R choice and parking models) in Emme software

For the public transport (PT) modelling which is the focus of this report, the key changes from previous versions of the Emme model include

- Rebasing the model to 2014 through the collection of new survey data
- Changes to the arrangement of calibration and validation screenlines/cordons
- The updating of the highway model and its validation is contained in Doc Ref 342869/7/A

1.3 Purpose of Report

The purpose of this report is to document the development of the revised 2014 PT model including:

- The key characteristics of the model;
- The data used to develop the model;
- The process used to develop PT demand; and
- The calibration and validation of the model.

This report constitutes the local model validation report for the PT (Emme) model and describes the development of the model in detail and presents the validation of model outputs against observed counts.

1.4 Structure of Report

Following the introductory chapter, this report is structured as follows:

- Chapter 2 provides a description of the data used in model development;
- Chapter 3 presents the development of the PT network;
- Chapter 4 describes the development of the PT matrices;

- Chapter 5 covers the work involved in calibrating the network and matrices;
- Chapter 6 describes the local model validation.
- Chapter 7 sets out conclusions

2 Data Collection

2.1 Overview

The public transport data collection in 2014 comprised the following

- Park and Ride (P&R) intercept surveys
- Bus intercept surveys
- Bus occupancy surveys
- Rail intercept surveys

Those survey information including passenger counts formed the necessary dataset to create the observed public transport matrices. Surveys were conducted by NDC and were cleaned and processed before being returned.

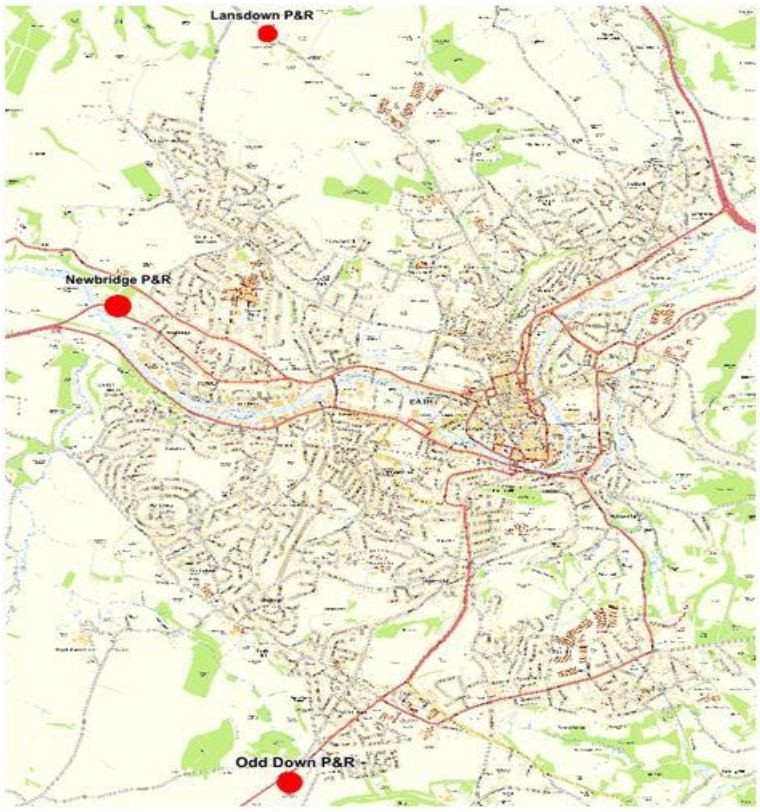
2.2 P&R intercept surveys

Origin and destination surveys were conducted on Monday 29th September 2014 at the existing three P&R sites in Bath:

- Lansdown (north of Bath)
- Newbridge (west of Bath)
- Odd Down (south of Bath)

These three sites are shown in Figure 2.1 below.

Figure 2.1: P&R Sites in Bath



Source: Ordnance Survey data © Crown copyright and database right 2015

Interviews were carried out with passengers boarding the P&R services at the P&R bus stops. They covered the entire operational period, i.e. from 06:15 to 20:30.

Intercept surveys were supplemented by (for the same 06:15-20:30 interval):

- Entry and exit counts (i.e. vehicle counts) at the P&R car parks
- Full occupancy count at the start of the survey period (i.e. number of vehicles in the car park). This allowed deducing car park occupancies throughout the day
- Total numbers of passengers boarding/alighting at the P&R bus stops

The survey form included the question of whether the respondent has a concessionary travel pass, and also the question of the return time at the P&R site. The form used for undertaking the survey is shown in Figure A.1.

Table 2.1 below shows the number of interviews carried out along with the counts and the achieved sample rates. Good sample rates were achieved at all three P&R sites.

Table 2.1: P&R Surveys - Sample Rates

Site	Date	Interviews	Boarding Count	Sample
Lansdown	29 September 2014	233	753	30.9%
Odd Down	29 September 2014	559	1,376	40.6%
Newbridge	29 September 2014	171	579	29.5%

Source: NDC

The P&R data was used for creating the 2014 base matrices, both for the Highway and Public Transport legs of the trip.

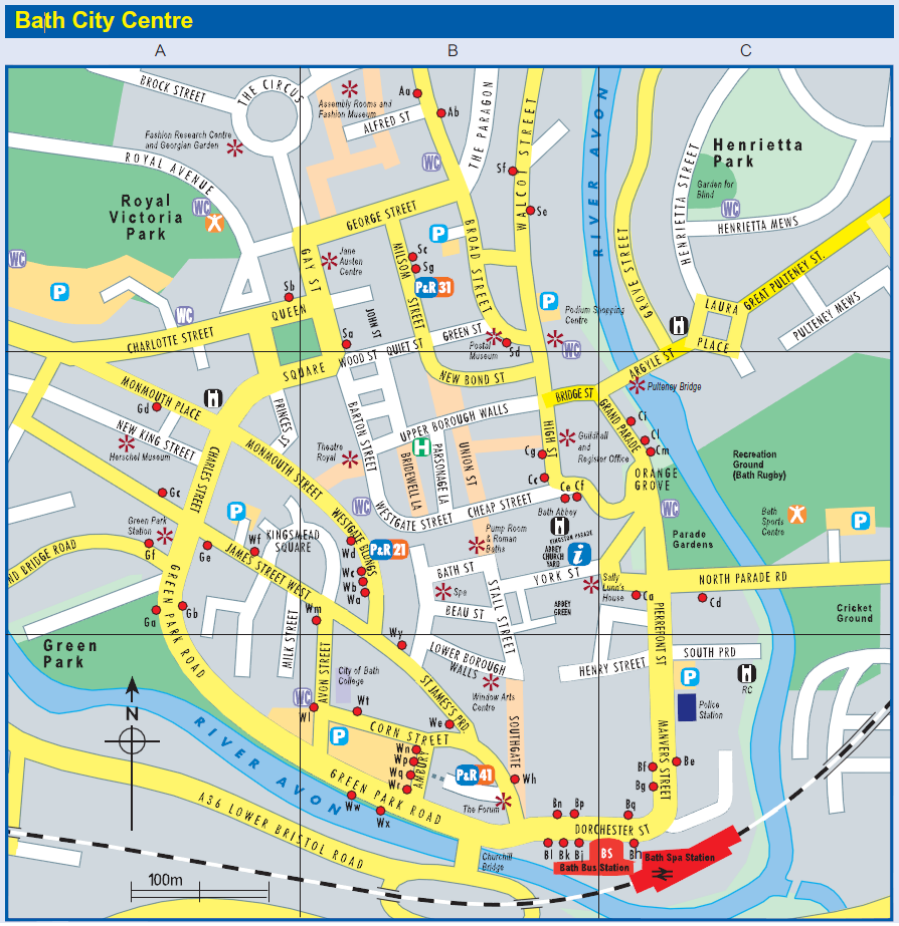
2.3 Bus intercept surveys

A series of bus intercept surveys (aimed at obtaining origin and destination trip information) were carried out at the following locations:

- Bath City Centre stops (including the bus station) - see Figure 2.2. In total 35 stops were surveyed.
- Bath Spa University and Bath University - See Figure 2.3 and Figure 2.4. In total 8 stops were surveyed.
- Hospital - see Figure 2.5. In total 4 stops were surveyed.

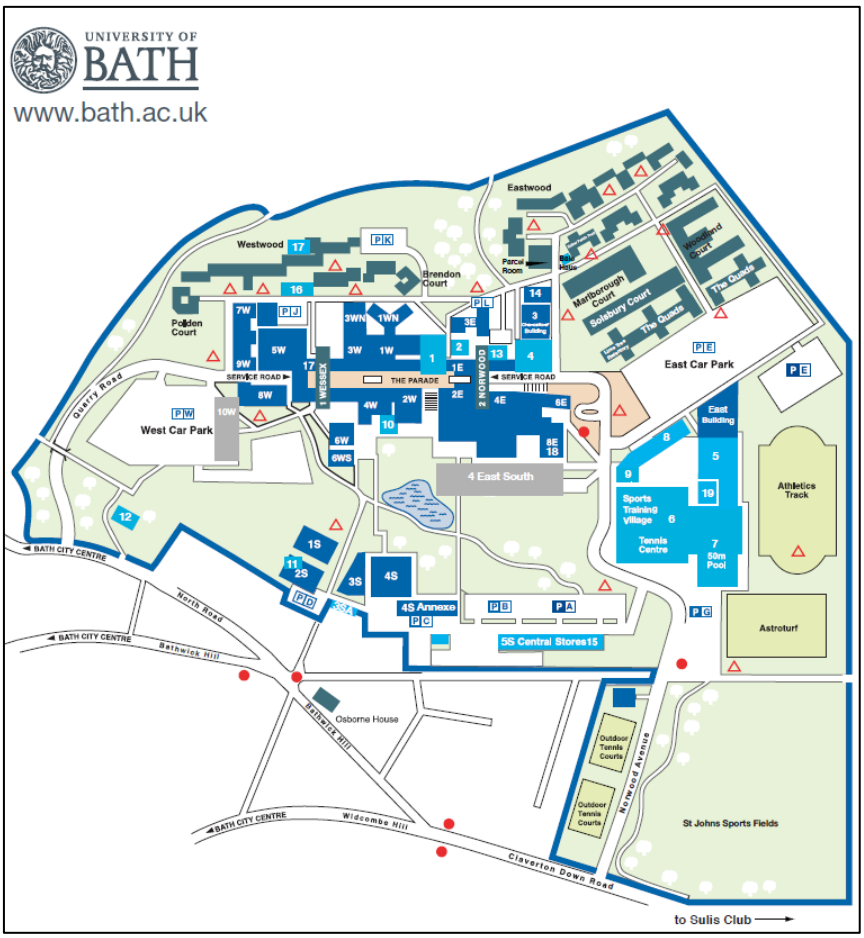
Boarding bus passengers were interviewed between 07:00 and 19:00, with boarding and alighting counts carried out on the same day of the intercept survey. The survey included questions about the availability of a concessionary travel pass and also the trip in the reverse direction. The form used for undertaking the survey is shown in Figure A.2.

Figure 2.2: Bath City Centre Bus stop locations



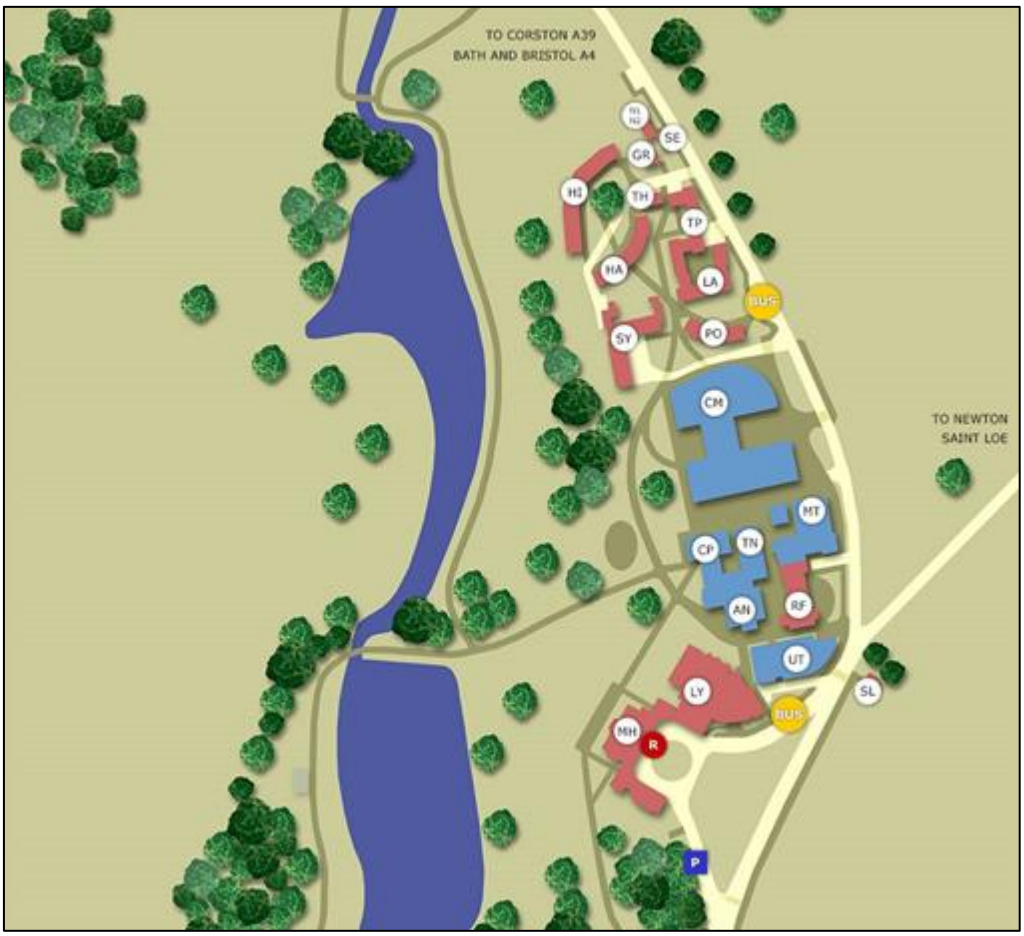
Source: B&NES leaflet, bus stops are marked with red dots

Figure 2.3: Bath University Bus stop locations



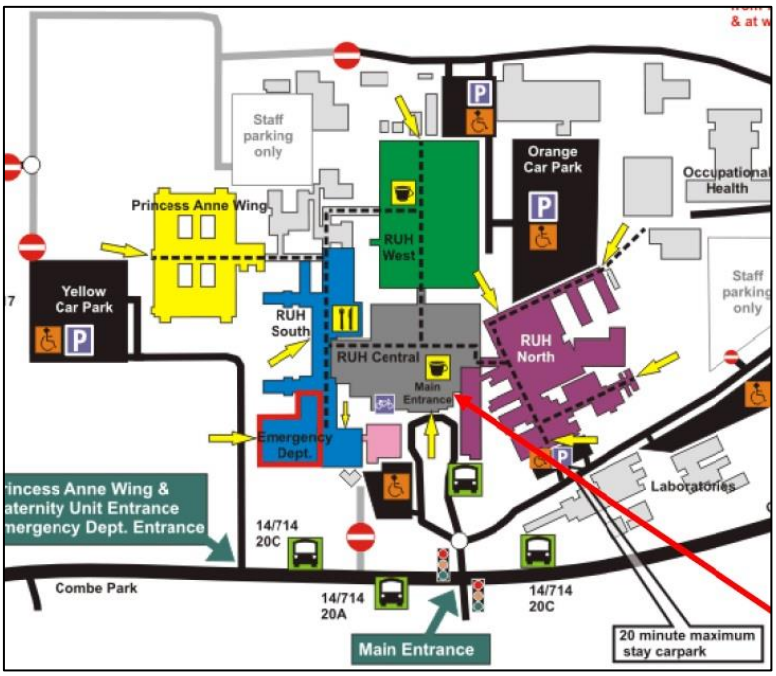
Source: Bath University website, bus stops are marked with red dots

Figure 2.4: Bath SPA University Bus stop locations



Source: Bath SPA University website, bus stops are marked with yellow dots

Figure 2.5: Bus stop locations at the Hospital



Source: RUH website, bus stops are marked with a green box with bus pictogran

Table 2.2 summaries the sample rates gathered from the bus intercept surveys.

Table 2.2: City Centre / Universities / Hospital sample rates

Site	Date	Interviews	Boarding Count	Sample
Bath Spa University	01/10/2014	91	1,838	5.0%
Bath University	30/09/2014	517	5,772	9.0%
Royal United Hospital	30/09/2014	136	945	14.4%
City Centre Stops total		3,343	17,005	19.7%
Individual City Centre Stops sample rates				
Bath Bus Station	02/10/2014	1,004	6,545	15.4%
AA	09/10/2014	48	71	67.6%
AB	02/10/2014	2	7	28.6%
BE	07/10/2014	22	49	44.9%
BF	02/10/2014	0	46	N/A
BG	07/10/2014	52	96	54.2%
bh	07/10/2014	55	126	43.7%
BJ	07/10/2014	0	17	N/A
BK	07/10/2014	78	499	15.6%

Site	Date	Interviews	Boarding Count	Sample
BL	07/10/2014	83	639	13.0%
BN	07/10/2014	265	1,588	16.7%
BP	07/10/2014	59	629	9.4%
BQ	08/10/2014	45	105	42.9%
CA	08/10/2014	0	0	N/A
CC	08/10/2014	73	422	17.3%
CD	09/10/2014	2	35	5.7%
CE	02/10/2014	0	0	N/A
CF	08/10/2014	308	843	36.5%
CG	08/10/2014	126	479	26.3%
CI	08/10/2014	30	99	30.3%
CL	02/10/2014	8	49	16.3%
CM	02/10/2014	0	0	N/A
GA	Not Covered	Not Covered	Not Covered	Not Covered
GB	Not Covered	Not Covered	Not Covered	Not Covered
GC	01/10/2014	0	10	N/A
GD	01/10/2014	62	112	55.4%
GE	01/10/2014	174	540	32.2%
GF	01/10/2014	0	0	N/A
SA	09/10/2014	0	0	N/A
SB	Not Covered	Not Covered	Not Covered	Not Covered
SC	09/10/2014	0	7	N/A
SD	08/10/2014	80	199	40.2%
SE	Not Covered	Not Covered	Not Covered	Not Covered
SF	Not Covered	Not Covered	Not Covered	Not Covered
SG	09/10/2014	130	859	15.1%
WA	09/10/2014	0	0	N/A
WB	07/10/2014	87	325	26.8%
WC	01/10/2014	92	392	23.5%
WD	01/10/2014	56	520	10.8%
WE	07/10/2014	8	24	33.3%
WF	01/10/2014	20	67	29.9%
WH	06/10/2014	121	882	13.7%
WL	30/09/2014	0	0	N/A
WM	06/10/2014	82	249	32.9%
WN	07/10/2014	0	0	N/A
WP	06/10/2014	0	0	N/A
WQ	06/10/2014	0	0	N/A
WR	07/10/2014	0	0	N/A

Site	Date	Interviews	Boarding Count	Sample
WT	06/10/2014	158	453	34.9%
WW	06/10/2014	0	1	N/A
WX	06/10/2014	0	0	N/A
WY	06/10/2014	13	21	61.9%

Source: P:\Southampton\ITW\Projects\342869 Bath East Access\Technical notes\PT\ Bus and Rail Sample Rates.xlsx

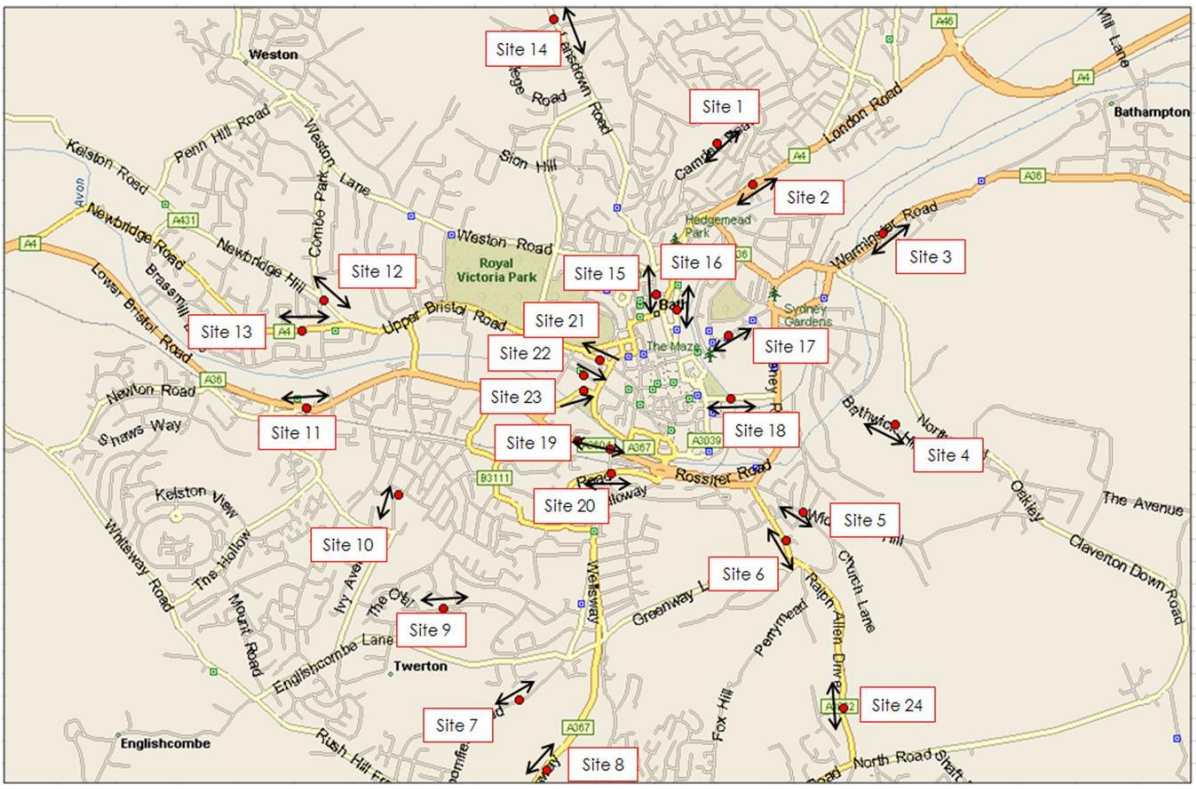
The intercept bus survey data was used to build the 2014 bus matrices which fed onto the Public Transport Emme model. A small number of sites in the city centre were not used for interviews or counts for various operational reasons. Other sites have counts but no interviews or vice-versa. These situations are rare and in each case the numbers are very low. This does not significantly affect the final matrices as interviews and counts across a number of sites were grouped together.

2.4 Bus Occupancy Surveys

In addition to the bus intercept surveys, bus occupancy surveys were carried out at 24 sites on radial routes on two cordons into Bath City Centre. Surveys were conducted from 07:00 to 19:00 on a weekday between 13 and 24 October 2014.

The service number, operator, arrival time, boarding and alighting passengers at each stop and total number of on-board passengers for each bus were recorded by boarding on the bus. Any buses which did not stop were identified in the data and an estimate of on-board passengers was made. The location of the bus occupancy surveys is shown in Figure 2.6, with both directions having been surveyed.

Figure 2.6: Bath bus occupancy surveys



Source: NDC, red dots indicate occupancy survey bus stop locations, blue and green dots indicate other bus stops

Table 2.3 shows the number of travellers boarding and alighting and on-board passengers for the peak hours of AM 08:00-09:00, average IP 10:00-16:00 and PM 17:00-18:00.

Table 2.3: Bus Occupancy Surveys - Peak Hour data

Site	Direction	Boarding			Alighting			On-Board Counts		
		AM	Avg IP	PM	AM	Avg IP	PM	AM	Avg IP	PM
1	Inbound	14	6	2	0	0	0	33	16	10
	Outbound	0	0	0	1	6	7	0	20	23
2	Inbound	12	3	3	1	4	2	428	137	64
	Outbound	16	1	5	7	6	11	80	148	283
3	Inbound	2	1	0	0	0	0	67	44	24
	Outbound	0	0	0	0	1	0	7	41	51
4	Inbound	2	2	1	0	0	0	44	233	754
	Outbound	0	0	0	0	1	1	1,013	404	83
5	Inbound	0	1	0	0	1	0	0	11	11

Site	Direction	Boarding			Alighting			On-Board Counts		
		AM	Avg IP	PM	AM	Avg IP	PM	AM	Avg IP	PM
	Outbound	0	0	0	0	1	1	0	5	3
6	Inbound	0	0	0	0	0	0	16	16	6
	Outbound	0	1	0	0	0	0	20	20	34
7	Inbound	1	1	0	0	0	0	106	42	35
	Outbound	0	0	0	0	1	0	42	40	76
8	Inbound	3	1	1	1	0	0	213	108	63
	Outbound	0	0	0	0	0	0	84	118	196
9	Inbound	6	2	0	1	0	0	6	8	4
	Outbound	0	0	0	1	3	3	0	10	9
10	Inbound	4	4	5	0	2	2	207	78	62
	Outbound	0	0	0	0	4	4	19	79	140
11	Inbound	19	13	13	0	1	1	130	83	40
	Outbound	0	0	1	0	0	0	31	90	128
12	Inbound	2	5	0	4	5	0	141	186	217
	Outbound	2	5	4	5	7	11	115	190	272
13	Inbound	5	6	4	7	15	18	278	295	258
	Outbound	10	9	4	0	2	6	308	246	325
14	Inbound	0	0	0	19	0	0	251	83	3
	Outbound	0	0	0	0	0	0	0	59	162
15	Inbound	0	1	0	23	5	1	287	80	10
	Outbound	0	4	17	0	1	0	7	97	307
16	Inbound	0	0	0	74	24	7	146	95	63
	Outbound	0	0	0	0	0	0	56	124	257
17	Inbound	0	2	0	0	3	1	220	83	110
	Outbound	1	3	9	0	1	1	35	78	132
18	Inbound	9	1	0	12	73	34	33	214	349
	Outbound	21	11	0	0	1	1	1,605	598	213
19	Inbound	15	8	4	0	0	2	438	104	31
	Outbound	0	0	0	0	1	6	15	20	70
20	Inbound	0	0	0	11	1	4	574	402	141
21	Outbound	4	8	37	1	1	1	92	295	566
22	Inbound	2	3	2	19	14	10	516	279	190
23	Inbound	0	0	0	1	5	6	250	172	142
24	Inbound	0	0	0	0	0	0	23	16	7
	Inbound	0	0	0	0	0	0	23	16	7

Source: MM P:\Southampton\ITW\Projects\342869 Bath East Access\Survey data\Restored\Survey data\4284 - Bath Bus Occupancy Surveys\Bus occupancy_All.xlsx

The bus occupancy surveys provided the link passenger counts for the calibration of the PT Emme model.

2.5 Rail intercept surveys

As part of the annual rail survey for West of England, on Thursday 6th November 2014 postcard rail intercept surveys were carried out at various rail stations in Bath & North East Somerset, Bristol City, North Somerset and South Gloucestershire areas. In particular, NDC were commissioned to undertake the handover of the postcard surveys to boarding passengers at the rail stations in Bath & North East Somerset, i.e. Bath Spa, Keynsham, Oldfield Park and Freshford.

Due to a problem at Bath Spa on 6th November (a train was cancelled at 18:00 which had a consequential effect on local services) and the concern that not enough questionnaires were handed over at Keynsham and Oldfield Park, the intercept surveys (i.e. handover of questionnaires) were repeated on Wednesday 26th November 2014. Table 2.4 below details the programme with hours for the intercept surveys for the stations within Bath & North East Somerset.

Table 2.4: Rail Intercept Surveys

Site	6 November 2014	26 November 2014
Bath Spa	From 05:30 to 01:20	16:00 to 22:00
Keynsham		05:30 to 00:00
Oldfield Park		05:30 to 00:00
Freshford	From 06:00 to 00:00	

Source: NDC

In total, considering all surveyed stations in the four Districts above, 788 questionnaires were returned and processed.

The intercept rail surveys were supplemented by rail passenger boarding and alighting counts, where cyclist and wheelchair passengers were separately identified.

Table 2.5 shows the number of returned questionnaires at Bath Spa, Keynsham, Oldfield Park and Freshford, the boarding counts and the corresponding sample rates.

Table 2.5: 2014 Rail sample rates

Site	N° of returned questionnaires	N° of boarding passengers	Sample Rates
Bath Spa	488	6,993	6.98%
Keynsham	116	734	15.81%
Oldfield Park	178	684	26.04%
Freshford	6	50	12.00%

Source: P:\Southampton\ITW\Projects\342869 Bath East Access\Technical notes\PT\ Bus and Rail Sample Rates.xlsx

The intercept rail surveys along with the passenger counts were used to develop the rail matrices which fed onto the PT Emme model.

3 Network Development

3.1 Summary Approach

Significant changes were made to the B&NES 2006 Emme public transport network. These include:

- Updating the Bus network to be consistent with the Highway network.
- Addition of new bus services and removal of obsolete routes. Updating the frequency of all services in line with timetable data for October 2014.
- There are no changes on the rail network but changes to service patterns since 2006 which have been updated.

3.2 Zoning system

The zoning system from the existing 2006 G-Bath model has largely been retained for the 2014 rebase. The new 2014 zoning system (Table 3.1) now consists of 459 zones in total with 24 empty zones allocated for future development as requested by B&NES. More details on the zoning system can be found in Section 3.6.7 of the Highway local model validation report.

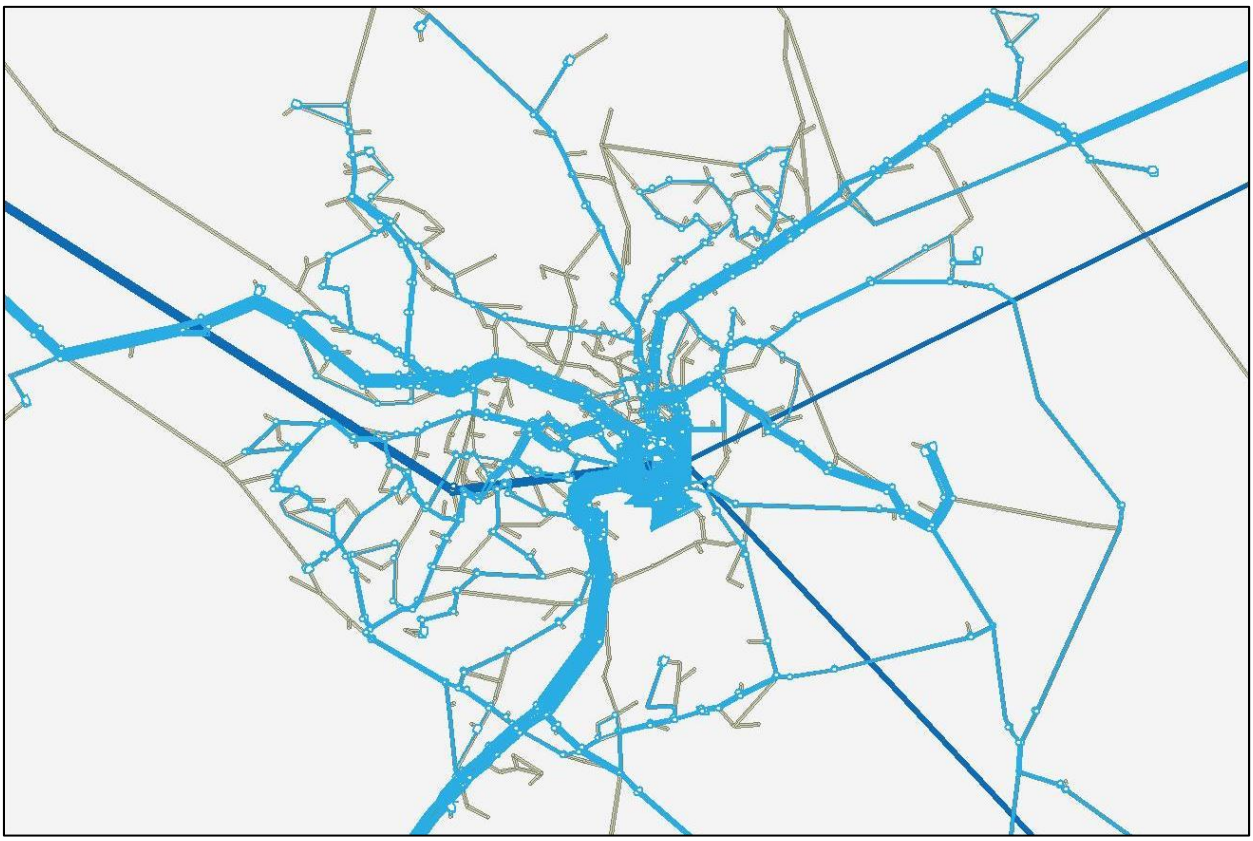
Table 3.1: Distribution of zones across study area

Area	Number of Zones
Bristol	45
North Somerset	32
B&NES	232
South Gloucester	41
Hinterland	68
Externals	13
P&R	4
Development Zones	24
Total	459

3.3 Extent of the Public Transport Network

The public transport network includes all bus services serving Bath. These also include 3 P&R bus services. Bus services included in the model are highlighted in light blue while rail services are highlighted in dark blue in Figure 3.1.

Figure 3.1: Extent of the main PT network



Source: 2014 Base EMME Model

3.4 Key Model Parameters

Modelling software - the public transport model has been developed using the Emme v3.4 software.

Modelling base year - the model represents an average weekday in October for a base year of 2014.

Modelled time periods - the modelled hours are as follows:

- AM Peak hour (08:00 – 09:00)
- Average Inter Peak Hour (10:00 – 16:00)
- PM Peak hour (17:00 – 18:00)

3.5 2006 – 2014 Service Update

The public transport network was updated to take account of service additions, changes and withdrawals. The bus network was updated using Traveline National Data Set (TNDS). Bus routes and bus stops were

extracted from National Public Transport Access Nodes (NAPTAN) data, and assigned to the corresponding node in the PT model. The service frequencies were also updated. In cases where there was no link to represent part of a route in the model, the service was rerouted appropriately. Services have been updated using May-Dec 2014 timetable information. All rail services that call at stations in the study area in the modelled time periods were included. This data was obtained from national rail timetables. Table 3.2 and Table 3.3 show main bus services and rail services included in the model respectively.

Table 3.2: Bus Services included in the model

Service	Route Description	Operator
1	Upper Weston - Bath Centre - Combe Down	First
2	Ensleigh - Bath Centre - Bath Riverside	First
4	Kingsway - Bath Bus Station - Bathampton	First
5	Bath Bus Station - Lower Bristol Rd - Twerton - Whiteway - Twerton - Lower Bristol Rd - Bus Station	First
6	Bath Bus Station - Fairfield Park - Larkhall - Bath Bus Station	First
7	Bath Bus Station - Larkhall - Fairfield Park - Bath Bus Station	First
10	Bath Bus Station - Coronation Avenue - Southdown - Bath Bus Station	First
12	Whiteway - Lower Oldfield Park - Bus Station	Wessex
13	Foxhill - Bath Bus Station - Bathford	First
14	Weston - RUH - Bath Bus Station - Bear Flats - Odd Down	First
15	Bath Spa University - Bath Centre - Bath Spa University	First
18	Lower Oldfield Park - Bath Centre - University - Bath Centre - Lower Oldfield Park	First
18B	Bath University - Bathwick Hill - Bath Centre - Bathwick Hill - Bath University	Bugler Coaches
20A	Bath Bus Station - Weston - R.U.H. - Twerton - Fox Hill - University - Widcombe - Bus Station	Wessex
20C	Bath Bus Station - Widcombe - University - Fox Hill - Twerton - R.U.H. - Weston - Bus Station	Wessex
94	Trowbridge - Wingfield - Westwood - Freshford - Bath	Libra Travel
173	Wells - Norton Radstock - Bath	First
175	Bath Bus Station - Peasedown Orchard Way - Radstock - Midsomer Norton	Somerbus
178	Bath - Norton Radstock - Bristol	First
179	Bath Bus Station - Timsbury - Farmborough - Paulton -Welton - Midsomer Norton	First
184	Bath - Norton Radstock - Frome	First
228	Bath - Batheaston - Colerne - Thickwood	Faresaver
231	Bath - Corsham - Chippenham - Pewsham	First
265	Bath - Bradford on Avon - Trowbridge - Westbury - Warminster - Salisbury	First
267	Bath - Hinton Charterhouse - Norton St. Philip - Beckington - Frome	First
267	Frome - Beckington - Bath	Faresaver
271	Bath - Melksham - Devizes - Urchfont	First
272	Bath - Melksham - Bowerhill	First
319	Bath - Britton - Kingswood - Cribs Causeway	First
37	Bath - Keynsham - Longwell Green - Hanham - Bristol (First No.37 now, coded as	First

Service	Route Description	Operator
	37KSM)	
38	Bath - Keynsham - Brislington - Bristol Centre	First
379	Bath - Radstock - Midsomer Norton - Paulton - Pensford - Bristol	First
620	Old Sodbury - Chipping Sodbury - Yate - Pucklechurch - Wick - Bath	Wessex
700	Bath Bus Station - Sion Hill - Bath Bus Station	CT Coaches
716	Bath Bus Station - Newbridge Road - Bath Bus Station	CT Coaches
734	Bath Bus Station - Forrester Road - Bath Bus Station	CT Coaches
768	Clutton - Midsomer Norton - Bath Centre	CT Coaches
A4	Bath - Keynsham - South Bristol - Bristol Airport	Bath Bus Company
U18	University of Bath - Lower Oldfield Park - City Centre - University of Bath	Wessex
X31	Bath - Chippenham	Faresaver
X39	Bath Bus Stn - Newbridge Rd - Saltford - Brislington - Bristol Bus Stn	First
X72	Bath - Melksham - Devizes	Faresaver
PR21	Newbridge Park & Ride - Bath Centre	First
PR31	Lansdown Park & Ride - Bath Centre	First
PR41	Odd Down Park & Ride - Bath Centre	First

Table 3.3: Rail Services included in the model

Service	Route Description
123	Brighton, Portsmouth & Weymouth – Bristol, Cardiff, Gloucester & Great Malvern
125	London – Swindon, Cheltenham Spa, Bristol, Weston-super-Mare & South Wales
132	Bath Spa, Bristol & Gloucester – Cardiff
134	Taunton - Gloucester
135	London & Birmingham – Devon & Cornwall
160	London – Salisbury & Exeter

Source: National Rail Timetable

3.6 Journey Times

It is important to note that in the current G-BATH model, the bus network was created from the SATURN highway network. This enables a linkage to be established between highway travel times and bus travel times. Bus services are coded in the SATURN network and these are converted into the equivalent PT lines file for the Emme model. The rail network is added to the Emme bus network to create the full PT network. Travel times for the bus network are derived from the corresponding highway network. This linkage also allows the impact on bus journey times of new bus lanes and bus priority measures at junctions to be modelled. The total journey time for a bus service is calculated as:

$$\sum BusLinkTime + BusTurnTime$$

Both the link and turn times are calculated using inputs from the SATURN model. The bus journey time on links is calculated according to the equation below

$$Bus\ Link\ Time = 1.2 * (Link\ Time + Link\ Length * BSD * Delay)$$

where

- Link time = SATURN congested link time (if no bus lane), SATURN free-flow link time (if a bus lane exists)
- BSD = Bus Stop Density per km {2.83 (urban), 1.70 (rural) – based on SATURN link types – derived from actual bus stop intervals}.
- Delay = 10 seconds to allow for boarding / alighting

3.7 Bus and Rail Fares

According to *Atkins' G-BATH v2.3 PT LMVR*, the PT sub-mode choice was undertaken within the demand model based on the standard WebTAG generalised cost formulation (which includes fares). The PT assignment model does not consider the impact of fares. As bus services are provided principally by First, we have adopted their stage based fare system according to Table 3.4 below. A passenger would pay for a flat fare if both origin and destination are located within the Bath Inner Zone. If an origin or destination or both belongs to the Bath Outer Zone, the passenger would pay a distance based fare. As a result, bus fares are input into the Emme model as OD based fares while P&R fares are a flat fare and rail fares are distance based. All fares have been included at 2014 level but at 2010 prices.

Table 3.4: Bus fare structure

	Fare (£' 2014)					
		Bath Outer Zone				
Zone type	Bath Inner Zone	Up to 3 miles	3-6 miles	6-9 miles	9-12 miles	Over 12 miles
Bath Inner Zone	2.20	1.50	2.50	3.50	4.50	5.50
Bath Outer Zone	-	1.50	2.50	3.50	4.50	5.50

Notes: These are standard adult fares. No special treatment is made for season, child or student fares.

3.8 Assignment Parameters

The generalised cost function used for the PT assignment routing, measured in units of time (minutes), is given by:

$$G_{PT} = V_{WK} * A + V_{WT} * W + T + B$$

where:

- V_{WK} is the weight applied to time spent walking (walk time weight);
- A is the total walking time to and from the services;

- $V_{WT}$is the weight applied to time spent waiting;
- W is the total waiting time for all services used on the journey;
- T is the total in-vehicle time; and
- B is the total boarding penalty applied for each service boarded on the journey

Most assignment parameters have been retained from the 2006 model except boarding penalties. The boarding penalties were in addition to any walk access times that may apply. First, all those defined in the 2006 base model had been removed. New boarding penalties were then added in order to dissuade unrealistic interchanges. Their values were calibrated specifically for the 2014 model, to ensure a realistic assignment of trips. These factors are applied to both bus and rail. The parameters' values are provided in Table 3.5 below.

Table 3.5: Assignment Parameters

Parameter	Value
Wait time factor	0.5
Wait time weight	2.5
Walk time weight	2
Boarding Penalty (min)	2 to 10

The PT assignment takes the standard transit assignment option in the Emme software. Full details about this assignment method can be found in the Emme manual.

4 Development of Demand

4.1 Travel Demand Data

Mott MacDonald has developed a range of surveys in order to collect data that was used to create the observed public transport matrices. The surveys were conducted near the end of 2014 for Bus, Rail and P&R trips in and around Bath. Passenger counts back up these surveys so that they can be expanded. The following purpose matrices have been created for Bus, P&R and Rail:

- Home – Work
- Home – Employer Business
- Home – Other
- Non-Home – Employer Business
- Non-Home – Other

24-hour production-attraction (PA) matrices are required for home-based trips, with non-home based trips represented by origin-destination (OD) matrices. For assignment, peak hour origin/destination matrices must then derived, requiring the development of time period factors to be applied to the PA matrices. As mentioned before surveys were conducted by NDC and were cleaned and processed before being returned. The other parts of this section give more details on how each type of matrix was created and the extent of the surveys.

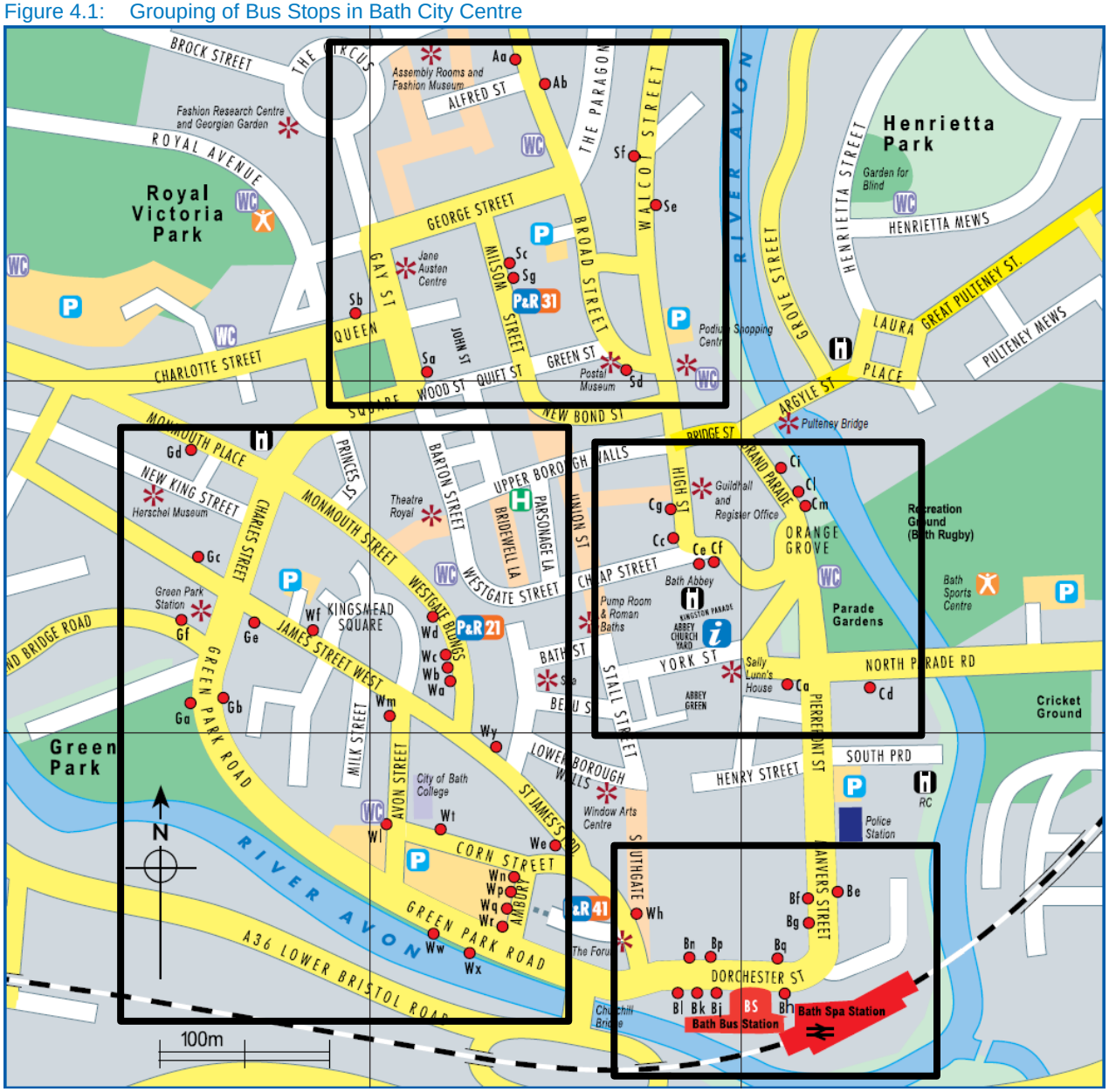
4.2 Observed Bus Matrices

Passenger surveys were conducted at bus stops covering a large area of Bath. Passengers were surveyed boarding services at the following stops:

- 37 stops in the City Centre, one of which was Bath Bus station which has 16 stands
- 2 stops at Bath Spa University
- 5 Stops at the University of Bath
- 3 stops at the Royal United Hospital

Counts were conducted at all stops which were surveyed. The counts included boarding counts as well as alighting counts, which are used to expand return trips. In order to expand the records in the outbound direction it was decided that expansion factors should be calculated for each individual service and not the individual stops. This is clearly more accurate. However in order to reduce the possibility of large expansion factors it was decided that records from multiple stops should be grouped together. Also surveys and counts were grouped into 3 hour intervals starting at 7am and finishing at 7pm. The individual stops belonging to the sites outside of Bath City Centre were grouped together. Figure 4.1 shows the groups inside the City Centre.

Figure 4.1: Grouping of Bus Stops in Bath City Centre



In order to expand the records for the return trips an outbound and return direction was given to each survey record. Each direction is North, East, South or West. This is done because it cannot be sure which bus stop the passenger will return to even though the stop they make their outbound trip from is known. Therefore return trips are grouped by these directions and also by the areas shown in the diagram.

The company NDC processed the count and survey data before sending it to Mott MacDonald. This included analysing the postcode data entered into the survey forms to see if it was sensible. OSGRs were identified from these postcodes and survey origins and destinations were allocated to the zoning system.

Double counting can occur in different ways during the process of collecting data. Firstly a bus user can be counted at 2 or more surveyed bus stops on one trip and secondly there is also the possibility that a user can be surveyed twice. There is a low chance that a passenger will be surveyed twice though it is more likely for a passenger to be surveyed on their outbound trip and then on their return trip than to be surveyed twice in one direction. In these cases the resulting cell in the matrix may be up to twice the size it should be. As a result the trips which may be subject to double counting have been identified and the expansion factor for the corresponding survey record has been halved.

Double counting could have occurred in many ways:
- For passengers interchanging in Bath city centre
- For passengers interchanging at other survey sites outside of the city centre
- For passengers travelling between surveyed areas

To identify which survey records are subject to double counting the origins and destinations of records have been plotted in mapping software. Then the origins and destinations have been tagged with a number if they are inside a surveyed area or within 500m of a survey area boundary. This tag has been used to mark which records will have been counted twice.

The sizes of the observed bus matrices are given in Table 4.1 below.

Table 4.1: Bus Matrix Totals

Purpose	Home	Non-Home AM	Non-Home IP	Non-Home PM
Work	2,118	N/A	N/A	N/A
Employer Business	52	34	107	83
Other	11,710	548	3,011	1,615

Note that the Home based matrices are in PA format while non-home based purposes are in OD format.

4.3 Observed P&R Matrices

Surveys and boarding and alighting counts have been completed for boarding passengers at three park and ride sites in Bath.

Each of the sites has a single P&R service to Bath city centre. The surveys are very similar to the bus passenger surveys and hence were expanded in a similar way. Where possible an expansion factor was created for each half hour period between 7am and 7pm. Expansion factors were created for each site in turn and the resulting matrices were added together.

The P&R matrices and the Bus matrices can pick up the same movements and this type of double counting is removed from both types of matrices. I.e. bus only trips in the P&R matrices are removed and trips believed to have a car leg are removed from the Bus matrices. If a trip has an origin or destination further than 500m from the surveyed P&R site then it is assumed to have a car leg and therefore belongs to the P&R segment. Otherwise the trip should belong to the Bus segment.

The sizes of the observed P&R matrices are given in Table 4.2 below.

Table 4.2: P&R Matrix Totals

Purpose	Home	Non-Home AM	Non-Home IP	Non-Home PM
Work	839	N/A	N/A	N/A
Employer Business	78	38	10	0
Other	1,490	23	205	8

Note that the Home based matrices are in PA format while non-home based purposes are in OD format.

4.4 Observed Rail Matrices

Postcard surveys and boarding and alighting counts have been completed for the following rail stations:

- Bath Spa Rail Station
- Keynsham Rail Station
- Oldfield Park Rail Station
- Freshford Rail Station

Postcard surveys were given out to boarding passengers at these stations and a sample of the surveys were returned to NDC before being cleaned and sent to Mott Macdonald. Counts of boarding and alighting passengers were undertaken at each platform for each service throughout the day for two days in November. For each of the stations there are two platforms only. To make things simpler the counts were grouped by platform for each half hour period from 7am to 7pm.

Survey records were given an outbound platform number and a return platform number so that they could be expanded by platform. Outbound trips were expanded using the boarding counts at the relevant stations. The reverse trips were expanded using the alighting counts at the return platform. A question for the return trip time is included in the postcard survey however this is the time the passenger will leave to make the return trip and not the time that they arrive at their destination station. Therefore there is a mismatch between the time given as the return time and the time of arrival. In order to reduce this inaccuracy an average straight line speed for a selection of trains was calculated and applied to the direct distance between the origin OSGR and the destination OSGR.

Double counting is removed by firstly identifying the survey records for trips between 2 surveyed stations. For example this would include the trip between Bath Spa and Keynsham. Further still the percentages of records with double counted trips were identified for each platform for each time period. These

percentages were used to adjust the counts at the platforms. E.g. If x% of surveys are for trips arriving at Bath Spa from another surveyed station in the AM period then the alighting count at Bath Spa is reduced by x% for that period. Alternatively the boarding count for the return trip is also reduced. Table 4.3 shows the extent of the double counting.

Table 4.3: Double Counting

Count Type	W Double Counting	W/O Double Counting	% Double Counting
Boarding	8,460	7,845	7.27%
Alighting	7,801	7,031	9.86%

Matrices were created with the same trip purposes as with the Bus and P&R matrices. Users had the option to choose “Commute”, “Employer Business” or “Other” as their overall trip purpose. NTEM data for BANES was used to split the expanded trips into the correct purposes. E.g. Records with “Other” given as the trip purpose were split into the Home Other matrix and the Non-Home Other matrix using the values from the NTEM dataset. Table 4.4 gives the NTEM splits for rail trips in BANES in 2014.

Table 4.4: NTEM Trip Purpose Splits

Trip Purpose	Work	Employer Business	Other
Home	92.0%	66.2%	78.5%
Non-Home	8.0%	33.8%	21.5%

The sizes of the observed matrices are given in Table 4.5 below.

Table 4.5: Matrix Totals

Matrix Purpose	Home	Non-Home AM	Non-Home IP	Non-Home PM
Work	3,754	N/A	N/A	N/A
Employer Business	670	287	171	297
Other	1,716	242	514	209

Note that the Home based matrices are in PA format while non-home based purposes are in OD format.

4.5 Journey to Work (JTW) Matrices

Census 2011 Journey to Work (JTW) was obtained for all workers who live and/or work in Bath & NE Somerset, for bus and rail modes. The data provides the usual mode of travel to the usual place of work, and the home and workplace locations for all people in employment. The data required further processing for use in the transport model, as follows.

The spatial detail of the JTW data is Middle Super Output Area (MSOA). The transport model zones are smaller than MSOAs in the core area of the model, particularly in Bath itself so the MSOA level had to be split down to model zones. This was done in proportion to the population (for residential location) and total

employment in each zone (for workplace location), where the population and employment data is that used for the CTRIPEND work described in Section 4.2 Highway Model Validation Report.

The “units” of the JTW is “workers”. This needs to be converted to trips per average weekday for modelling purposes. The average number of trips on an average weekday per worker was calculated from TEMPRO data for Bath & NE Somerset. The total commuting trip productions for an average weekday was divided by the total number of resident workers, giving 0.786 trips per worker on an average weekday. Applying this factor results in a more conventional 24 hour production-attraction matrix for commuting trips on an average weekday[1].

The JTW data is from 2011. It was factored to 2015 by applying TEMPRO growth for commuting trips in Bath & NE Somerset. This gave a growth factor of 1.0359.

JTW gives the “usual mode” of travel. The mode splits obtained from this therefore do not necessarily reflect an average day. For instance, suppose someone drives to work three days a week and gets the bus on the remaining two days. JTW data will only record the use of the car mode, not the bus. Some further adjustment of the JTW is inevitable.

This was done by comparing observed commuting and JTW matrices for fully observed movements. This provided factors of 1.184 and 1.196 to be applied to JTW bus and rail modes respectively.

4.6 Matrix Merge

As noticed in previous sections, matrices are developed from various data sources. These matrices are merged as described in Table 4.6. Only HB work required merging and these are merged at 24 hour level.

Table 4.6: Matrix Merge Methodology

Mode	Purpose	Matrix sources	Merge method
Rail	HB work	Observed, JTW	50% Observed, 50% JTW
	HB EB	Observed	Not required
	HB other		
	NHB EB		
	NHB other		
Bus	HB work	Observed, JTW	50% Observed, 50% JTW
	HB EB	Observed	Not required
	HB other		
	NHB EB		
	NHB other		
P&R	HB work	Observed	Not required
	HB EB		

[1] This is an average weekday over the whole year, which is not the same as an average weekday in October 2014 (school term time). Adjustment for any difference is implicitly included in the adjustment factors calculated later in the process.

Mode	Purpose	Matrix sources	Merge method
	HB other		
	NHB EB		
	NHB other		

Notes: Both Rail and P&R matrices are fully observed

4.7 Creation of Time Period Matrices

As described before home-based elements of the demand matrix are initially built as 12-hour origin destination matrices. Bus and rail 12-hour matrix is factored to 24 hours using a factor calculated by purpose as shown in Table 4.7 below. The factors used have been derived from NTS data that has been locally adjusted using a factor calculated from a sample of PT data.

Table 4.7: 12-24hr factors for PT modes

Purpose	Factor	
	Bus	Rail
HB Work - To Home	1.140	1.088
HB Work - From Home	1.140	1.088
HB EB - To Home	1.209	1.167
HB EB - From Home	1.209	1.167
HB Other - To Home	1.091	1.163
HB Other - From Home	1.091	1.163

Notes: P&R matrices are not required uplifting to 24hr level since P&R only operate just over a 12hr period

The matrices for the various trip purposes were prepared in different ways with home-based purpose matrices ultimately being constructed as 24-hour PA and the other non-home based purposes being peak period OD matrices.

For assignment the matrices were required to represent the peak hour for AM and PM and an average hour for the inter-peak period. To achieve this, 24-hour PA matrices were first converted to period matrices and then all the period matrices (including the NHB OD elements) were subsequently factored to represent the relevant peak hour.

The 24/12-hour PA matrices were converted to AM, IP, PM and OP period matrices using a series of factors derived from PT count data, interview data and from NTS as indicated in Table 4.8 to Table 4.10 below.

Table 4.8: PA to OD conversion factors – Bus

Purpose	Direction	Peak period			
		AM	Interpeak	PM	OP
HB work	From home	0.585	0.221	0.100	0.093

Purpose	Direction	Peak period			
		AM	Interpeak	PM	OP
	To home	0.026	0.297	0.528	0.148
HB EB	From home	0.157	0.740	0.000	0.103
	To home	0.000	0.344	0.424	0.232
HB other	From home	0.297	0.579	0.060	0.064
	To home	0.025	0.553	0.318	0.104

Table 4.9: PA to OD conversion factors - Rail

Purpose	Direction	Peak period			
		AM	Interpeak	PM	OP
HB work	From home	0.671	0.166	0.122	0.041
	To home	0.015	0.088	0.779	0.177
HB EB	From home	0.520	0.255	0.142	0.082
	To home	0.070	0..366	0.360	0.204
HB other	From home	0.340	0.456	0.089	0.115
	To home	0.004	0.529	0.294	0.174

Table 4.10: PA to OD conversion factors – P&R

Purpose	Direction	Peak period		
		AM	Interpeak	PM
HB work	From home	0.895	0.105	0.000
	To home	0.000	0.156	0.844
HB EB	From home	1.000	0.000	0.000
	To home	0.000	0.694	0.306
HB other	From home	0.299	0.689	0.012
	To home	0.000	0.662	0.338

Notes: P&R only operate for just over a 12hr period, hence no OP factors

For each time period the resulting “from Home” period matrices were then added to the transpose of the “to Home” matrices to form equivalent OD period matrices for the home-based purposes.

Following the merge the 12-hour non-home based matrices are subsequently factored back to time period matrices using the factors in Table 4.11 below. These factors were derived from observed count data.

Table 4.11: 12hr to peak period factors for NHB purposes

PT mode	Purpose	Peak period		
		AM	IP	PM
Bus	NHB EB	0.152	0.478	0.371
	NHB Other	0.106	0.582	0.312

PT mode	Purpose	Peak period		
		AM	IP	PM
Rail	NHB EB	0.380	0.227	0.393
	NHB Other	0.251	0.533	0.216
P&R	NHB EB	0.792	0.208	0.000
	NHB Other	0.097	0.869	0.034

Subsequently the period matrices were factored to hourly matrices using values derived from observed passenger count data. The factors applied are presented in Table 4.12 below.

Table 4.12: Time period to hourly factors

PT mode	Peak hour		
	AM	IP	PM
Bus	0.453	0.167	0.382
Rail	0.498	0.167	0.372
P&R	0.402	0.167	0.387

5 Model Calibration

5.1 Overview

The calibration of the public transport model was undertaken for the bus and rail modes separately. As mentioned in Section 2, data from both intercept and occupancy surveys have been used in the matrix calibration process. For bus, the base model calibration excludes the P&R site choice model by combining the observed PT leg of the P&R trips and other observed bus trips to form a new single demand. For rail, only the intercept counts on four main railway stations have been used for calibration.

5.2 Matrix Adjustment

The matrix adjustment was carried out using select link analysis (SLA) adjustment method due to the lack of a matrix estimation tool in Emme. Both bus (including the PT leg of P&R) and rail demand matrices were adjusted using this method. All bus link counts forming the two cordons were used to adjust the scale of corridor demand matrix obtained from the SLA process in order to match them. Boarding and alighting counts at 5 main bus stops, 3 P&R sites as well as 4 rail stations were also used for matrix adjustment in order to get the correct level of boarding and alighting at these locations.

The matrix adjustment process used the 2014 observed PT demand matrices as prior matrices and these were adjusted by SLA to match the 2014 observed passenger counts. The goodness of fit of the matrix estimation was assessed by comparing the modelled passenger flows against the corresponding observed figures for each modelled peak hour in the AM, PM and average Inter-peak. The public transport calibration guidelines in TAG Unit M3.2 state that "*Across modelled screenlines, modelled flows should, in total, be within 15% of the observed values. On individual links in the network, modelled flows should be within 25% of the counts, except where observed hourly flows are particularly low (less than 150 passengers per hour).*"

All flow comparisons were undertaken at the hourly level. Table 5.1 to Table 5.3 provide comparisons of observed and modelled bus passenger flows (both pre-SLA and post-SLA) across both Inner and Outer Cordons, as well as boarding and alighting count validation at five main bus stops, three P&R sites and four railway stations at each individual time period. These indicate that as a result of the matrix calibration process the validation criteria have been fully satisfied with all screen line flows within 15% of the observed values. Also, the majority of differences between modelled flows and counts on individual corridors were within validation criterion although some differences (1 or 2 corridors per time period) were outside of the 25% validation criteria. One noticeable divergence is on North Parade in the AM peak. The on board counts at this stop in the AM peak were very difficult due to the articulated university buses operating close to capacity. The reasonably close match at other outbound stops on both cordons, especially at Bathwick Hill and at Bath University gives reasonable confidence that the model result at North Parade is reasonable and that the count is overestimated.

Table 5.1: Bus Passenger Flow Calibration AM Peak

Cordon & Direction	Link Name	Count	Modelled	(M-C)/C %	Flow >=150	Meeting Criteria
Inner Cordon Inbound	Widcombe Hill	0	2	-	N	-
	Prior Park Road	16	20	26.2	N	-
	Lansdown Road	287	241	-15.9	Y	Y
	Walcott Street	146	299	104.5	N	-
	Great Pultney Street	220	192	-12.9	Y	Y
	North Parade	33	31	-4.6	N	-
	Lower Bristol/ Riverside Road	438	178	-59.4	Y	N
	Wells Road	574	541	-5.7	Y	Y
	James Street West	516	519	0.5	Y	Y
	Midland Bridge Road	250	274	9.8	Y	Y
	Sub Total	***2,480***	***2,297***	***-7.4***	***Y***	***Y***
Inner Cordon Outbound	Widcombe Hill	0	46	-	N	-
	Prior Park Road	20	45	122.6	N	-
	Lansdown Road	7	4	-48.9	N	-
	Walcott Street	56	49	-11.9	N	-
	Great Pultney Street	35	71	103.4	N	-
	North Parade*	1,605	1,074	-33.1	Y	N
	Lower Bristol/ Riverside Road	15	10	-31.1	N	-
	Wells Road	147	241	63.9	N	-
	Monmouth Place	92	154	66.9	N	-
	Sub Total	***1,977***	***1,693***	***-14.4***	***Y***	***Y***
Outer Cordon Inbound	Camden Road	33	22	-33.2	N	-
	London Road	428	448	4.7	Y	Y
	Minster Way	67	124	85.7	N	-
	Bathwick Hill	44	42	-4.1	N	-
	Bloomfield Road	106	203	91.5	N	-
	Wells Way	213	228	7.3	Y	Y
	Moorfields Road	6	0	-99.5	N	-
	Bridge Road	207	238	14.9	Y	Y
	Lower Bristol Road	130	32	-75.1	N	-
	Newbridge Hill	141	158	11.9	N	-
	Newbridge Road	278	309	11.3	Y	Y
	Lansdown Road	251	208	-17.2	Y	Y
	Ralph Allen Drive	23	20	-11.6	N	-
	Sub Total	***1,927***	***2,034***	***5.5***	***Y***	***Y***

Cordon & Direction	Link Name	Count	Modelled	(M-C)/C %	Flow >=150	Meeting Criteria
Outer Cordon Outbound	Camden Road	0	1	-	N	-
	London Road	80	64	-20.4	N	-
	Minster Way	7	14	104.3	N	-
	Bathwick Hill	1,013	1,105	9.1	Y	Y
	Bloomfield Road	42	49	15.7	N	-
	Wells Way	84	173	106.0	N	-
	Moorfields Road	0	0	-	N	-
	Bridge Road	19	20	5.2	N	-
	Lower Bristol Road	31	39	26.6	N	-
	Newbridge Hill	115	121	5.6	N	-
	Newbridge Road	308	311	0.9	Y	Y
	Lansdown Road	0	22	-	N	-
	Sub Total	***1,699***	***1,919***	***13.0***	***Y***	***Y***
Boarding Bus	Bath Bus Station	250	210	-16.0	Y	Y
	Dorchester Street	356	412	15.7	Y	Y
	Bath University	26	26	0.0	N	-
	Bath Spa University	5	6	20.0	N	-
	RUH A&E	29	34	17.2	N	-
Boarding P&R	Lansdown	165	168	1.8	Y	Y
	Newbridge	92	95	3.3	N	-
	Odddown	217	189	-12.9	Y	Y
Boarding Rail	Bath	630	702	11.4	Y	Y
	Keynsham	206	155	-24.8	Y	Y
	Oldfield	195	191	-1.8	Y	Y
	Freshford	14	4	-71.4	N	-
Alighting Bus	Bath Bus Station	546	462	-15.4	Y	Y
	Dorchester Street	140	327	133.6	N	-
	Bath University	1,292	1,173	-9.2	Y	Y
	Bath Spa University	218	213	-2.3	Y	Y
	RUH A&E	63	94	49.2	N	-
Alighting P&R	Lansdown	1	6	500.0	N	-
	Newbridge	0	0	-	N	-
	Odddown	60	59	-1.7	N	-
Alighting Rail	Bath	1,229	1,123	-8.6	Y	Y
	Keynsham	46	61	34.1	N	-
	Oldfield	118	114	-3.0	N	-
	Freshford	7	2	-71.4	N	-

Notes: * Due to crowding and the busy nature of this site in the AM peak patronage counts were estimates for several instances. Therefore the observed counts may be an overestimate.

Table 5.2: Bus Passenger Flow Calibration Inter Peak

Cordon & Direction	Link Name	Count	Modelled	(M-C)/C %	Flow >=150	Meeting Criteria
Inner Cordon Inbound	Widcombe Hill	11	17	53.1	N	-
	Prior Park Road	16	14	-14.7	N	-
	Lansdown Road	80	97	21.2	N	-
	Walcott Street	95	106	12.4	N	-
	Great Pultney Street	83	76	-8.5	N	-
	North Parade	214	209	-2.6	Y	Y
	Lower Bristol/ Riverside Road	104	80	-23.0	N	-
	Wells Road	402	432	7.4	Y	Y
	James Street West	279	331	18.5	Y	Y
	Midland Bridge Road	172	173	0.3	Y	Y
	Sub Total	***1,456***	***1,534***	***5.4***	***Y***	***Y***
Inner Cordon Outbound	Widcombe Hill	5	29	444.1	N	-
	Prior Park Road	20	22	10.3	N	-
	Lansdown Road	97	60	-38.4	N	-
	Walcott Street	124	149	21.0	N	-
	Great Pultney Street	78	72	-8.4	N	-
	North Parade	598	431	-27.8	Y	N
	Lower Bristol/ Riverside Road	20	30	52.3	N	-
	Wells Road	300	352	17.2	Y	Y
	Monmouth Place	295	344	16.4	Y	Y
	Sub Total	***1,537***	***1,488***	***-3.1***	***Y***	***Y***
Outer Cordon Inbound	Camden Road	16	10	-39.8	N	-
	London Road	137	142	4.0	N	-
	Minster Way	44	58	30.4	N	-
	Bathwick Hill	233	283	21.6	Y	Y
	Bloomfield Road	42	70	69.0	N	-
	Wells Way	108	109	0.5	N	-
	Moorfields Road	8	17	133.1	N	-
	Bridge Road	78	109	40.4	N	-
	Lower Bristol Road	83	58	-30.1	N	-
	Newbridge Hill	186	203	9.1	Y	Y
	Newbridge Road	295	326	10.5	Y	Y

Cordon & Direction	Link Name	Count	Modelled	(M-C)/C %	Flow >=150	Meeting Criteria
	Lansdown Road	83	82	-1.0	N	-
	Ralph Allen Drive	16	14	-12.0	N	-
	Sub Total	***1,329***	***1,482***	***11.6***	***Y***	***Y***
Outer Cordon Outbound	Camden Road	20	21	5.6	N	-
	London Road	148	162	9.7	N	-
	Minster Way	41	58	41.4	N	-
	Bathwick Hill	404	454	12.3	Y	Y
	Bloomfield Road	40	74	86.0	N	-
	Wells Way	118	136	14.8	N	-
	Moorfields Road	10	4	-56.4	N	-
	Bridge Road	79	90	13.7	N	-
	Lower Bristol Road	90	90	-0.4	N	-
	Newbridge Hill	190	197	3.6	Y	Y
	Newbridge Road	246	292	18.8	Y	Y
	Lansdown Road	59	65	11.3	N	-
	Sub Total	***1,444***	***1,642***	***13.7***	***Y***	***Y***
Boarding Bus	Bath Bus Station	602	481	-20.1	Y	Y
	Dorchester Street	293	318	8.7	Y	Y
	Bath University	380	331	-12.9	Y	Y
	Bath Spa University	203	189	-6.7	Y	Y
	RUH A&E	104	121	16.5	N	-
Boarding P&R	Lansdown	59	60	1.7	N	-
	Newbridge	44	40	-9.1	N	-
	Odddown	83	82	-1.2	N	-
Boarding Rail	Bath	386	368	-4.5	Y	Y
	Keynsham	22	25	12.8	N	-
	Oldfield	14	13	-9.3	N	-
	Freshford	1	1	-14.3	N	-
Alighting Bus	Bath Bus Station	494	391	-20.8	Y	Y
	Dorchester Street	79	183	131.2	N	-
	Bath University	482	440	-8.8	Y	Y
	Bath Spa University	180	158	-12.3	Y	Y
	RUH A&E	86	85	-1.2	N	-
Alighting P&R	Lansdown	57	56	-1.8	N	-
	Newbridge	38	25	-34.2	N	-
	Odddown	81	75	-7.4	N	-
Alighting	Bath	349	333	-4.6	Y	Y

Cordon & Direction	Link Name	Count	Modelled	(M-C)/C %	Flow >=150	Meeting Criteria
Rail	Keynsham	17	30	77.3	N	-
	Oldfield	22	16	-26.4	N	-
	Freshford	3	0	-100.0	N	-

Table 5.3: Bus Passenger Flow Calibration PM Peak

Cordon & Direction	Link Name	Count	Modelled	(M-C)/C %	Flow >=150	Meeting Criteria
Inner Cordon Inbound	Widcombe Hill	11	50	358.5	N	-
	Prior Park Road	6	9	52.8	N	-
	Lansdown Road	10	7	-25.2	N	-
	Walcott Street	63	69	10.2	N	-
	Great Pultney Street	110	71	-35.1	N	-
	North Parade	349	347	-0.7	Y	Y
	Lower Bristol/ Riverside Road	31	1	-97.1	N	-
	Wells Road	141	149	5.5	N	-
	James Street West	190	201	6.0	Y	Y
	Midland Bridge Road	142	138	-2.5	N	-
	Sub Total	***1,053***	***1,044***	***-0.9***	***Y***	***Y***
Inner Cordon Outbound	Widcombe Hill	3	3	1.3	N	-
	Prior Park Road	34	14	-60.1	N	-
	Lansdown Road	307	225	-26.9	Y	N
	Walcott Street	257	274	6.4	Y	Y
	Great Pultney Street	132	82	-38.2	N	-
	North Parade	213	246	15.4	Y	Y
	Lower Bristol/ Riverside Road	70	65	-7.4	N	-
	Wells Road	502	429	-14.6	Y	Y
	Monmouth Place	566	534	-5.6	Y	Y
	Sub Total	***2,084***	***1,870***	***-10.3***	***Y***	***Y***
Outer Cordon Inbound	Camden Road	10	-	-	N	-
	London Road	64	105	63.7	N	-
	Minster Way	24	58	143.6	N	-
	Bathwick Hill	754	836	10.9	Y	Y
	Bloomfield Road	35	42	19.3	N	-
	Wells Way	63	70	10.4	N	-
	Moorfields Road	4	10	138.0	N	-
	Bridge Road	62	59	-4.5	N	-

Cordon & Direction	Link Name	Count	Modelled	(M-C)/C %	Flow >=150	Meeting Criteria
	Lower Bristol Road	40	72	80.8	N	-
	Newbridge Hill	217	205	-5.8	Y	Y
	Newbridge Road	258	301	16.5	Y	Y
	Lansdown Road	3	5	81.0	N	-
	Ralph Allen Drive	7	9	32.3	N	-
	Sub Total	***1,541***	***1,771***	***14.9***	***Y***	***Y***
Outer Cordon Outbound	Camden Road	23	4	-83.4	N	-
	London Road	283	293	3.6	Y	Y
	Minster Way	51	64	24.6	N	-
	Bathwick Hill	83	152	82.6	N	-
	Bloomfield Road	76	107	40.8	N	-
	Wells Way	196	203	3.5	Y	Y
	Moorfields Road	9	3	-68.6	N	-
	Bridge Road	140	154	10.1	N	-
	Lower Bristol Road	128	159	24.4	N	-
	Newbridge Hill	272	252	-7.4	Y	Y
	Newbridge Road	325	409	25.9	Y	N
	Lansdown Road	162	187	15.1	Y	Y
	Sub Total	***1,748***	***1,986***	***13.6***	***Y***	***Y***
Boarding Bus	Bath Bus Station	834	771	-7.6	Y	Y
	Dorchester Street	413	336	-18.6	Y	Y
	Bath University	1162	878	-24.4	Y	Y
	Bath Spa University	167	151	-9.6	Y	Y
	RUH A&E	73	69	-5.5	N	-
Boarding P&R	Lansdown	4	0	-100.0	N	-
	Newbridge	0	0	-	N	-
	Odddown	5	1	-80.0	N	-
Boarding Rail	Bath	1,143	1,234	8.0	Y	Y
	Keynsham	47	71	52.7	N	-
	Oldfield	59	54	-8.5	N	-
	Freshford	3	3	0.0	N	-
Alighting Bus	Bath Bus Station	328	301	-8.2	Y	Y
	Dorchester Street	42	76	81.0	N	-
	Bath University	132	142	7.6	N	-
	Bath Spa University	94	88	-6.4	N	-
	RUH A&E	43	43	0.0	N	-
Alighting	Lansdown	184	185	0.5	Y	Y

Cordon & Direction	Link Name	Count	Modelled	(M-C)/C %	Flow >=150	Meeting Criteria
P&R	Newbridge	155	119	-23.2	Y	Y
	Odddown	226	175	-22.6	Y	Y
Alighting Rail	Bath	721	807	11.9	Y	Y
	Keynsham	251	248	-1.0	Y	Y
	Oldfield	290	221	-23.7	Y	Y
	Freshford	11	1	-90.9	N	-

5.3 Impact of the matrix adjustment

The impacts of matrix adjustment on the structure of the matrix were investigated by looking at sectoral changes (see Figure 5.1 for sectors used) in the matrix and changes in the trip length distributions. The sector system used here is consistent with the sector system used in highway model validation checks.

A summary of the overall impact from the ME process on total demand of is provided in Table 5.4 below, which indicates that the adjustment process did not significantly change the overall size of matrices as the absolute % differences are all sitting within the 15% range. Sectoral changes to the matrices are presented in Table 5.5 to Table 5.10. As expected, they show that the majority of the changes have occurred in cells related to sector 8, which is the core area of city of Bath.

Table 5.4: Overall Impact of Matrix Estimation – Summary

	Total Bus Demand			Total Rail Demand		
	Prior	Estimated	% Change	Prior	Estimated	% Change
AM	4015	4527	12.8%	2560	2519	-1.6%
IP	3954	3775	-4.5%	738	847	14.7%
PM	4206	4609	9.6%	2311	2657	15.0%

Figure 5.1: Sector Definition

Table 5.5: Impact of Matrix Estimation – Bus – AM Peak

Prior	1	2	3	4	5	6	7	8	Total
1	2	11	1	3	2	1	0	459	478
2	14	196	0	13	5	8	2	465	703
3	0	0	0	0	0	0	0	1	1
4	2	23	0	2	0	0	0	137	164
5	0	5	0	3	1	1	0	39	49
6	0	8	0	0	1	0	1	45	54
7	0	1	0	0	0	0	0	10	11
8	57	279	0	34	22	13	2	2,145	2,554
Total	75	522	1	56	30	24	5	3,302	**4,015**
Estimated	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
1	2	7	1	2	1	1	0	421	435
2	14	169	0	4	2	2	1	214	405
3	0	0	0	0	0	0	0	1	1
4	4	26	0	2	0	0	0	262	294
5	0	4	0	1	1	1	0	39	46

Prior	1	2	3	4	5	6	7	8	Total
6	0	6	0	0	0	0	0	7	13
7	0	0	0	0	0	0	0	3	3
8	85	330	0	24	15	11	2	2,864	3,330
Total	105	540	1	33	19	15	3	3,812	**4,527**
E-P	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
1	0	-4	0	-1	0	0	0	-38	-43
2	0	-27	0	-9	-4	-6	0	-251	-298
3	0	0	0	0	0	0	0	0	0
4	2	2	0	0	0	0	0	125	130
5	0	-1	0	-2	0	0	0	0	-3
6	0	-2	0	0	-1	0	-1	-37	-41
7	0	0	0	0	0	0	0	-8	-8
8	28	50	0	-11	-7	-2	0	718	776
Total	30	18	0	-23	-11	-8	-2	510	**513**
%Diff(E-P)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
1	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-54%	-42%
3	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	91%	79%
5	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-
8	-	18%	-	-	-	-	-	33%	30%
Total	-	-	-	-	-	-	-	15%	**13%**

Table 5.6: Impact of Matrix Estimation – Bus – Inter Peak

Prior	1	2	3	4	5	6	7	8	Total
1	2	11	0	3	1	1	0	244	260
2	10	104	0	20	6	7	0	381	528
3	0	0	0	0	0	0	0	0	0
4	3	18	0	1	0	0	0	86	108
5	1	4	0	0	1	1	0	19	26
6	1	9	0	0	1	0	1	27	39
7	0	0	0	0	0	1	0	2	3
8	249	373	0	80	19	24	2	2,241	2,989
Total	266	520	0	103	28	34	3	3,000	**3,954**
Estimated	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
1	2	7	0	1	1	1	0	167	179
2	5	123	0	13	2	3	0	350	496

Prior	1	2	3	4	5	6	7	8	Total
3	0	0	0	0	0	0	0	0	0
4	1	11	0	1	0	0	0	64	77
5	1	2	0	0	1	0	0	34	37
6	1	13	0	0	0	0	0	10	24
7	0	0	0	0	0	0	0	5	6
8	152	308	0	54	14	6	1	2,419	2,956
Total	162	465	0	69	18	11	1	3,049	**3,775**
E-P	1	2	3	4	5	6	7	8	Total
1	0	-4	0	-1	0	0	0	-77	-81
2	-4	19	0	-7	-3	-4	0	-31	-31
3	0	0	0	0	0	0	0	0	0
4	-2	-7	0	0	0	0	0	-23	-31
5	0	-3	0	0	0	-1	0	15	11
6	-1	4	0	0	-1	0	-1	-17	-15
7	0	0	0	0	0	-1	0	4	3
8	-97	-65	0	-26	-5	-18	-2	178	-33
Total	-104	-55	0	-34	-9	-24	-3	49	**-179**
%Diff(E-P)	1	2	3	4	5	6	7	8	Total
1	-	-	-	-	-	-	-	-31%	-31%
2	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-
8	-39%	-17%	-	-	-	-	-	8%	-
Total	-39%	-11%	-	-	-	-	-	-	-5%

Table 5.7: Impact of Matrix Estimation – Bus – PM Peak

Prior	1	2	3	4	5	6	7	8	Total
1	2	11	0	4	0	2	0	61	80
2	9	178	0	20	5	8	1	318	538
3	1	0	0	0	0	0	0	0	1
4	4	11	0	2	1	0	0	38	56
5	1	5	0	0	1	1	0	17	24
6	1	8	0	0	1	0	0	23	33
7	0	1	0	0	0	1	0	3	5
8	424	462	1	121	35	42	8	2,375	3,468
Total	442	676	1	147	42	54	9	2,836	**4,206**

Estimated	1	2	3	4	5	6	7	8	Total
1	1	7	0	4	0	1	0	53	67
2	4	160	0	53	2	4	0	317	541
3	1	0	0	0	0	0	0	1	2
4	2	6	0	2	0	0	0	49	59
5	1	2	0	1	1	0	0	56	60
6	1	5	0	0	0	0	0	15	22
7	0	1	0	0	0	0	0	1	2
8	252	236	1	114	19	5	0	3,231	3,857
Total	261	418	1	174	23	10	1	3,723	**4,609**
E-P	1	2	3	4	5	6	7	8	Total
1	0	-4	0	0	0	-2	0	-8	-13
2	-5	-18	0	33	-2	-4	0	-1	2
3	0	0	0	0	0	0	0	1	1
4	-2	-5	0	0	-1	0	0	10	2
5	0	-3	0	0	0	-1	0	39	36
6	0	-2	0	0	-1	0	0	-8	-11
7	0	0	0	0	0	-1	0	-1	-2
8	-172	-227	0	-8	-16	-37	-8	856	390
Total	-180	-258	0	27	-19	-44	-8	887	**403**
%Diff(E-P)	1	2	3	4	5	6	7	8	Total
1	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-
8	-41%	-49%	-	-	-	-	-	36%	11%
Total	-41%	-38%	-	-	-	-	-	31%	**10%**

Table 5.8: Impact of Matrix Estimation – Rail – AM Peak

Prior	1	2	3	4	5	6	7	8	Total
1	14	14	0	8	23	0	0	220	278
2	4	136	0	27	47	6	2	415	636
3	0	0	0	1	0	0	0	4	5
4	10	32	4	10	13	3	0	250	322
5	23	8	0	1	13	0	0	154	199
6	0	16	0	0	3	9	0	40	68
7	0	1	0	0	2	0	0	28	31

Prior	1	2	3	4	5	6	7	8	Total
8	53	538	5	167	202	21	5	31	1,021
Total	103	745	9	214	302	38	7	1,141	**2,560**
Estimated	1	2	3	4	5	6	7	8	Total
1	14	12	0	7	19	0	0	263	315
2	4	130	0	23	34	5	2	484	681
3	0	0	0	0	0	0	0	5	6
4	12	27	4	10	9	2	0	280	345
5	23	10	0	1	13	0	0	207	254
6	0	17	0	0	3	9	0	45	74
7	0	1	0	0	1	0	0	28	31
8	42	443	3	138	138	14	5	31	814
Total	95	641	7	180	217	30	7	1,343	**2,519**
E-P	1	2	3	4	5	6	7	8	Total
1	0	-1	0	-1	-4	0	0	43	37
2	0	-6	0	-4	-13	-1	0	69	45
3	0	0	0	0	0	0	0	1	1
4	2	-5	0	0	-4	-1	0	31	22
5	0	2	0	0	0	0	0	53	55
6	0	1	0	0	0	0	0	5	6
7	0	0	0	0	-1	0	0	0	-1
8	-10	-95	-2	-30	-64	-6	0	0	-207
Total	-9	-104	-2	-35	-86	-8	0	202	**-41**
%Diff(E-P)	1	2	3	4	5	6	7	8	Total
1	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	17%	-
3	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	34%	28%
6	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-
8	-	-18%	-	-	-32%	-	-	-	-20%
Total	-	-14%	-	-	-28%	-	-	18%	-

Table 5.9: Impact of Matrix Estimation – Rail – Inter Peak

Prior	1	2	3	4	5	6	7	8	Total
1	9	1	0	1	13	0	0	35	60
2	1	28	0	7	11	6	1	106	160
3	0	0	0	1	0	0	0	2	3
4	1	7	2	14	1	0	0	62	87

Prior	1	2	3	4	5	6	7	8	Total
5	10	11	0	2	3	0	1	65	93
6	0	6	0	0	0	8	0	12	27
7	0	0	0	0	1	0	0	4	5
8	31	105	2	66	75	15	2	7	304
Total	52	159	4	91	104	30	4	293	**738**
Estimated	1	2	3	4	5	6	7	8	Total
1	9	2	0	2	19	0	0	39	71
2	1	30	0	7	15	8	1	115	177
3	0	0	0	1	0	0	0	2	4
4	1	8	3	14	2	0	0	66	93
5	14	13	0	3	3	1	1	76	111
6	0	7	0	1	1	8	0	13	29
7	0	0	0	0	1	0	0	4	5
8	35	123	3	72	97	17	2	7	357
Total	61	184	6	100	137	33	4	323	**847**
E-P	1	2	3	4	5	6	7	8	Total
1	0	0	0	1	6	0	0	4	11
2	0	2	0	1	3	2	0	9	17
3	0	0	0	0	0	0	0	0	1
4	0	1	1	0	0	0	0	4	7
5	4	2	0	0	0	0	0	12	18
6	0	1	0	0	0	0	0	1	2
7	0	0	0	0	0	0	0	0	0
8	4	18	1	6	22	2	0	0	52
Total	8	24	2	8	32	3	0	30	**109**
%Diff(E-P)	1	2	3	4	5	6	7	8	Total
1	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	17%
Total	-	-	-	-	-	-	-	-	**15%**

Table 5.10: Impact of Matrix Estimation – Rail – PM Peak

Prior	1	2	3	4	5	6	7	8	Total
1	7	5	0	10	13	0	0	69	104

Prior	1	2	3	4	5	6	7	8	Total
2	12	122	0	30	15	11	1	474	665
3	0	0	0	2	0	0	0	5	7
4	9	25	1	9	2	0	0	162	208
5	16	33	0	7	9	1	1	167	234
6	0	5	0	2	0	5	0	20	32
7	0	1	0	0	2	0	0	7	10
8	191	406	4	219	142	28	26	32	1,048
Total	235	598	5	279	184	46	28	936	**2,311**
Estimated	1	2	3	4	5	6	7	8	Total
1	7	25	0	10	13	0	0	77	132
2	12	148	0	31	15	14	1	474	696
3	0	0	0	2	0	0	0	5	7
4	9	30	1	9	2	1	0	162	213
5	16	34	0	7	9	2	1	167	235
6	0	6	0	2	0	5	0	20	33
7	0	1	0	0	2	0	0	7	10
8	191	647	4	244	142	44	26	32	1,330
Total	235	890	5	305	184	66	28	944	**2,657**
E-P	1	2	3	4	5	6	7	8	Total
1	0	20	0	0	0	0	0	8	27
2	0	26	0	1	0	4	0	0	31
3	0	0	0	0	0	0	0	0	0
4	0	4	0	0	0	0	0	0	5
5	0	0	0	0	0	0	0	0	1
6	0	1	0	0	0	0	0	0	1
7	0	0	0	0	0	0	0	0	0
8	0	241	0	25	0	16	0	0	282
Total	0	292	0	26	0	20	0	8	**346**
%Diff(E-P)	1	2	3	4	5	6	7	8	Total
1	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-
8	-	59%	-	-	-	-	-	-	27%
Total	-	49%	-	-	-	-	-	-	**15%**

Changes in average trip length and trip length distribution as a result of matrix adjustment are shown in Table 5.11 and Figure 5.2 to Figure 5.7 by mode and time period. The comparisons in general indicate:

- On rail, it shows that the changes are almost insignificant on the medium distance trips (25km -100km) while relatively modest on both short distance (0-25km) trips and long distance (>100km) trips and this is generally consistent across all time periods.
- On bus, the impact of matrix adjustment varies among the three time periods. For Inter Peak and PM Peak, although there are some small increase in short distance (<10km) trips, the resulted trip length distribution profiles are very much retained from the priors'. For AM peak, there is a significant increase in trips that fall into 5 to 10 km, which distorts the original trip length distribution profile. However, our further investigation indicates that this is purely due to the matrix adjustment that is performed at North Parade's outbound direction in order to lift its modelled flow up as well as having a good match on the number of alighting at Bath University.
- The overall impact of matrix adjustment on average trip length is provided in Table 5.11 below. For bus, there is a reduction on the average trip length across all time periods, mainly as a result of fewer long distance trips as mentioned above. For rail, the impact is much less significant with all changes are less than 6%.
- Overall, it has been shown that the matrix adjustment has generated some minor impacts to the prior matrices. While the adjustment process has some relatively more significant impacts on the distribution of bus trips, with a shift towards more short distance trips, such changes that took place are in response to the count data in order to bring them more into line with the cordon counts.

Table 5.11: Average trip length

	Bus (km)			Rail (km)		
	Prior	Estimated	% Change	Prior	Estimated	% Change
AM	14.8	12.0	-18.7%	68.0	66.8	-1.8%
IP	12.3	11.7	-4.8%	82.2	87.2	6.0%
PM	13.5	11.4	-15.5%	66.3	62.7	-5.4%

Figure 5.2: Changes in trip length distribution – AM Peak – Bus

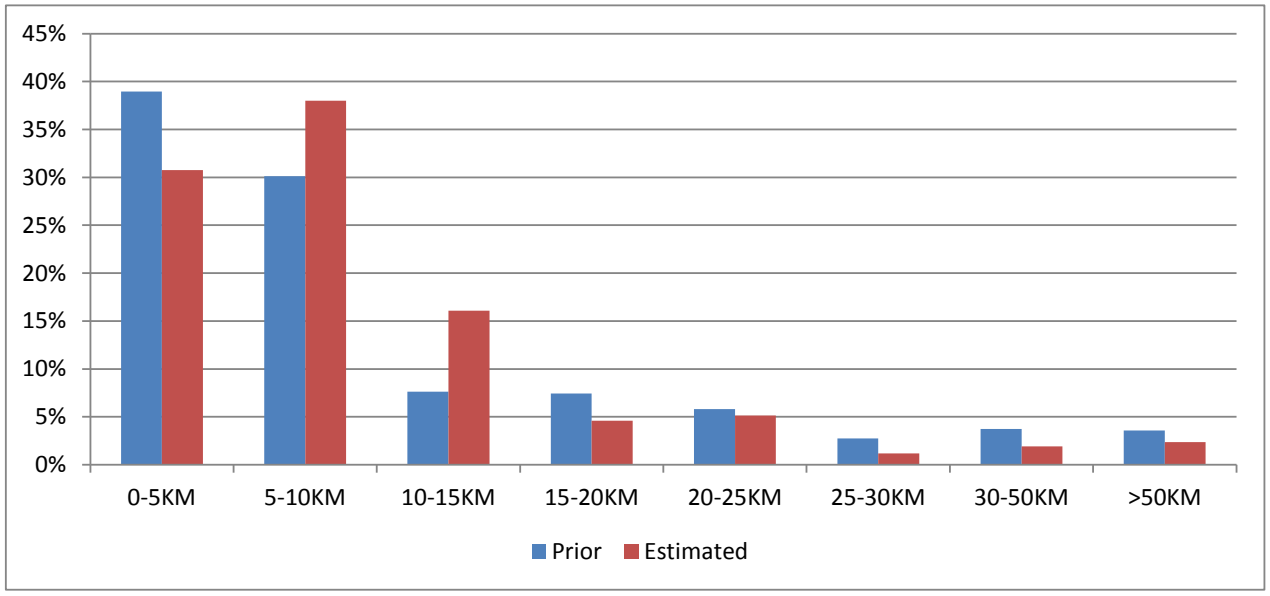


Figure 5.3: Changes in trip length distribution – Inter Peak – Bus

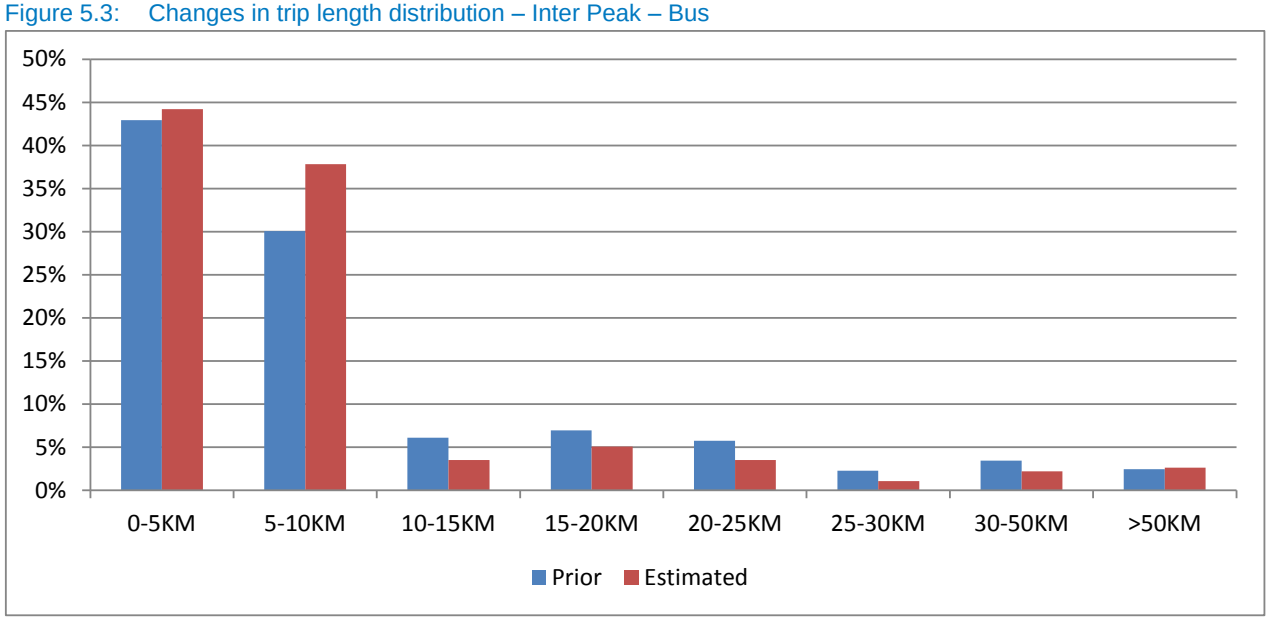


Figure 5.4: Changes in trip length distribution – PM Peak – Bus

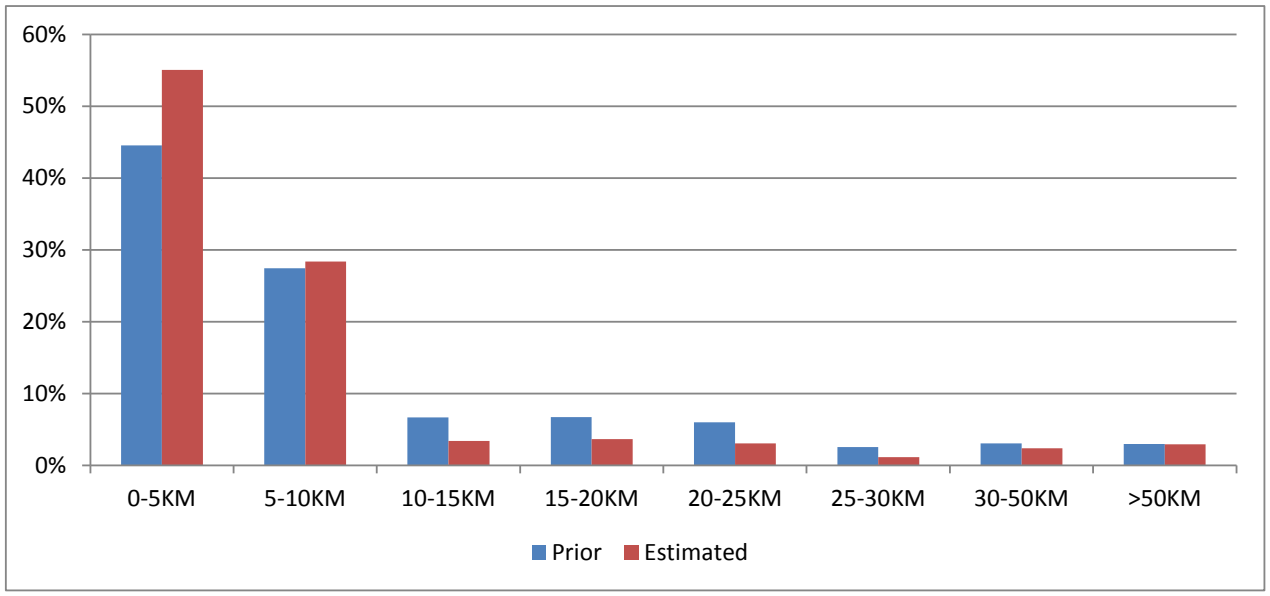


Figure 5.5: Changes in trip length distribution – AM Peak – Rail

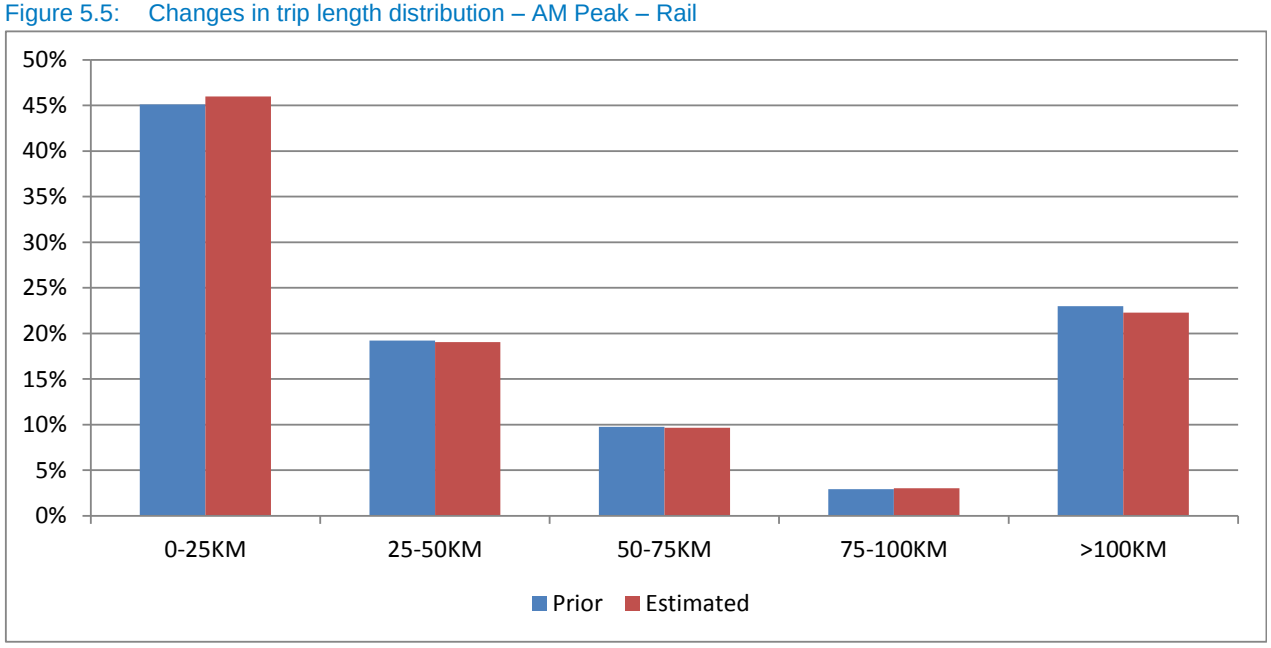


Figure 5.6: Changes in trip length distribution – Inter Peak – Rail

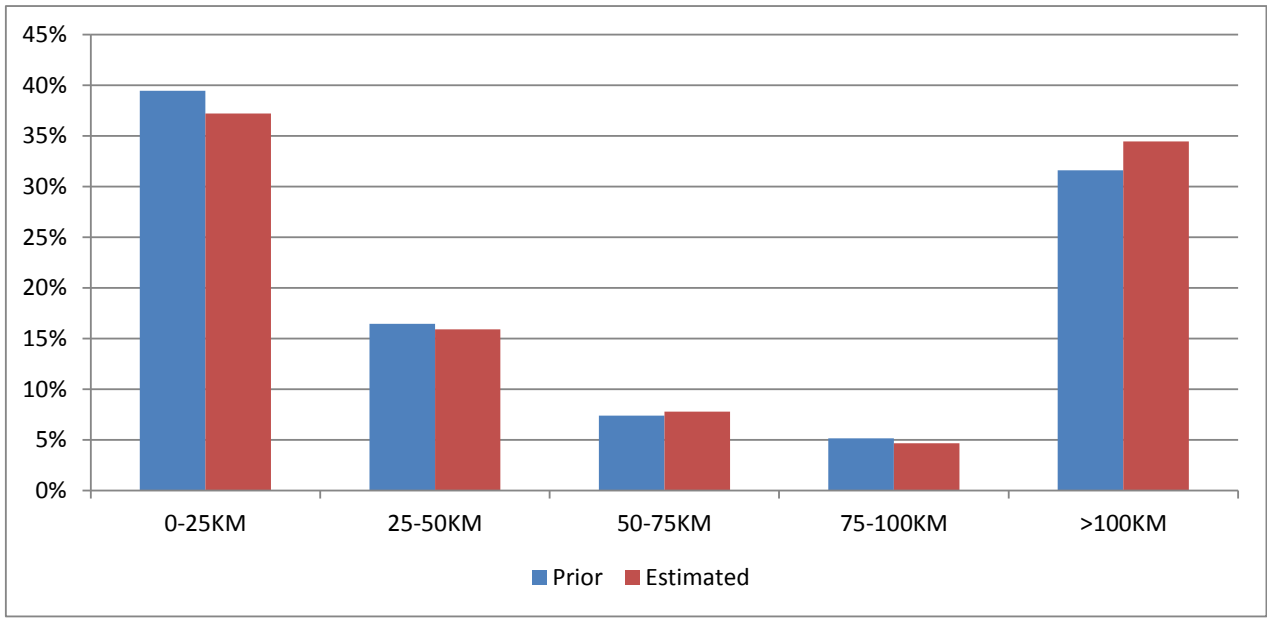
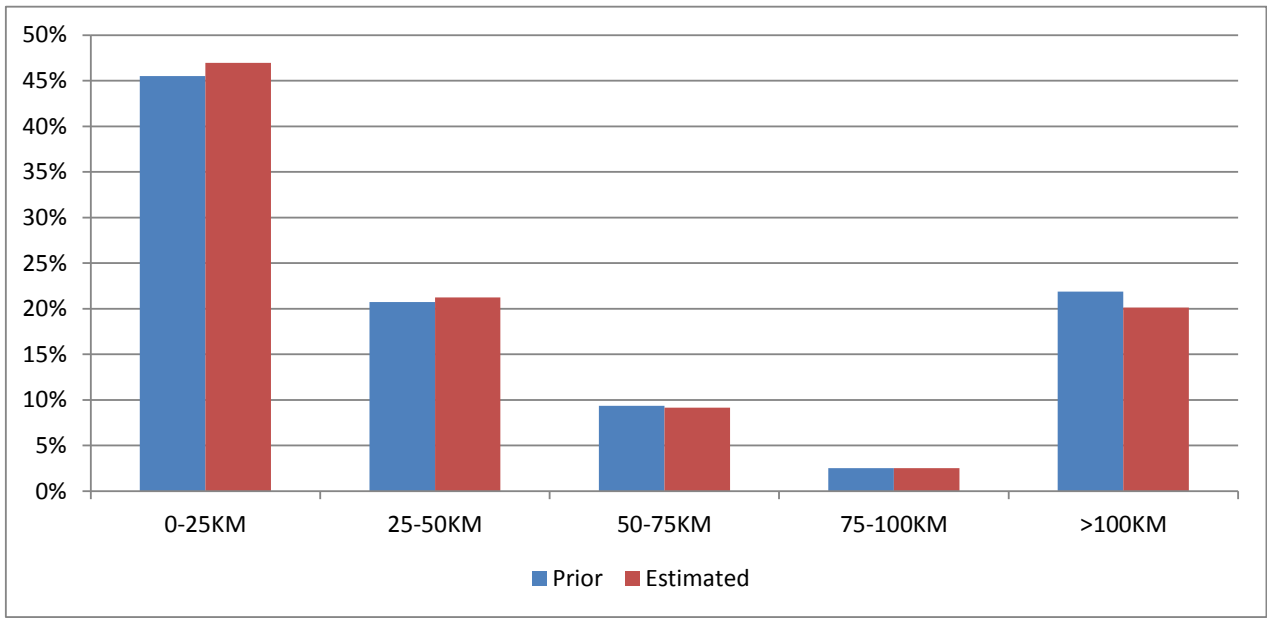


Figure 5.7: Changes in trip length distribution – PM Peak – Rail



6 Model Validation

6.1 Introduction

Section 7 in WebTAG Unit M3.2 outlines the validation criteria for public transport models. The guideline states that there are three checks that are required:

- Validation of the trip matrix;
- Network and service validation; and
- Assignment validation.

6.2 Validation of the trip matrix

The guidelines state that the Validation of the trip matrix should involve comparisons of assigned and counted passengers across complete screenlines and cordons (as opposed to individual services). "*At this level of aggregation, the Department's suggested guideline is that the differences between assigned and counted flows should, in 95% of the cases, be less than 15%.*"

Table 6.1 to Table 6.3 below shows a dependant (because each individual link count had been used in the matrix adjustment) validation on total inbound and outbound bus flow observed and modelled across both the inner cordon and outer cordon and the criteria set out above are met in all cases.

Table 6.1: Total bus passenger flows across cordons – AM peak

Cordon	Count	Modelled	(M-C)/C%	Meeting Criteria
Inner Cordon Inbound	2,480	2,297	-7.4%	Y
Inner Cordon Outbound	1,977	1,693	-14.4%	Y
Outer Cordon Inbound	1,927	2,034	5.5%	Y
Outer Cordon Outbound	1,699	1,919	13.0%	Y

Table 6.2: Total bus passenger flows across cordons – Inter peak

Cordon	Count	Modelled	(M-C)/C%	Meeting Criteria
Inner Cordon Inbound	1,456	1,534	5.4%	Y
Inner Cordon Outbound	1,537	1,488	-3.1%	Y
Outer Cordon Inbound	1,329	1,482	11.6%	Y
Outer Cordon Outbound	1,444	1,642	13.7%	Y

Table 6.3: Total bus passenger flows across cordons – PM peak

Cordon	Count	Modelled	(M-C)/C%	Meeting Criteria
Inner Cordon Inbound	1,053	1,044	-0.9%	Y
Inner Cordon Outbound	2,084	1,870	-10.3%	Y
Outer Cordon Inbound	1,541	1,771	14.9%	Y
Outer Cordon Outbound	1,748	1,986	13.6%	Y

6.3 Network and Service validation

A number of checks have been carried out on the network and representation of services. These included:

- The routing for each service included in the model has been checked against routeing included in the timetables by plotting each service.
- In the PT model, the public transport journey times are derived from the highway model rather than the based on fixed bus time tables. As such, the mode may not reproduce the observed journey time across all the routes in the various modelled time periods, reflecting the variability of the observed bus journey times. Table 6.4 to Table 6.6 represent the journey time validation for four typical bus routes from each side of the city and the analysis is compared to the timetabled run times. In total, 17 of 18 journey times are within 15% of the timetable, and all but 1 is within 25% of the timetabled journey time.
- Network and service validation also involves examining the level of patronage. Those are shown in Figure 6.1 to Figure 6.3, all of which indicate an accurate representation of service patterns within the city area.

Table 6.4: Bus Journey Time Validation – AM Peak

Service No.	Route	Modelled	Timetable	M-T	(M-T)/T
13	Southbound - Bathford to Foxhill	52	56	-4	-8%
	Northbound - Foxhill to Bathford	61	56	5	8%
14	Northbound - Odd Down to Weston	44	39	5	13%
	Southbound - Weston to Odd Down	44	49	-5	-11%
15	Bath Spa University - Bath Centre - Bath Spa University	56	57	-1	-1%
18	Lower Oldfield Park - Bath Centre - University - Bath Centre - Lower Oldfield Park	64	58	6	10%

Table 6.5: Bus Journey Time Validation – Inter Peak

Service No.	Route	Modelled	Timetable	M-T	(M-T)/T
13	Southbound - Bathford to Foxhill	52	47	5	10%
	Northbound - Foxhill to Bathford	61	49	12	24%
14	Northbound - Odd Down to Weston	43	39	4	10%

Service No.	Route	Modelled	Timetable	M-T	(M-T)/T
	Southbound - Weston to Odd Down	43	47	-4	-8%
15	Bath Spa University - Bath Centre - Bath Spa University	56	54	2	4%
18	Lower Oldfield Park - Bath Centre - University - Bath Centre - Lower Oldfield Park	64	60	4	6%

Table 6.6: Bus Journey Time Validation – PM Peak

Service No.	Route	Modelled	Timetable	M-T	(M-T)/T
13	Southbound - Bathford to Foxhill	52	53	-1	-2%
	Northbound - Foxhill to Bathford	61	59	2	3%
14	Northbound - Odd Down to Weston	48	42	6	13%
	Southbound - Weston to Odd Down	47	48	-1	-1%
15	Bath Spa University - Bath Centre - Bath Spa University	56	58	-2	-3%
18	Lower Oldfield Park - Bath Centre - University - Bath Centre - Lower Oldfield Park	64	60	4	6%

Figure 6.1: Patronage plot – AM Peak

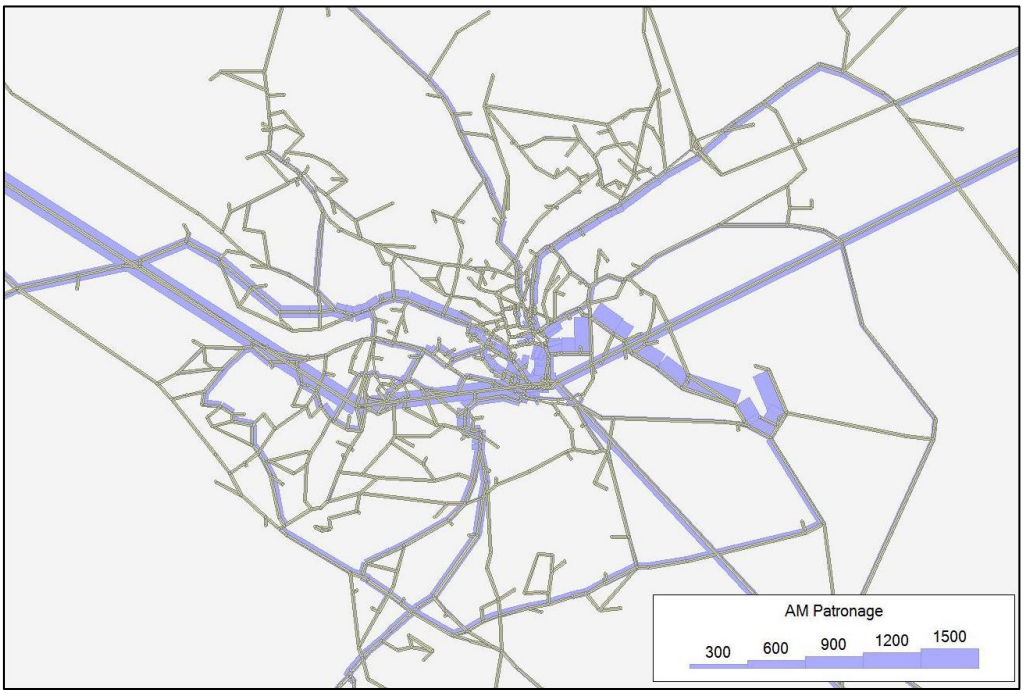


Figure 6.2: Patronage plot – Inter Peak

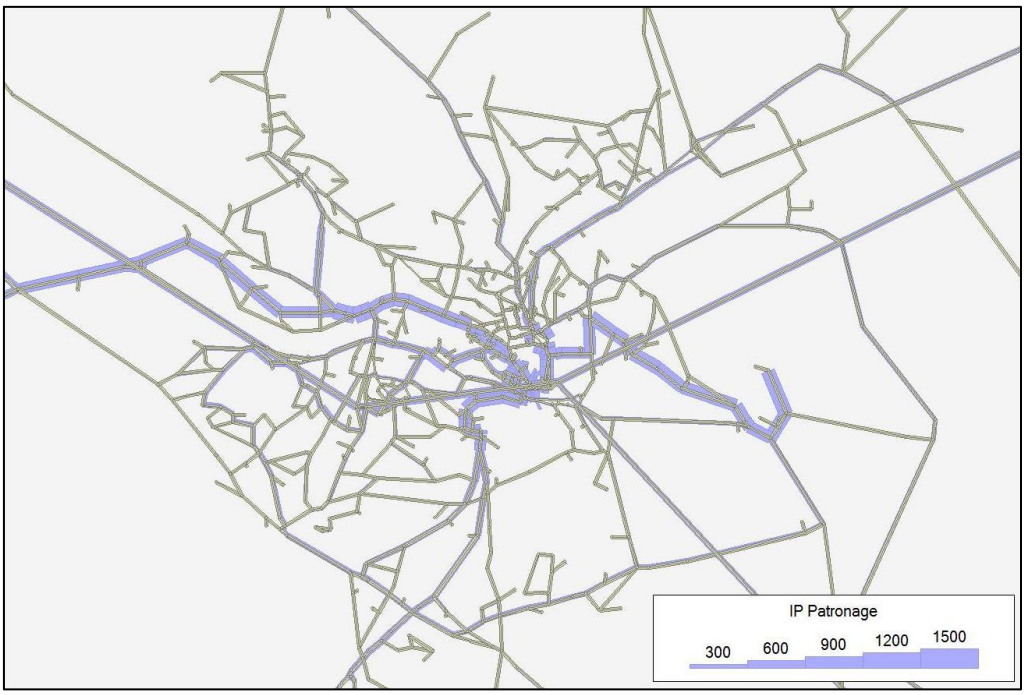
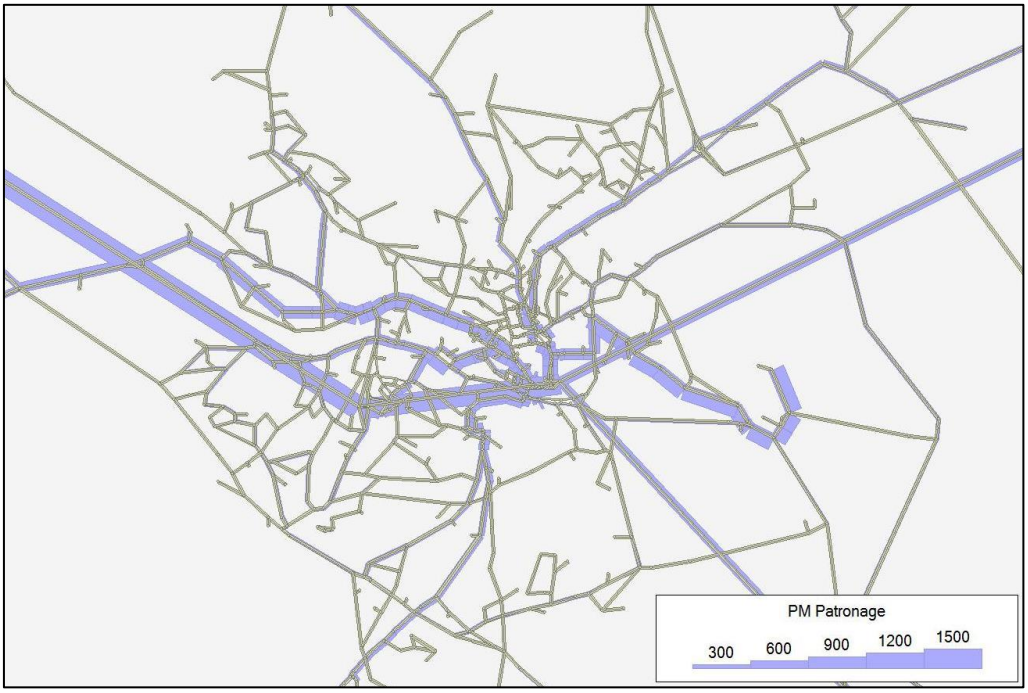


Figure 6.3: Patronage plot – PM Peak



6.4 Assignment validation

A series of sense checks have also been carried out on the assignment to ensure that the model was working properly, which included;

- A check of assignment statistics to ensure trips from all origins and destinations were assigned in all peaks.
- A check to ensure that majority of demand was assigned to a public transport service and there were very small amounts of walk only movements in all peaks. A summary on percentage of walk only trips for each time period is provided in Table 6.7 below.
- A comparison of modelled and observed passenger boarding and alighting at some key stops as seen in Table 5.1 to Table 5.3 above have already indicated a good match between the two.

Table 6.7: Percentage of walk only in the model

	Percent
AM	6.2%
IP	5.7%
PM	7.1%

6.5 PT flow validation

No independent PT flow validation was undertaken during the development of the 2014 public transport model. This was because all of the 2014 count data were used for expansion purpose during the matrix development process and were also used for adjusting the corridor flows during the SLA process, as it was considered that the benefits of using this data to provide a better representation of public transport movements was more important than using it in independent validation.

7 Conclusions

This report has described the process of updating the existing 2006 G-BATH public transport model into a new base year of 2014. The rebased G-Bath PT model calibrate/validate well against observed data to provide a good representation of the public transport conditions in Bath.

Guidance set out in WebTAG unit M3.2 has been applied in developing the model, including:

- Data collection;
- Network and service development;
- Matrix Development; and
- Model calibration and validation

The survey data were collected by NDC at the end of 2014 and provided comprehensive data on key bus routes into Bath city centre and at both the Bath rail station and three other minor rail stations serving routes into Bath. The survey was designed to generate a good sample that could be expanded using count data at corresponding sites in order to develop demand which would be representative of public transport patronage with reasonable confidence. In addition bus occupancy survey sites collectively form two cordons (Inner and Outer) that capture PT trips into and out of Bath.

The bus network was developed to be consistent with the highway model while bus stops were added according to the NaPTAN dataset and bus routes were coded based on TNDS. Rail network was retained from the previous 2006 model but 2014 timetable information being used to create new rail services.

The matrices were developed in a logical manner, with separate matrices built for bus, P&R and rail for the same set of purposes. Observed matrices derived from the surveys were combined with JTW matrices in order to derive final PT matrices.

The matrices calibrates/validates reasonably well against the count data. The assignment comparisons demonstrate that total screenline flows were fully satisfied with the validation criteria, though all the count data was used in the calibration to improve the model so that the validation did not use truly independent data. The majority of differences between modelled flows and counts on individual locations were also within validation criterion although 1 or 2 corridors per time period were outside of the 25% validation criteria.

All network and services were validated to ensure an appropriate representation of the service pattern and the model broadly reflects the timetabled journey times across the three time periods, with the vast majority of routes being within 15% of the timetabled time.

In conclusion, it is considered that the base year PT assignment models developed for the 2014 G-Bath transport model demonstrate a good representation of passenger behaviour and patronage flows in the study area and form a robust basis from which future year forecasts can be developed.

Appendices

Appendix A. Passenger Interview forms _____ 59

Appendix A. Passenger Interview forms

Figure A.1: P&R passenger interview form

BATH - BUS PASSENGER INTERVIEWS

BUS STOP No: ..... **LOCATION / NAME:** ..... **DATE** ..... **INTERVIEWER:** ..... *(office use)* **SERIAL No.** .....

1 **INTERVIEW TIME:** .....

Q1 - Which service are you waiting for?	Q3 - Please state the full address you have just come from?	Q4 - Why were you at that location?	Q5 - Please state the full address you are travelling to now?	Q6 - Why are you going to your destination?	Q7 - Did you have a car available for this journey?
.....	Firm, House Name	1 Home	Firm, House Name	1 Home	1 Yes
	or ZONE	2 Holiday Home	or ZONE	2 Holiday Home	2 No
Q2 - What type of ticket do you have?	Number & Street	3 Work	Number & Street	3 Work	3 Non-driver
	.....	4 Employer Business	.....	4 Employer Business	
1 Single Ticket	Town	5 Education	Town	5 Education	**Q8 - If this journey is part of a 2-way return trip, please give the start time of your trip in the other direction (to nearest half hour)?**
2 Return Ticket	.....	6 Shopping	.....	6 Shopping	
3 Daily Ticket	County	7 Personal Business	County	7 Personal Business	
4 Weekly Pass	.....	8 Visit Friends	.....	8 Visit Friends	
5 Monthly Pass	Postcode	9 Recreation	Postcode	9 Recreation	1 Return Time .....
6 Multi-Journey (CARNET)	.....	10 Other (specify)	.....	10 Other (specify)	2 One-way trip
7 Concessionary Pass		.....		.....	

2 **INTERVIEW TIME:** .....

Q1 - Which service are you waiting for?	Q3 - Please state the full address you have just come from?	Q4 - Why were you at that location?	Q5 - Please state the full address you are travelling to now?	Q6 - Why are you going to your destination?	Q7 - Did you have a car available for this journey?
.....	Firm, House Name	1 Home	Firm, House Name	1 Home	1 Yes
	or ZONE	2 Holiday Home	or ZONE	2 Holiday Home	2 No
Q2 - What type of ticket do you have?	Number & Street	3 Work	Number & Street	3 Work	3 Non-driver
	.....	4 Employer Business	.....	4 Employer Business	
1 Single Ticket	Town	5 Education	Town	5 Education	**Q8 - If this journey is part of a 2-way return trip, please give the start time of your trip in the other direction (to nearest half hour)?**
2 Return Ticket	.....	6 Shopping	.....	6 Shopping	
3 Daily Ticket	County	7 Personal Business	County	7 Personal Business	
4 Weekly Pass	.....	8 Visit Friends	.....	8 Visit Friends	
5 Monthly Pass	Postcode	9 Recreation	Postcode	9 Recreation	1 Return Time .....
6 Multi-Journey (CARNET)	.....	10 Other (specify)	.....	10 Other (specify)	2 One-way trip
7 Concessionary Pass		.....		.....	

3 **INTERVIEW TIME:** .....

Q1 - Which service are you waiting for?	Q3 - Please state the full address you have just come from?	Q4 - Why were you at that location?	Q5 - Please state the full address you are travelling to now?	Q6 - Why are you going to your destination?	Q7 - Did you have a car available for this journey?
.....	Firm, House Name	1 Home	Firm, House Name	1 Home	1 Yes
	or ZONE	2 Holiday Home	or ZONE	2 Holiday Home	2 No
Q2 - What type of ticket do you have?	Number & Street	3 Work	Number & Street	3 Work	3 Non-driver
	.....	4 Employer Business	.....	4 Employer Business	
1 Single Ticket	Town	5 Education	Town	5 Education	**Q8 - If this journey is part of a 2-way return trip, please give the start time of your trip in the other direction (to nearest half hour)?**
2 Return Ticket	.....	6 Shopping	.....	6 Shopping	
3 Daily Ticket	County	7 Personal Business	County	7 Personal Business	
4 Weekly Pass	.....	8 Visit Friends	.....	8 Visit Friends	
5 Monthly Pass	Postcode	9 Recreation	Postcode	9 Recreation	1 Return Time .....
6 Multi-Journey (CARNET)	.....	10 Other (specify)	.....	10 Other (specify)	2 One-way trip
7 Concessionary Pass		.....		.....	

Source: Insert source text here

Figure A.2: Bus passenger interview form

BATH - BUS PASSENGER INTERVIEWS

BUS STOP No: ..... **LOCATION / NAME:** ..... **DATE** ..... **INTERVIEWER:** ..... *(office use)* **SERIAL No.** .....

1 **INTERVIEW TIME:** .....

Q1 - Which service are you waiting for?	Q3 - Please state the full address you have just come from?	Q4 - Why were you at that location?	Q5 - Please state the full address you are travelling to now?	Q6 - Why are you going to your destination?	Q7 - Did you have a car available for this journey?
.....	Firm, House Name	1 Home	Firm, House Name	1 Home	1 Yes
Q2 - What type of ticket do you have?	or ZONE	2 Holiday Home	or ZONE	2 Holiday Home	2 No
1 Single Ticket	Number & Street	3 Work	Number & Street	3 Work	3 Non-driver
2 Return Ticket	Town	4 Employer Business	Town	4 Employer Business	**Q8 - If this journey is part of a 2-way return trip, please give the start time of your trip in the other direction (to nearest half hour)?**
3 Daily Ticket	County	5 Education	County	5 Education	
4 Weekly Pass	Postcode	6 Shopping	Postcode	6 Shopping	
5 Monthly Pass		7 Personal Business		7 Personal Business	1 Return Time .....
6 Multi-Journey (CARNET)		8 Visit Friends		8 Visit Friends	2 One-way trip
7 Concessionary Pass		9 Recreation		9 Recreation	
		10 Other (specify)		10 Other (specify)	

2 **INTERVIEW TIME:** .....

Q1 - Which service are you waiting for?	Q3 - Please state the full address you have just come from?	Q4 - Why were you at that location?	Q5 - Please state the full address you are travelling to now?	Q6 - Why are you going to your destination?	Q7 - Did you have a car available for this journey?
.....	Firm, House Name	1 Home	Firm, House Name	1 Home	1 Yes
Q2 - What type of ticket do you have?	or ZONE	2 Holiday Home	or ZONE	2 Holiday Home	2 No
1 Single Ticket	Number & Street	3 Work	Number & Street	3 Work	3 Non-driver
2 Return Ticket	Town	4 Employer Business	Town	4 Employer Business	**Q8 - If this journey is part of a 2-way return trip, please give the start time of your trip in the other direction (to nearest half hour)?**
3 Daily Ticket	County	5 Education	County	5 Education	
4 Weekly Pass	Postcode	6 Shopping	Postcode	6 Shopping	
5 Monthly Pass		7 Personal Business		7 Personal Business	1 Return Time .....
6 Multi-Journey (CARNET)		8 Visit Friends		8 Visit Friends	2 One-way trip
7 Concessionary Pass		9 Recreation		9 Recreation	
		10 Other (specify)		10 Other (specify)	

3 **INTERVIEW TIME:** .....

Q1 - Which service are you waiting for?	Q3 - Please state the full address you have just come from?	Q4 - Why were you at that location?	Q5 - Please state the full address you are travelling to now?	Q6 - Why are you going to your destination?	Q7 - Did you have a car available for this journey?
.....	Firm, House Name	1 Home	Firm, House Name	1 Home	1 Yes
Q2 - What type of ticket do you have?	or ZONE	2 Holiday Home	or ZONE	2 Holiday Home	2 No
1 Single Ticket	Number & Street	3 Work	Number & Street	3 Work	3 Non-driver
2 Return Ticket	Town	4 Employer Business	Town	4 Employer Business	**Q8 - If this journey is part of a 2-way return trip, please give the start time of your trip in the other direction (to nearest half hour)?**
3 Daily Ticket	County	5 Education	County	5 Education	
4 Weekly Pass	Postcode	6 Shopping	Postcode	6 Shopping	
5 Monthly Pass		7 Personal Business		7 Personal Business	1 Return Time .....
6 Multi-Journey (CARNET)		8 Visit Friends		8 Visit Friends	2 One-way trip
7 Concessionary Pass		9 Recreation		9 Recreation	
		10 Other (specify)		10 Other (specify)	

Source: Insert source text here