Cabinet

Supplementary Information

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Time: 4.00 pm

Venue: Virtual Meeting - Zoom Committee Meeting with Public Access via YouTube

16. Improving Public Health - Bristol Clean Air Zone Update

FBC 19-26 **(Pages 2 - 438)**

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Bristol Clean Air Plan

Air Quality Modelling Report (AQ3)

FBC-19 | 4

17 February 2021

Bristol City Council

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Acronyms and Abbreviations

AAQD	Ambient Air Quality Directive
AQMA	Air Quality Management Area
BCC	Bristol City Council
CAP	Clean Air Plan
CAZ	Clean Air Zone
Defra	Department for Environment, Food & Rural Affairs
FBC	Full Business Case
HGV	Heavy Goods Vehicle
JAQU	Joint Air Quality Unit (Defra and the Department for Transport)
LDV	Light Duty Vehicle
OBC	Outline Business Case
$\mu g/m^3$	micrograms per cubic metre
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides (taken to be NO_2 + NO)
PCM	Pollution Climate Mapping

1. Introduction

1.1 Background

Poor air quality is the largest known environmental risk to public health in the UK[1]. Investing in cleaner air and doing more to tackle air pollution are priorities for the EU and UK governments, as well as for Bristol City Council (BCC). The Mayor of Bristol has often cited Bristol's 'moral and legal duty' to improve air quality in the city and the administration recognises that achieving improved air quality is not solely a transport issue. Notwithstanding the Council's work on a Clean Air Zone, efforts have been made to make citizens more aware of – and take personal responsibility for – various sources of air pollution, from traffic fumes to solid fuel burning. The Mayor has articulated a 'call to action' for local people, businesses and organisations to consider how small changes can make a significant difference in cutting toxic fumes across the city. BCC has monitored and endeavoured to address air quality in Bristol for decades and declared its first Air Quality Management Area in 2001. Despite this, Bristol has ongoing exceedances of the legal limits for Nitrogen Dioxide (NO_2) and these are predicted to continue until around 2027 without intervention.

The added context is that of the COVID-19 pandemic. Recent research suggests that poor air quality may be correlated with higher death / infection rates from COVID-19. This is further compounded by growing evidence that suggests that those from black, Asian and minority ethnic communities are more at risk of catching and dying from the virus and the fact that individuals from these communities are more likely to live in areas where air quality is poor. The challenge of maintaining public health and supporting economic recovery while also achieving legal air quality levels after lockdown restrictions are lifted will remain live and intersecting issues for the foreseeable future.

The UK Government continue to transpose European Union law into its Environment Bill[2] , to ensure that certain standards of air quality continue to be met, by setting air quality assessment levels (AQALs) on the concentrations of specific air pollutants. It's very unlikely that these AQALs will differ to EU Limit Values prescribed by the European Union's Air Quality Directive and transcribed in the UK's Air Quality Standards Regulation 2010. Therefore, these Limit Values will remain in enforcement post-Brexit. In common with many EU member states, the EU Limit Value for annual mean nitrogen dioxide (NO_2) is breached in the UK and there are on-going breaches of the NO_2 limit value in Bristol. The UK government is taking steps to remedy this breach in as short a time as possible, with the aim of reducing the harmful impacts on public health. Within this objective, the Government has published a UK Air Quality Plan and a Clean Air Zone Framework, both originally published in 2017 (noting there have been subsequent revisions). The latter document provides the expected approach for local authorities when implementing and operating a Clean Air Zone (CAZ). The following business cases have been submitted to JAQU for the Clean Air Plan; Strategic Outline Case (April 2018), and an Outline Business Case (November 2019 and updated between April and June 2020).

The PCM model predicted exceedances of the nitrogen dioxide (NO_2) EU Limit Value on Newfoundland Way and M32, as shown in Figure 1-1. According to PCM modelling year 2021 was the earliest that total compliance of the annual mean NO_2 EU Limit Value could be achieved through the application and rollout of a clean air zone. The Clean Air Plan (CAP) must set out how BCC will achieve sufficient air quality improvements in the shortest possible time to resolve these exceedances. In line with Government guidance BCC is considering implementation of a Clean Air Zone (CAZ), including both charging and non-charging measures, in order to achieve sufficient improvement in air quality and public health.

[1] Public Health England (2014) Estimating local mortality burdens associated with particular air pollution. https://www.gov.uk/government/publications/estimating-local-mortality-burdens-associated-with-particulate-air-pollution
[2] Environment Bill 2019-21 https://services.parliament.uk/bills/2019-21/environment.html

The OBC recommended the Medium CAZ C/Small CAZ D option for further analysis. However, following the submission of the OBC, further work was undertaken to develop the scheme, which resulted in the development of a new option - the Small area CAZ D. It should however be noted that BCC has been directed to progress a Medium CAZ C/Small CAZ D option, subject to further evidence. The option development work undertaken as part of and following the OBC, is presented in an updated Option Assessment Report (Appendix C FBC-16). The OBC version of this report is appended to the updated Option Assessment Report.

Jacobs has been commissioned to support BCC to produce a Full Business Case (FBC) for the delivery of the CAP; a package of measures which will bring about compliance with the Limit Value for annual mean NO_2 in the shortest time possible in Bristol. The FBC assesses the Small CAZ D and Fast Track Measures as a Medium CAZ C/Small CAZ D has already been assessed and results reported in AQ3 (submitted April 2020).

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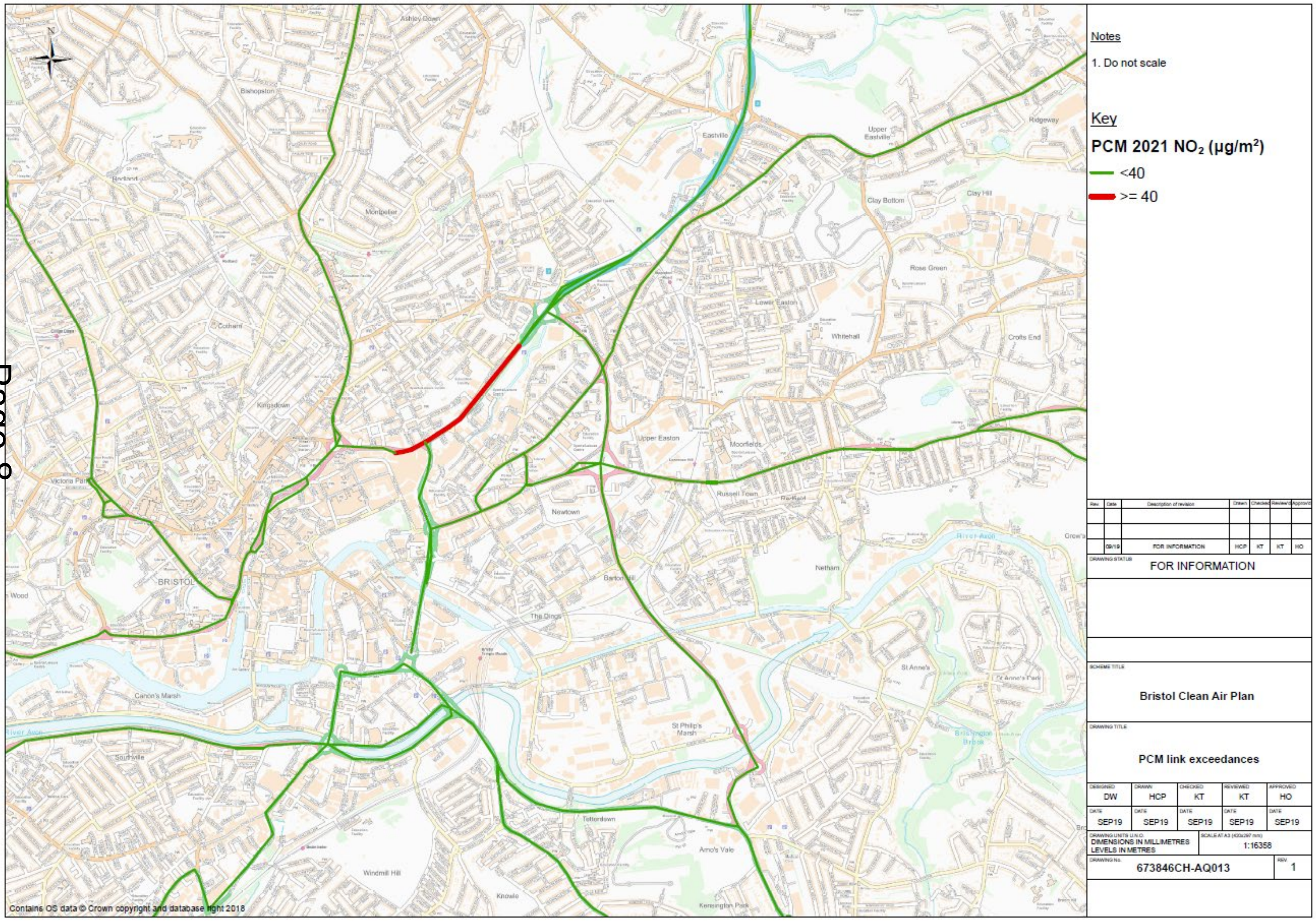

Figure 1-1. The location of predicted NO_2 non-compliance in 2021 according to the PCM model 2015

In addition to the Small CAZ D scenario the baseline representing the situation within Bristol without any intervention to tackle NO_2 exceedances has also been updated for the FBC to include Street Space Schemes (e.g. restricting access of vehicles onto Baldwin Street) and introducing a dedicated cycle lane on Upper Maudlin Street).

This document is written to support the FBC. It provides a discussion of the air quality modelling results and any consequent conclusions.

1.2 Purpose of this Report

This AQ3 report includes the results of the future baseline scenario and the proposed with CAZ scenario for years 2021, 2023 and 2031. Prior to presenting projection results for the options testing, this report provides an update to monitored concentrations in BCC and an overview of background concentrations, building on that presented in the April 2020 AQ3 report.

The following aspects previously reported have had no updates and therefore remain fully described in the April 2020 AQ3 report:

- Model verification;
- Target determination; and
- Results of the previous Medium CAZ D, Revised Hybrid, and Medium CAZ C/Small CAZ D scenarios.

2. Air Quality Monitoring

Air quality monitoring, undertaken by local authorities for Local Air Quality Management (LAQM) purposes, had been used in this assessment to provide indications of annual mean NO_2 concentrations in areas of interest, and in the model verification process.

The OBC and April 2020 AQ3 reports presented NO_2 concentrations for the year 2017 and 2018 respectively, as this was the most recent year for which ratified data were available. The 2019 data is now available and has been presented in Figure 2-1. Table 2-1 provides a summary of these 3 years of monitoring data.

Table 2-1 Summary of 2017 to 2019 Bristol NO_2 monitoring (diffusion tubes and continuous analysers)

Tube ID	2017	2018	2019
No. Monitors (Continuous and Passive)	112	134	109
No. Compliant (<= 40 µg/m^3)	67	87	81
No Non-Compliant (> 40 µg/m^3)	45	47	28
Compliant %	59.8%	64.9%	74.3%

Table 2-1 indicates that air quality has generally improved over these 3 years, with just 28 monitors indicating non-compliance with the EU Limit Values. Figure 2-1 provides the locations of the 2019 monitoring sites within the BCC administrative boundary and highlights the sites where monitored annual mean NO_2 concentrations exceeded the EU Limit Value. Monitoring data for both 2017, 2018 and 2019 are provided in Table 5-1.

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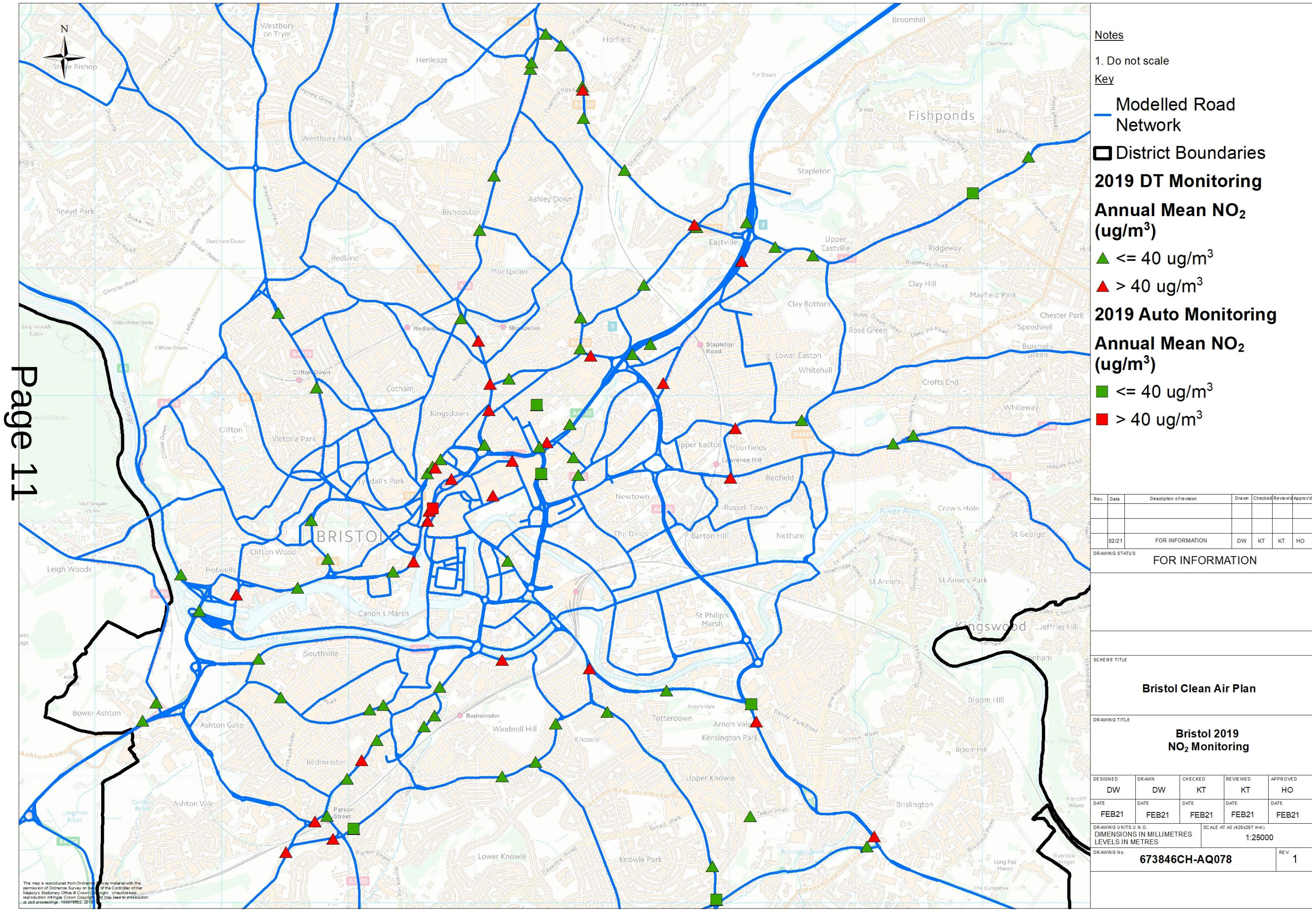

Figure 2-1. Air Quality Monitoring Within BCC administration boundary – 2019 Annual Mean NO_2

The monitoring indicated that exceedance locations in 2019 were similar to those in 2017 and 2018, with several exceedances of the EU Limit Value measured, in particular, in the city centre (represented by red in Figure 2-1). The likely cause of the exceedances at these locations is a combination of the traffic mix (particularly diesel vehicles), road speed (i.e. slower speeds are generally accompanied by more frequent acceleration events) and the presence of canyons (generally tall buildings on either side of the road which prevent pollutants from dispersing as effectively as they would in an open area). BCC diffusion tube locations BCC20 and BCC374 are located alongside the exceeding PCM Census ID 57291 shown in Figure 1-1 and indicate that this location was still exceeding the EU Limit Value in 2019. Note that the map of air quality monitoring indicates that exceedances are not limited to locations around PCM Census IDs.

In 2019, BCC deployed two additional diffusion tubes on Upper Maudlin Street, near to the Bristol Royal Infirmary. The monitored concentrations on Upper Maudlin Street for 2019 are shown in Table 2-2, indicating that there has been a sustained 2017-2019 decrease in NO_2 concentrations at locations 9 and 423, with 2019 results showing tube 423 achieved compliance with the EU Limit Value in 2019. However, one non-compliance remained at site 561, on the eastern side of the road opposite the Bristol Royal Infirmary. The ratified 2019 concentrations are much lower (between 3.9 and 7.6 μg/m^3) than the preliminary figures presented in the April 2020 AQ3 Report.

Table 2-2 Monitored NO_2 concentrations on Upper Maudlin Street

			Monitored annual mean NO_2 concentration (μg/m^3)		
Tube ID	Easting	Northing	2017	2018	2019
9	358729	173499	46.5	44.7	37.8
423	358623	173386	45.0	42.3	35.2
560	358665	173439	-	-	40.4
561	358688	173431	-	-	47.0

As well as providing an indication of pollutant concentrations, a number of these monitoring locations have been used in the model verification process and are presented in Figure 2-2. The model verification was highly detailed in its approach and used monitoring information from both BCC and neighbouring South Gloucestershire Council (SGC). A total of 85 monitoring sites across BCC and SGC were used in the process. For a full description of the modelling process, see Section 2 of the AQ2 report and Section 3 of the April 2020 AQ3 report.

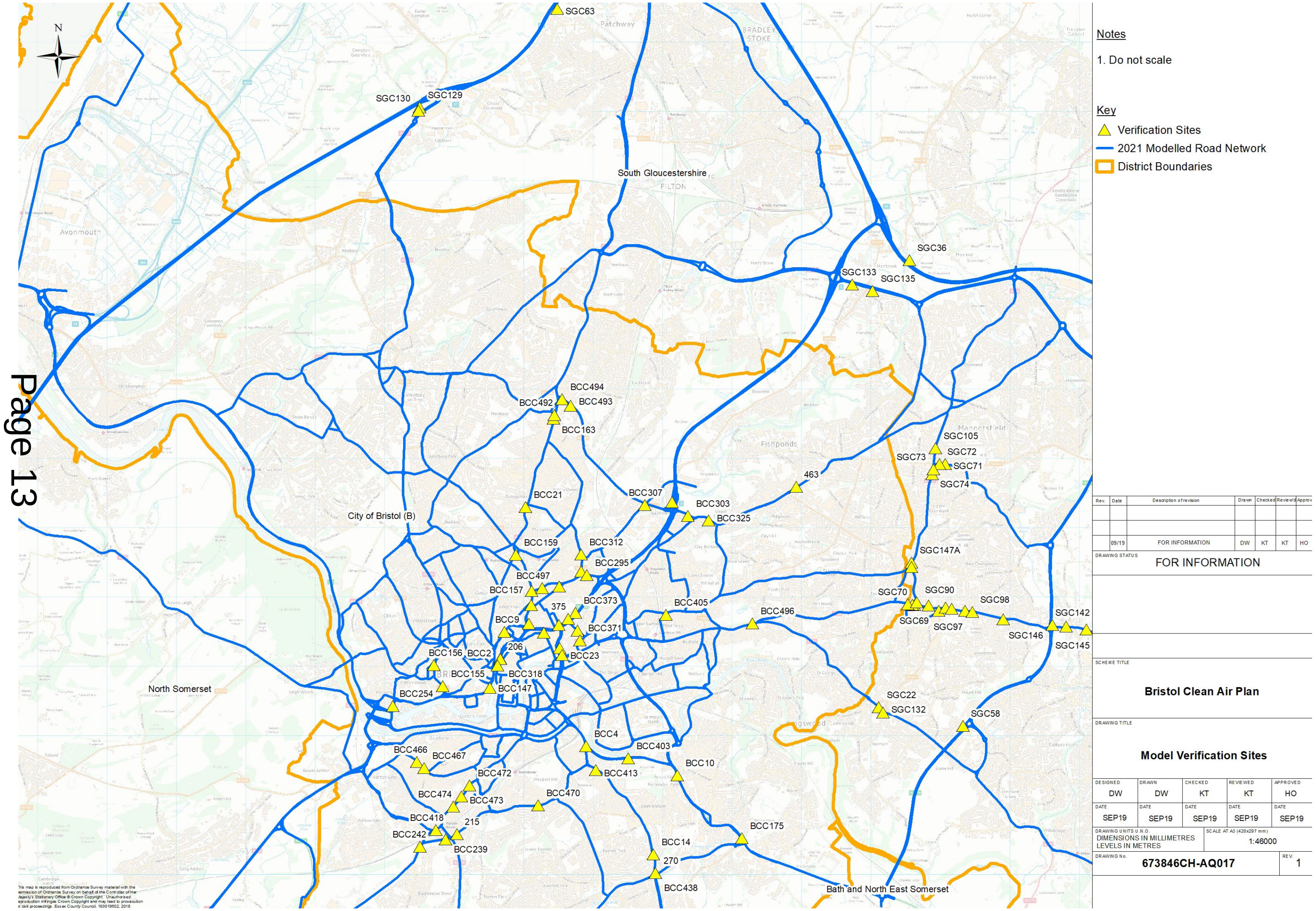

Figure 2-2. BCC & SGC monitoring sites used in model verification

2.1 Background Concentrations

Estimated background concentrations in the study area have been determined for 2015 and the future years 2021, 2023 and 2031[3] using Defra's background maps (Defra, 2018b), with the NO_2 values interpolated to give concentrations specific to each receptor. The range of background concentration values interpolated for the different 1x1 km grid squares covering the study area are set out in Table 2-3 for the receptors at the reported critical locations, as listed in Table 3-1 (and detailed in Section 4 Target Determination in the April 2020 AQ3 report). These have been derived as described in the Air Quality Modelling Methodology Report (AQ2). The background concentrations are all well below the EU Limit Values, indicating that any modelled / monitored non-compliance is likely attributable to local emission sources.

Table 2-3. Estimated Annual Mean Background Pollutant Concentrations in 2021, 2023 and 2031 (μg/m^3)

Year	NOx	NO_2
2021	21.8 - 27.7	15.7 - 19.4
2023	19.3 - 24.7	14.0 - 17.4
2031	16.4 – 21.0	12.1 - 15.1
EU Limit Value	**-**	**40.0**

[3] Background concentrations for 2030 are applied to represent 2031 conditions because Defra datasets are only available up to 2030.

3. Updated Baseline Model Results

Since the updated AQ3 report was submitted in April 2020, the baseline scenario has been updated to account for additional street space schemes (SSS), whilst the impact of proposed fast track measures form part of the Small CAZ D scheme. The SSS have been incorporated in an updated baseline model which has helped refine the Bristol Clean Air Zone scheme presented in the Outline Business Case submission, prior to the Full Business Case submission. These are summarised in Section 8 of the Options Assessment Report (submitted February 2021) and can be summarised as:

- Closure of Bristol Bridge;
- Baldwin St priority changes; and
- Walking, cycling and public transport improvements in the city centre.

The 2021, 2023 and 2031 modelled annual mean NO_2 concentrations and the calculated compliance years for the Street Space Scheme Baseline (excluding fast track measures) scenario are presented in Table 3-1 and Figure 3-1 to Figure 3-3.

The following observations are drawn primarily with respect to the eleven critical locations driving compliance of the AAQD EU Limit Value of 40 μg/m^3. The compliance years have been calculated based on a threshold value of 40.5 μg/m^3 (i.e. 40.4 μg/m^3 and below is compliant with the EU Limit Value), in line with the JAQU method for reporting air quality compliance to the EU, as applied to other CAZ-related projects.

In this scenario, natural compliance within BCC is driven by receptor 12649, located outside the Bristol Royal Infirmary (BRI) on Marlborough Street. The modelled annual mean NO_2 concentrations at this receptor in 2021, 2023 and 2031 were 57.7, 49.4 and 33.3 μg/m^3 respectively. Non-linear interpolation (based on emission rates produced by Defra's Emission Factor Toolkit) of these results indicated an anticipated natural compliance year of 2027.

The air quality modelling also indicated other locations with very high annual mean NO_2 concentrations and correspondingly relatively late compliance years, when compared to the rest of Bristol. These include locations such as Rupert Street, Upper Maudlin Street and Newfoundland Way, which had calculated natural compliance years of 2026, 2024 and 2025 respectively.

Baldwin Street's calculated compliance year was 2021 or before, as a result of this road being closed off to traffic (as part of the Street Spaced Scheme intervention). The highest modelled annual mean NO_2 concentrations (at receptor 11589) in 2021, 2023 and 2031 respectively were 26.5, 23.7 and 18.8 μg/m^3.

To summarise, as Marlborough Street is the location driving compliance, any measures introduced should aim to significantly reduce concentrations of annual mean NO_2 in this area to achieve the earliest possible compliance year.

Table 3-1. 2021, 2023 and 2031 Street Space Scheme Baseline modelled annual mean NO_2 results at critical locations

	Rupert Street (nr Bridewell St)	Marlborough Street	Upper Maudlin Street	Park Row	Park Street	Queen's Road	College Green	Cheltenham Road	Newfoundland Way	Church Road	Baldwin Street
Receptor ID	15160	12649	12636	12014	6925	7098	11949	12708	13742	24587	11589
2021 Annual Mean NO_2 Concentrations (µg/m^3)	51.4	57.7	48.3	44.7	37.8	34.7	40.7	41.4	49.9	43.5	26.5
2023 Annual Mean NO_2 Concentrations (µg/m^3)	46.0	49.4	42.1	38.9	32.4	30.1	35.2	37.0	43.9	37.9	23.7
2031 Annual Mean NO_2 Concentrations (µg/m^3)	33.3	33.3	28.2	26.3	22.9	21.5	24.2	26.8	29.4	25.2	18.8
Calculated Compliance Year	2026	2027	2024	2023	2021	2021	2022	2022	2025	2022	2021

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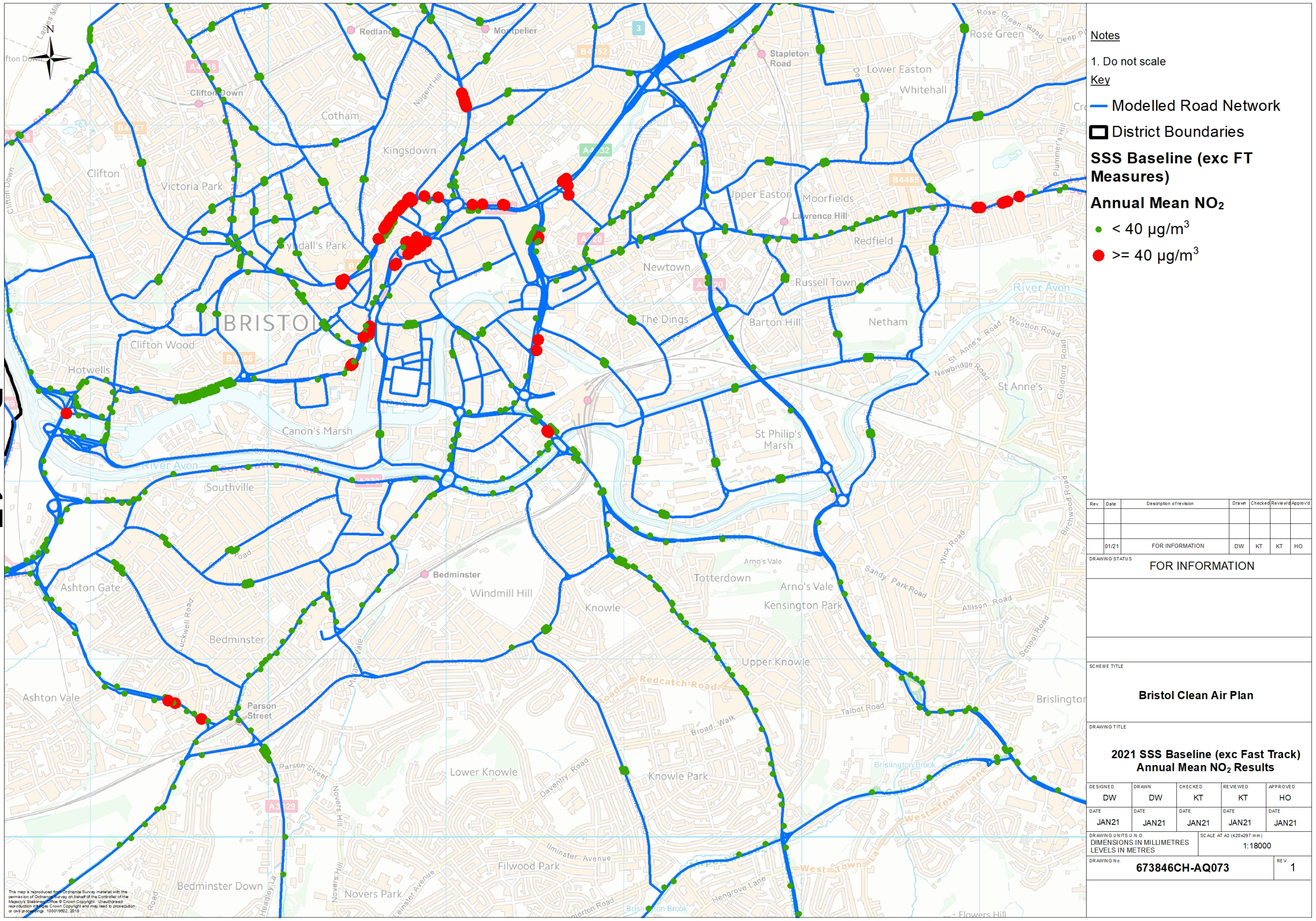

Figure 3-1. 2021 SSS Baseline scenario modelled annual mean NO_2 results

Jacobs

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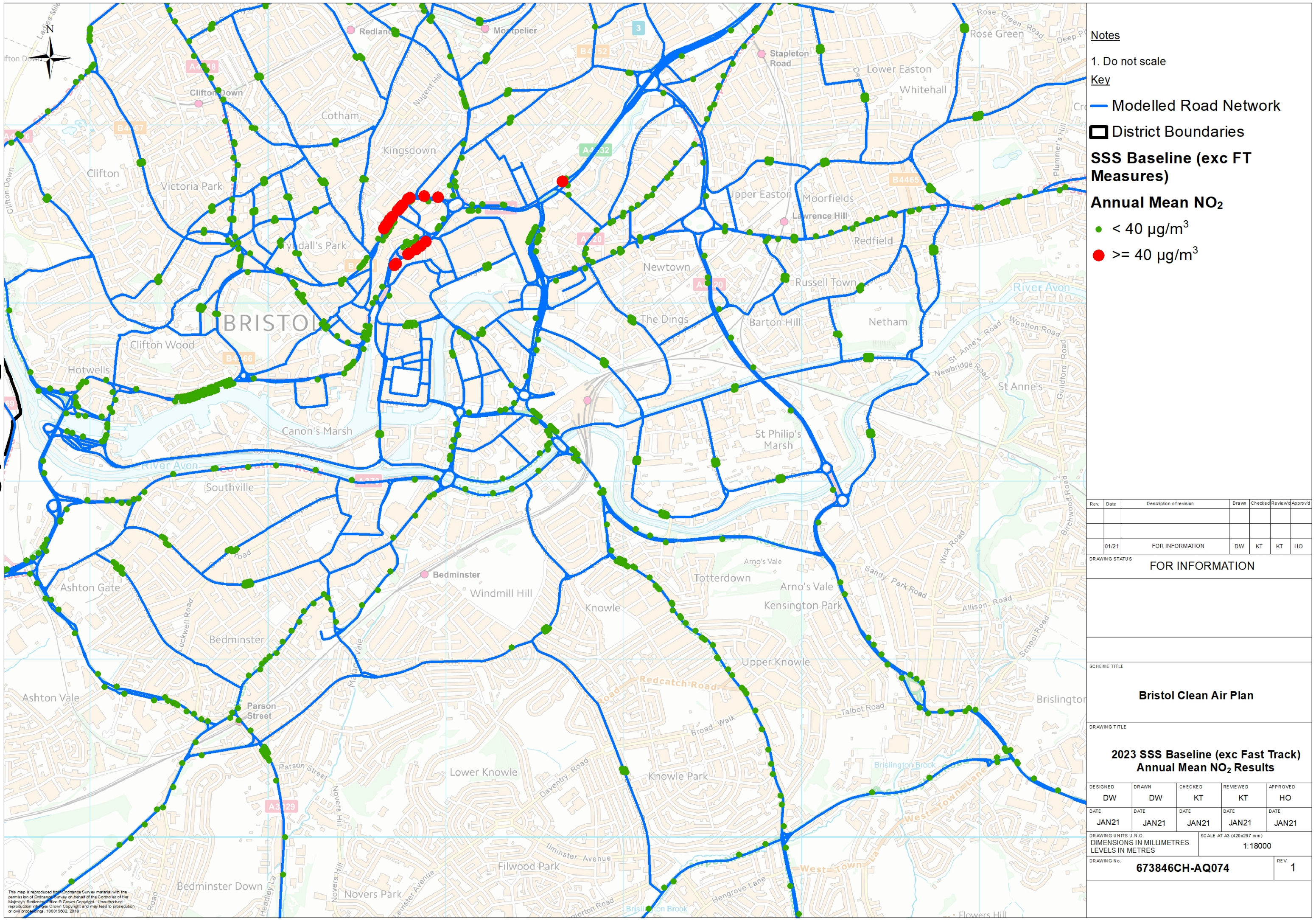

Figure 3-2. 2023 SSS Baseline scenario modelled annual mean NO_2 results

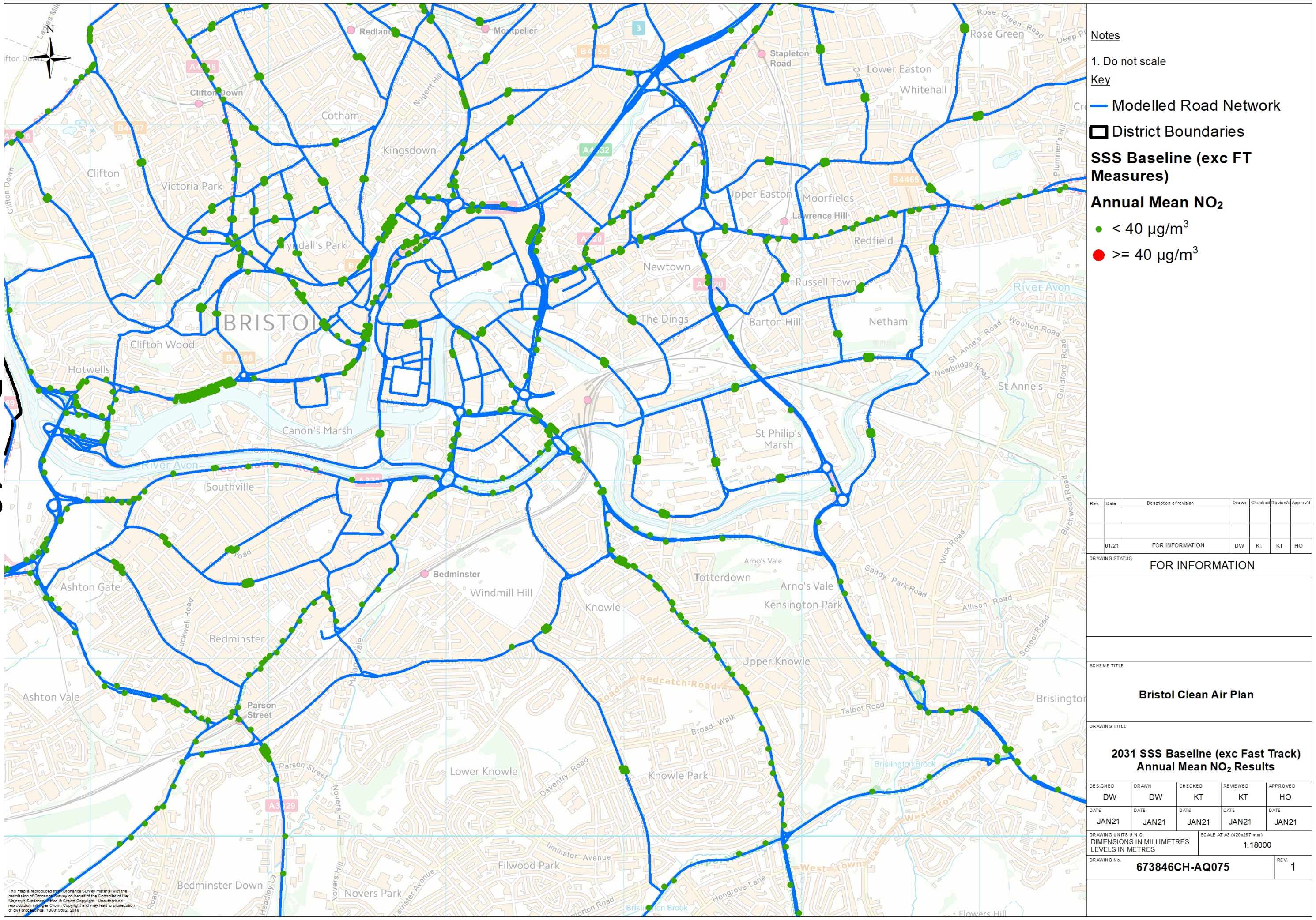

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Figure 3-3. 2031 SSS Baseline scenario modelled annual mean NO_2 results

4. Small Area CAZ D Scenario

The Small Area CAZ D scenario is the full set of measures that will be implemented in 2021 to bring annual mean NO_2 concentrations to within the EU limit values in the shortest possible timeframe. The natural anticipated compliance year (with SSS in place) is 2027.

This scenario includes the following aspects:

- SSS (as per the baseline – see Section 3);
- Small Area Class D CAZ (charging non-compliant cars, buses, coaches, taxis, HGVs and LGVs);
- Fast Track measures;
    a) Closure of Cumberland Road inbound to general traffic; and
    b) Holding back traffic to the city centre through the use of existing signals.
- Revisions to the boundary at Cabot Circus so vehicles can enter / exist Cabot Cercus car park via Houlton St access without going through the CAZ; and
- Application of speed / flow correction factors as per spring 2020 sensitivity test to the model outputs.

The results of this model scenario are presented in Table 4-1 and Figure 4-1 to Figure 4-6. As with the Baseline scenario, modelling was undertaken for future years 2021, 2023 and 2031.

4.1 2021 Modelled Results

It is evident looking at the 2021 model results that the Small Area CAZ D scenario has a very large impact on annual mean NO_2 concentrations at the majority of the critical locations presented in Table 4-1 (see Figure 4-1 and Figure 4-2). Marlborough St, where the highest reportable concentrations were modelled, had a decrease of 14.9 $\mu g/m^3$ at receptor 12549, bringing compliance forwards to 2023. On Upper Maudlin Street, Park Row, College Green, Cheltenham Road and Newfoundland Way, the implementation of the Small CAZ D and fast track measures reduced the annual mean NO_2 concentrations sufficiently so that they were compliant with the EU Limit Value. Despite the large impact of the scheme however, Rupert Street, Marlborough Street and Church Road remained non-compliant with the EU limit value in 2021.

With regards to change in annual mean NO_2 concentrations across BCC, the Small Area CAZ D and fast track measures scenario led to decreases (change in concentrations of -0.4 $\mu g/m^3$ or less) at 1,153 reportable receptors within BCC in the 2021 scenario. As above, the largest decrease was at receptor 12649 on Marlborough Street. In this scenario there were just 9 increases (of 0.4 $\mu g/m^3$ or greater) in annual mean NO_2 concentrations, which is likely attributable to redistribution of traffic across the network. The largest increase was 1.5 $\mu g/m^3$ on Lower Ashley Road, which caused this receptor to be non-compliant in 2021. Given the high modelled concentrations elsewhere though, this does not influence the overall anticipated compliance year for BCC.

4.2 2023 Modelled Results

The 2023 model scenario indicated broadly similar improvements to those seen in the 2021 scenario. The main difference is that in 2023 the changes are generally of smaller magnitudes to those in 2021 as a result of the natural improvements to the vehicle fleet over this two-year period. Even so, Marlborough Street still had a decrease in annual mean NO_2 concentrations of 9.1 $\mu g/m^3$ with the Small Area CAZ D in place. The proposals reduced concentrations at all remaining locations with non-compliance (i.e. Marlborough Street, Rupert Street, Upper Maudlin Street and Newfoundland Way) sufficiently to make these locations compliant with the EU limit values (see Figure 4-3).

The Small Area CAZ D resulted in a decrease of 0.4 μg/m^3 or greater at 1,059 reportable receptors within BCC authority boundary and no change (change of -0.3 to 0.3 μg/m^3) at 333 reportable receptors (see Figure 4-4). It also resulted in an increase (change greater than 0.4 μg/m^3) in annual mean NO_2 concentrations at 7 receptors, which is again likely attributable to redistribution of traffic across the network. The largest change was 3.2 μg/m^3, which occurred on the A37 Wells Road near the junction with the A4174 Callington Road.

4.3 2031 Modelled Results

By 2031 all reportable receptors within BCC authority boundary were estimated to be compliant with the EU Limit Value for at least 4 years (see Figure 4-5). The high proportions of compliant vehicles on the network by this point also means that the Small CAZ D will have little to no effect on air quality by 2031 (assuming that CAZ emissions compliance criteria remains the same). Changes estimated for this scenario compared to the updated baseline are likely attributable to the fast track measures. There were decreases (less than or equal to -0.4 μg/m^3) in annual mean NO_2 concentrations at 63 reportable receptors, and no change at 1,260 receptors. There were also increases of 0.4 μg/m^3 or more at 76 receptors, the largest of which was 2.0 μg/m^3 on Upper Maudlin Street. None of the increases caused non-compliance with the EU Limit Values (see Figure 4-6).

4.4 Compliance Years

The compliance year for the whole of Bristol with the Small Area CAZ D scenario in place is anticipated to be 2023, which is 4 years ahead of the 2027 natural compliance year. These years are based on the modelled concentrations at Marlborough Street, as this is where the largest annual mean NO_2 concentrations were modelled. With regards to the other critical locations, the proposals bring compliance forwards by:

- 4 years on Newfoundland Way (2025 to 2021);
- 3 years on Rupert Street and Upper Maudlin Street (2026 to 2023 and 2024 to 2021 respectively);
- 2 years on Park Row (2023 to 2021); and
- 1 year on College Green and Cheltenham Road (2022 to 2021 for both).

Note that a Small Area CAZ D was modelled in 2021 assuming a full years' worth of benefit would accrue during this period. At the time of writing this report the earliest this measure would be operational is approximately October 2021. Under these circumstances less than three months' worth of benefit would occur, compared to the full year that the modelling assumed. However, it is worth noting that this will only apply to locations with a compliance year of 2021 (e.g. Upper Maudlin Street). Overall compliance in 2023 would be unaffected.

4.5 Model Uncertainty

All modelled results have a degree of uncertainty. Air quality modelling uncertainty is reduced by drawing comparisons to observed monitoring data in the base year 2015. This verification process has been fully described in Section 3 of AQ2 and Section 3 of the April AQ3 reports. Part of this process is calculating the Root Mean Square Error (RMSE), which defines the average error or uncertainty of the model, and in this case was 7.6 μg/m^3. This value is within the ranges for acceptable RMSE values as recommended by Defra guidance document LAQM TG16[4] (i.e. 25% of the objective, which is equivalent to 10 μg/m^3). What this indicates is that modelled annual mean NO_2 concentrations would have to be equivalent to or below 32.8 μg/m^3 (i.e. 40.4 μg/m^3 minus the RMSE value) for there to be high confidence that compliance will occur at these locations. It is unlikely that this value will occur across the modelled results until much later than 2023. It is recommended that areas with modelled concentrations of over 32.8 μg/m^3 are observed for potential exceedances in the run up to the compliance year (i.e. be a factor of the Monitoring and Evaluation Plan). Similarly, this RMSE value indicates that modelled non-compliance with the EU Limit Value would need to be greater than 48.0 μg/m^3 for there to be high confidence that there is indeed an exceedance at that location.

[4] Defra, 2018. Local Air Quality Management Technical Guidance (TG16). Available online at: https://laqm.defra.gov.uk/technical-guidance/

Fractional bias is another metric for assessing model performance. It is used to identify if the model shows a systematic tendency to over or under predict, with the ideal value therefore being 0 (and the maximum and minimum values being +2 and -2 respectively). The results of the model verification produced a fractional bias of 0.03, which is very close to the ideal value and therefore indicates that there is no significant systematic over or under prediction of results. The adjustment factor is therefore sound.

4.6 Summary

Overall, the Small Area CAZ D (and fast track measures) has very large benefits across the Bristol City district and satisfies JAQU's criteria for a CAZ by achieving compliance with the EU Limit Value in the shortest possible timeframe (i.e. 2023). Although the proposals led to increases in some locations as a result of redistribution across the network, none of these increases were large enough to affect the compliance year.

Table 4-1. 2021, 2023 and 2031 Street Space Scheme Baseline and Small Area CAZ D (including Fast Track measures) modelled annual mean NO_2 results at critical locations

	Rupert Street (nr Bridewell St)	Marlborough Street	Upper Maudlin Street	Park Row	Park Street	Queen's Road	College Green	Cheltenham Road	Newfoundland Way	Church Road	Baldwin Street
Receptor ID	15160	12649	12636	12014	6925	7098	11949	12708	13742	24587	11589
2021 Results (µg/m^3)											
Baseline	51.4	57.7	48.3	44.7	37.8	34.7	40.7	41.4	49.9	43.5	26.5
Small Area CAZ D	43.1	42.8	37.4	35.3	29.3	28.5	32.8	38.9	39.8	41.6	24.5
Difference	-8.3	-14.9	-10.8	-9.4	-8.5	-6.1	-7.8	-2.5	-10.1	-1.9	-2.0
2023 Results (µg/m^3)											
Baseline	46.0	49.4	42.1	38.9	32.4	30.1	35.2	37.0	43.9	37.9	23.7
Small Area CAZ D	39.8	40.3	34.6	32.7	26.5	25.8	29.7	35.5	36.3	36.5	22.2
Difference	-6.2	-9.1	-7.5	-6.1	-5.9	-4.3	-5.4	-1.6	-7.5	-1.4	-1.5
2031 Results (µg/m^3)											
Baseline	33.3	33.3	28.2	26.3	22.9	21.5	24.2	26.8	29.4	25.2	18.8
Small Area CAZ D	32.9	35.3	28.1	26.6	22.1	21.4	23.9	27.3	29.0	25.6	18.8
Difference	-0.3	2.0	-0.1	0.3	-0.8	-0.1	-0.3	0.5	-0.4	0.4	-0.1
Compliance Year											
Baseline	2026	2027	2024	2023	2021	2021	2022	2022	2025	2022	2021
Small Area CAZ D	2023	2023	2021	2021	2021	2021	2021	2021	2021	2022	2021
Difference	-3	-4	-3	-2	0	0	-1	-1	-4	0	0

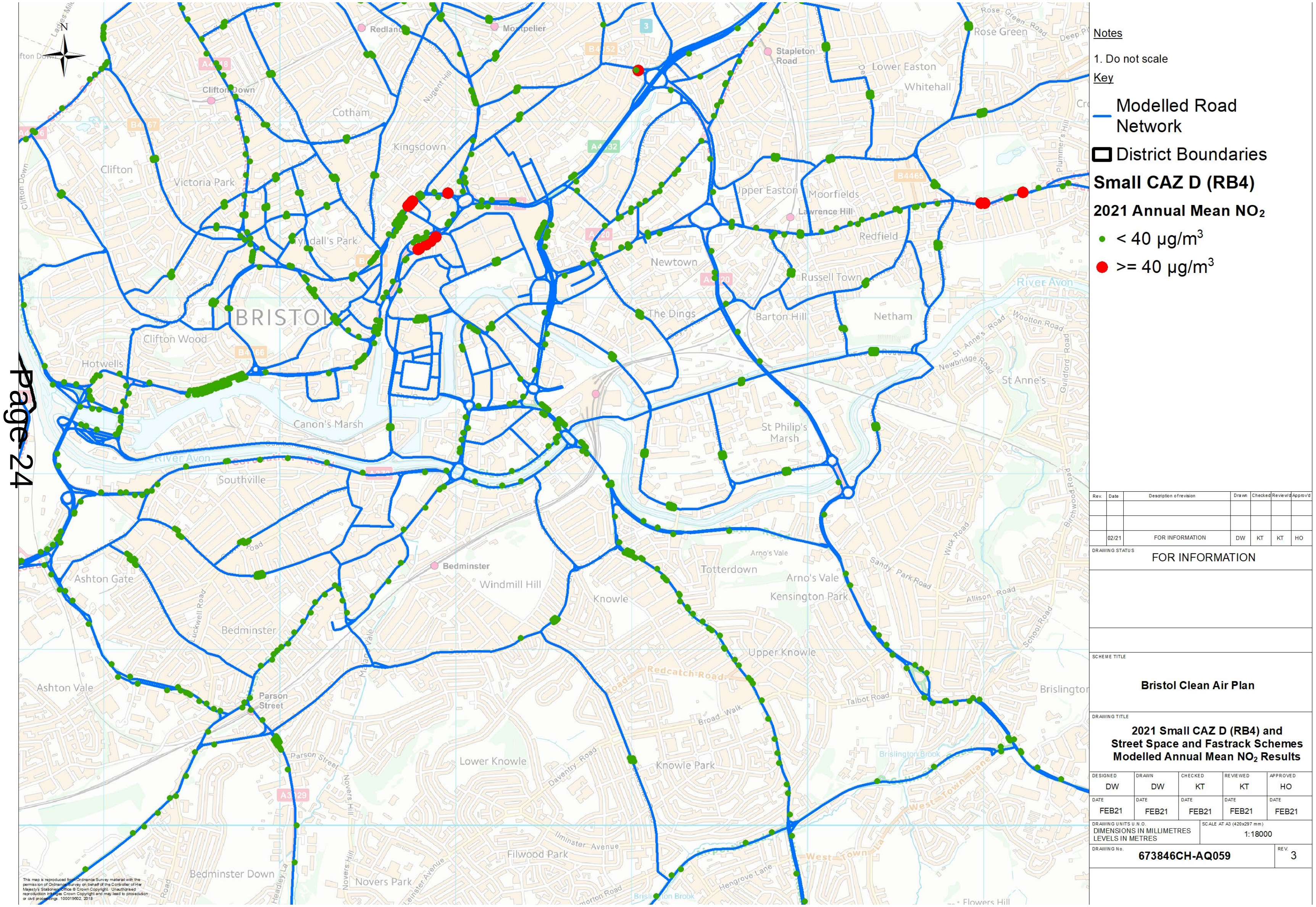

Figure 4-1. 2021 Small Area CAZ D scenario modelled annual mean NO_2 results

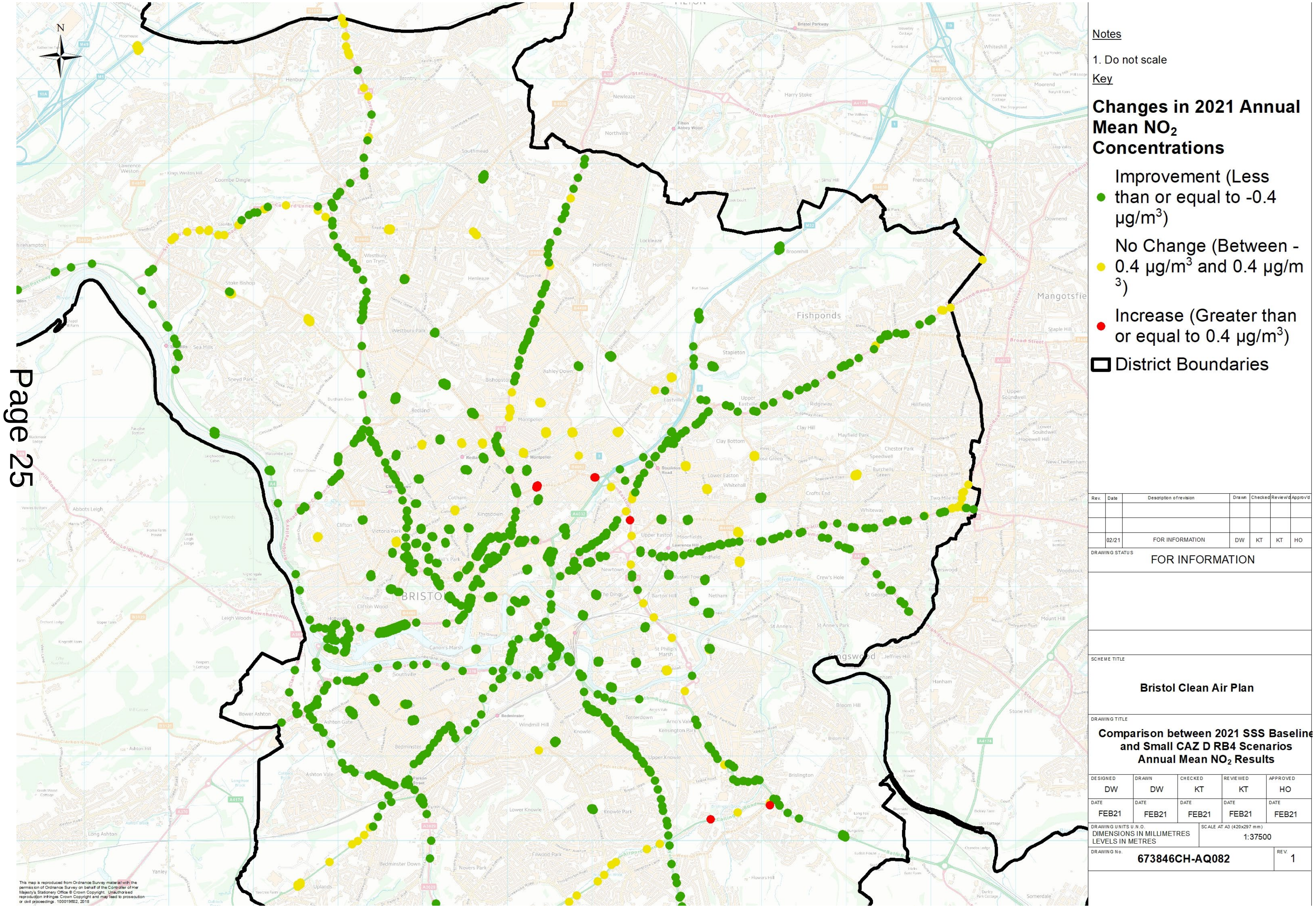

Figure 4-2. Comparison of Baseline and Small Area CAZ D 2021 modelled annual mean NO_2 results

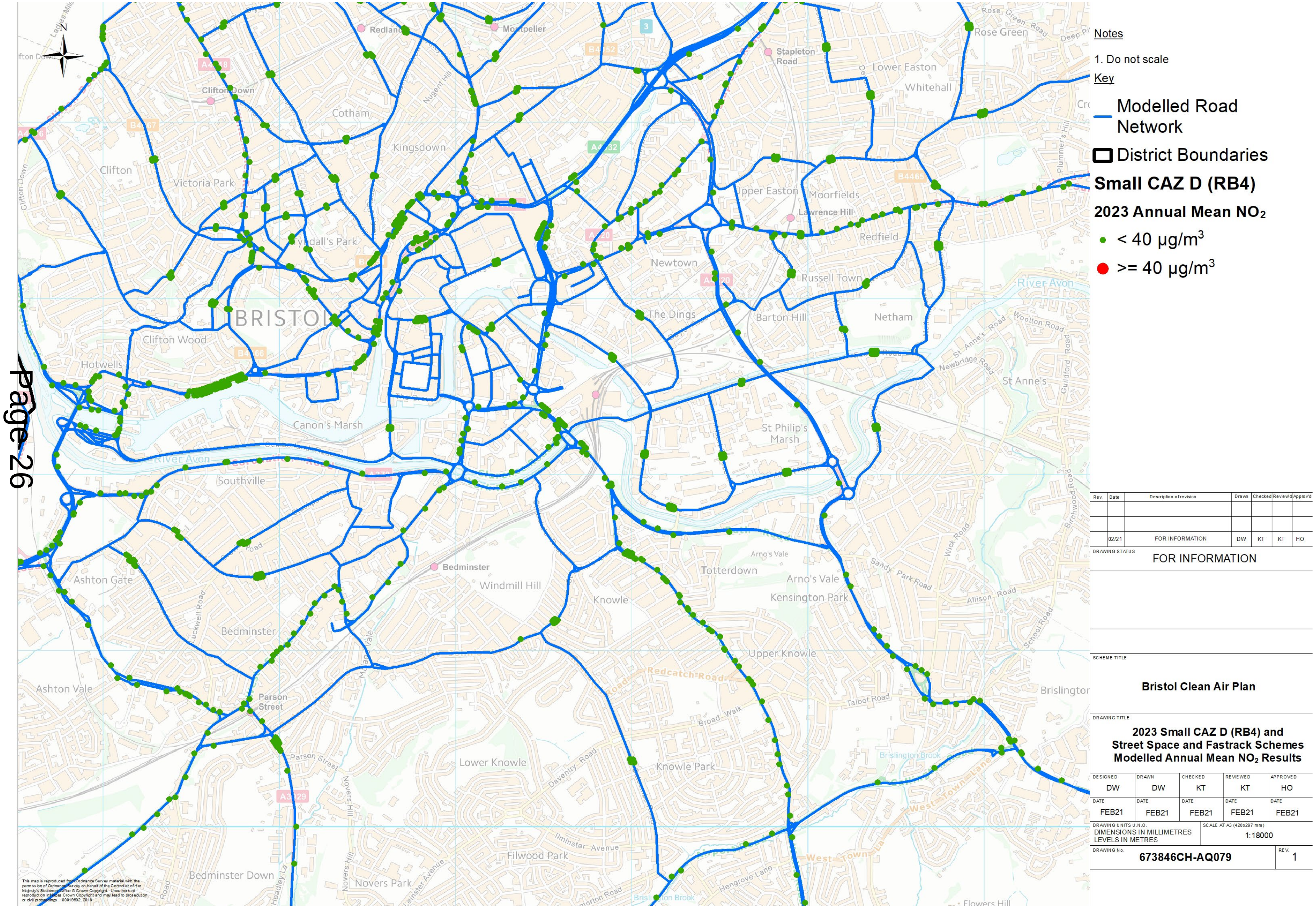

Figure 4-3. 2023 Small Area CAZ D scenario modelled annual mean NO_2 results

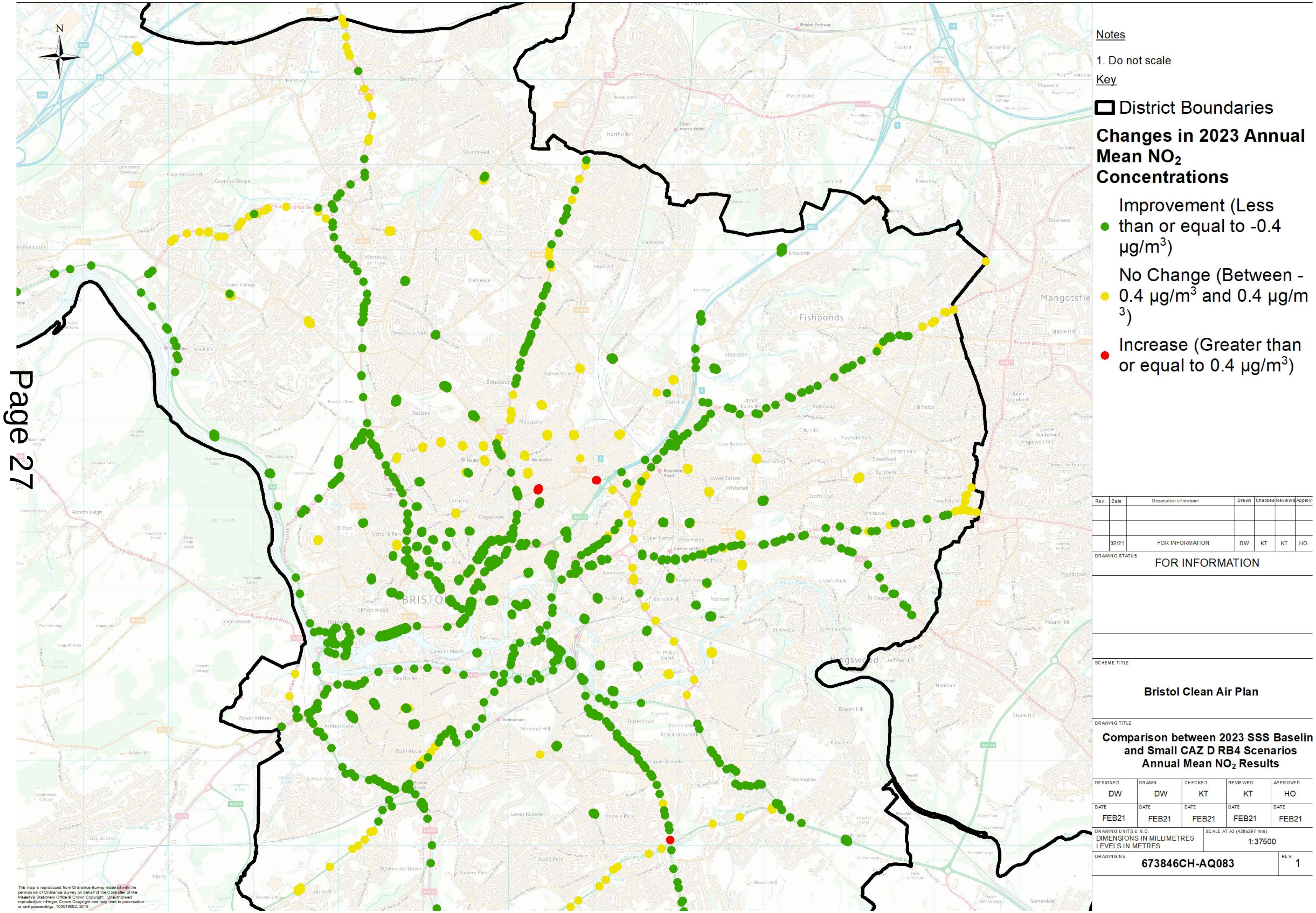

Figure 4-4. Comparison of Baseline and Small Area CAZ D 2023 modelled annual mean NO_2 results

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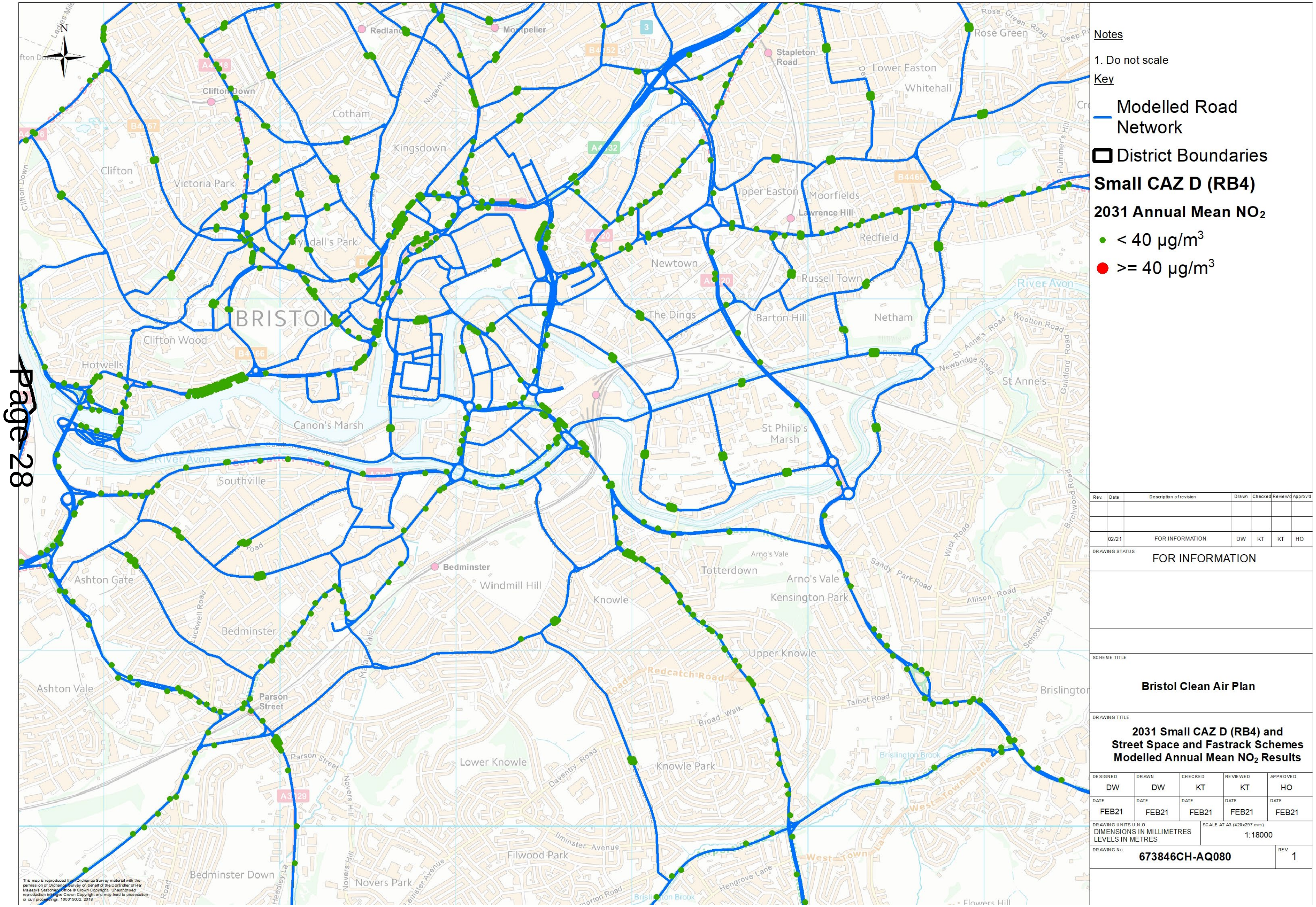

Figure 4-5. 2031 Small Area CAZ D scenario modelled annual mean NO_2 results

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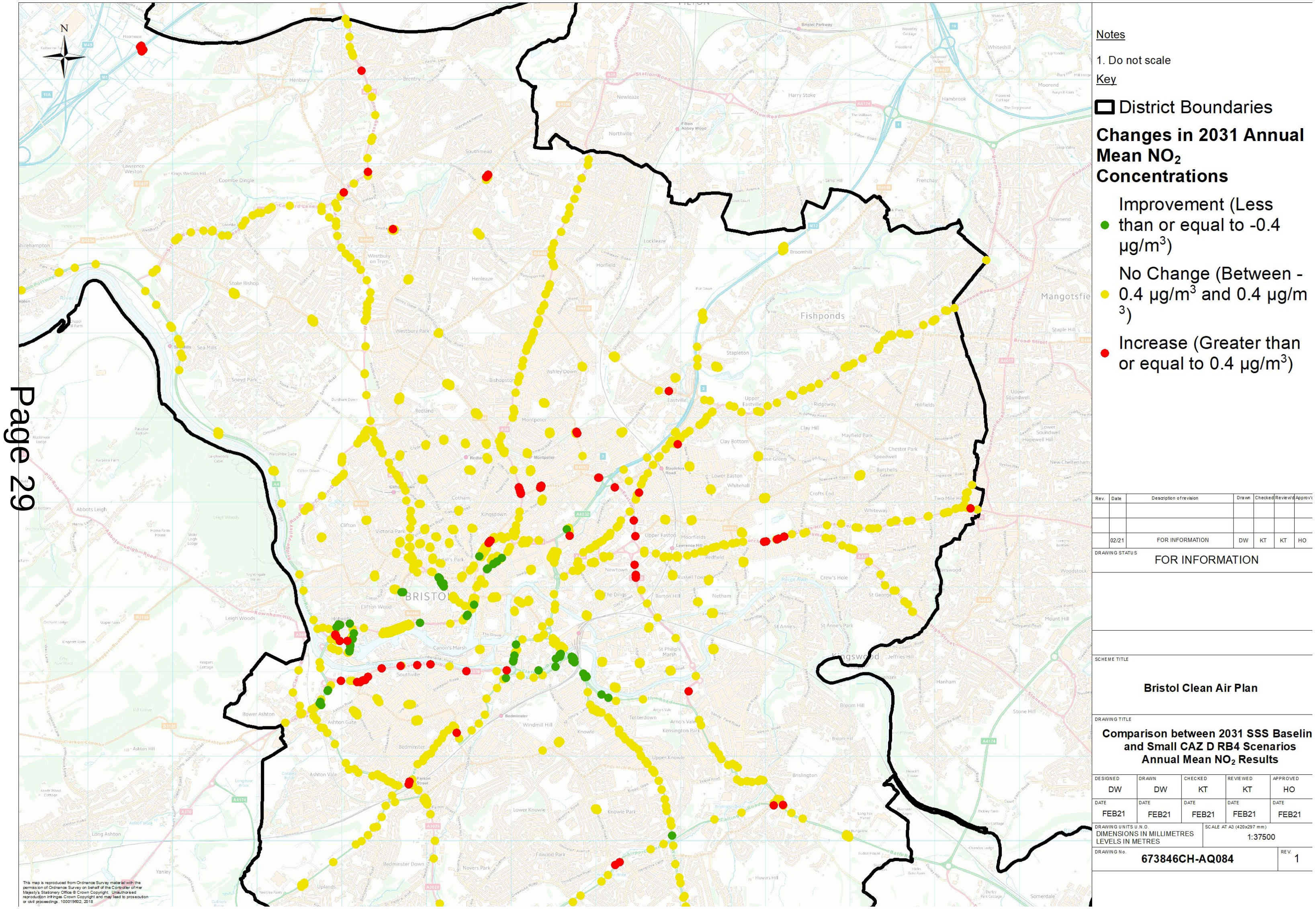

Figure 4-6. Comparison of Baseline and Small Area CAZ D 2031 modelled annual mean NO_2 results

5. Conclusion

The aim of the Bristol Clean Air Plan is to achieve compliance with the annual mean NO_2 EU Limit Value in the shortest possible timeframe, which is in line with Guidance provided by the JAQU. To this aim, the Small Area CAZ D (and fast track measures) scenario reported in this assessment is evidence based and has evolved over time with a focus on where improvements were needed most.

The main focus areas preventing earlier compliance were Marlborough Street, Upper Maudlin Street and Baldwin Street. The Small Area CAZ D achieves compliance on Marlborough Street in 2023. Compliance on Upper Maudlin Street is estimated to be 2021. Street space schemes in place on Baldwin street alone achieve compliance at this location by 2021. Overall, this scenario achieves compliance by 2023 across the whole of BCC.

With regards to individual receptors, the Small Area CAZ D improves annual mean NO_2 concentrations at 1,153 and 1,059 of the reportable receptors within Bristol in 2021 and 2023 respectively, whilst increasing concentrations at 9 and 7 receptors respectively in these years. The number of receptors that modelled improvements vastly outweighs the number that modelled disbenefits and the disbenefits to not push back the compliance year. By 2031, there are a larger number of disbenefits (76) predicted, which is attributable to the net disbenefit of the fast track measures and other non-charging measures over a largely redundant Small CAZ D by this year. However, these are not anticipated to result in non-compliance with the EU Limit Value. Uncertainty in the modelling was approximately 7 $\mu g/m^3$ and hence caution is recommended in terms of the anticipated outcomes of this study.

Overall, the Small Area CAZ D scenario is the most successful scenario assessed to date and aims to achieve compliance across BCC by 2023.

Appendix A. BCC Monitoring Results

Table 5-1. BCC Monitoring Results

Monitoring Type	ID	X	Y	Monitored Annual Mean NO_2 Concentration (µg/m^3)		
				2017	2018	2019
Continuous Analyser	203	361178	171566	29.5	25.4	25.2
Continuous Analyser	463	362926	175590	39.1	41.5	39.5
Continuous Analyser	215	358042	170582	41.1	39.0	32.3
Continuous Analyser	270	360903	170024	39.0	33.0	29.7
Continuous Analyser	452	359486	173922	23.7	23.8	23.4
Continuous Analyser	500	359522	173381	37.8	44.3	39.2
Continuous Analyser	501	358667	173108	N/A	67.2	65.5
Diffusion Tube	BCC2	358628	173011	63.1	58.2	53.7
Diffusion Tube	BCC3	357448	174650	34.4	34.4	27.7
Diffusion Tube	BCC4	359903	171850	52.7	53.5	41
Diffusion Tube	BCC5	358723	171704	45.8	45.8	39.9
Diffusion Tube	BCC6	361261	173413	32.3	N/A	N/A
Diffusion Tube	BCC7	351706	178250	26	N/A	N/A
Diffusion Tube	BCC8	359836	171903	21.9	N/A	N/A
Diffusion Tube	BCC9	358729	173499	46.5	44.7	37.8
Diffusion Tube	BCC10	361217	171429	51.6	51.5	42.2
Diffusion Tube	BCC11	358813	173342	49.2	48.1	41.1
Diffusion Tube	BCC12	359142	173211	56.6	57.5	51.8
Diffusion Tube	BCC13	354493	177489	20.1	N/A	N/A
Diffusion Tube	BCC14	360871	170291	41.1	47.6	38.7
Diffusion Tube	BCC15	359294	173485	49.4	47.5	42.2
Diffusion Tube	BCC16	352287	178698	35.2	32.6	28.7
Diffusion Tube	BCC17	357273	174582	19.7	N/A	N/A
Diffusion Tube	BCC18	360691	170081	18.4	N/A	N/A
Diffusion Tube	BCC19	362921	172122	21.3	N/A	N/A
Diffusion Tube	BCC20	359567	173630	61.2	50.1	42.4
Diffusion Tube	BCC21	359035	175306	49.3	46.4	38.3
Diffusion Tube	BCC22	359109	173886	52.5	51	44.3
Diffusion Tube	BCC23	359555	173166	46.7	N/A	N/A
Diffusion Tube	BCC81	361657	175362	18.8	N/A	N/A
Diffusion Tube	BCC99	357099	171627	28.5	N/A	N/A
Diffusion Tube	BCC105	359097	171368	19.1	N/A	N/A
Diffusion Tube	BCC113	359258	172696	49.9	40.5	37.4
Diffusion Tube	BCC125	359214	171917	56	50.3	45.2
Diffusion Tube	BCC147	358514	172691	61.5	56.6	50.9
Diffusion Tube	BCC154	357601	172483	38.5	36.2	30
Diffusion Tube	BCC155	357838	172713	37.9	40.1	31.1
Diffusion Tube	BCC156	357709	173018	39.3	36.2	30.5
Diffusion Tube	BCC157	359119	174090	48.6	45.4	43.1
Diffusion Tube	BCC159	358891	174608	42	43.3	35.8
Diffusion Tube	BCC161	359152	175733	38.8	38	31.7
Diffusion Tube	BCC163	359435	176574	38	36.6	30.8
Diffusion Tube	BCC175	362147	170525	54	54.9	44.6
Diffusion Tube	BCC239	357880	170506	66.8	65.2	54.4
Diffusion Tube	BCC242	357510	170401	56	51.1	41.1
Diffusion Tube	BCC254	357118	172429	52.2	49.4	40.5
Diffusion Tube	BCC260	361140	175366	42.6	43.1	36.2
Diffusion Tube	BCC261	361103	175059	52.4	51	41.5
Diffusion Tube	BCC263	360343	174473	33.5	N/A	N/A
Diffusion Tube	BCC295	359913	174315	65.1	59.6	48.1
Diffusion Tube	BCC300	363365	175883	45.9	41.1	35.1
Diffusion Tube	BCC303	361368	175170	44	43.8	36.5
Diffusion Tube	BCC305	360661	173373	32.9	N/A	N/A
Diffusion Tube	BCC307	360747	175328	32.6	37.3	30.7
Diffusion Tube	BCC311	359677	175057	46.4	N/A	N/A
Diffusion Tube	BCC312	359832	174616	38.5	38.5	32.8
Diffusion Tube	BCC314	357751	174063	38.3	37.7	31.3
Diffusion Tube	BCC320	361180	171567	30.7	27.9	23.5
Diffusion Tube	BCC325	361667	175103	49.2	48.1	39.4

Monitoring Type	ID	X	Y	Monitored Annual Mean NO_2 Concentration (µg/m^3)		
				2017	2018	2019
Diffusion Tube	BCC363	359075	173613	38.5	37.2	34
Diffusion Tube	BCC365	359520	173264	37.6	N/A	N/A
Diffusion Tube	BCC370	359775	173513	37.5	36.6	30.1
Diffusion Tube	BCC371	359813	173373	44.7	42.2	34.1
Diffusion Tube	BCC373	359747	173774	38.5	35.7	31.2
Diffusion Tube	BCC374	359509	173595	45.2	47.8	39.9
Diffusion Tube	BCC396	352593	177673	32.7	N/A	N/A
Diffusion Tube	BCC397	352578	177637	33.4	N/A	N/A
Diffusion Tube	BCC398	352501	177698	31.2	N/A	N/A
Diffusion Tube	BCC403	360508	171676	35.7	35.6	28.1
Diffusion Tube	BCC405	361051	173743	50.4	56.2	48.5
Diffusion Tube	BCC406	361576	173806	38.9	38.5	31
Diffusion Tube	BCC407	359829	174370	44.6	46.7	37.3
Diffusion Tube	BCC413	360043	171508	38.7	37.6	31.2
Diffusion Tube	BCC417	359635	171413	35.2	36	31
Diffusion Tube	BCC418	357737	170642	58.4	55.7	51.1
Diffusion Tube	BCC419	357832	170686	51.3	45	39.1
Diffusion Tube	BCC420	358277	171562	33.3	37.1	30.4
Diffusion Tube	BCC422	358168	171525	36.5	34.1	27.4
Diffusion Tube	BCC423	358623	173386	45	42.3	35.2
Diffusion Tube	BCC426	359517	174153	33.5	N/A	N/A
Diffusion Tube	BCC429	360484	174097	47.8	46.8	41.2
Diffusion Tube	BCC436	361013	173352	45.8	50.6	42
Diffusion Tube	BCC438	360903	170024	43.2	36.6	31.8
Diffusion Tube	BCC439	358042	170582	37.7	37.7	31.7
Diffusion Tube	BCC455	359487	173924	26	24.4	20.9
Diffusion Tube	BCC461	360381	174405	30.4	33.9	26
Diffusion Tube	BCC462	360385	174381	34.6	N/A	N/A
Diffusion Tube	BCC464	362927	175592	36.8	34.4	29.7
Diffusion Tube	BCC466	357466	171622	33.4	33.2	27.4
Diffusion Tube	BCC467	357568	171537	30.7	N/A	N/A
Diffusion Tube	BCC469	359479	171114	34.6	36.2	27.4
Diffusion Tube	BCC470	359213	170997	35.9	37.9	29.4
Diffusion Tube	BCC472	358226	171284	41.6	37.3	33.7
Diffusion Tube	BCC473	358105	171124	40.1	44	42.4
Diffusion Tube	BCC474	357991	170979	35.8	31.9	29.1
Diffusion Tube	BCC478	362091	170447	35.4	36.5	28.8
Diffusion Tube	BCC479	361917	170442	30.1	N/A	N/A
Diffusion Tube	BCC482	352450	177760	33.9	N/A	N/A
Diffusion Tube	BCC483	352484	177735	36.3	N/A	N/A
Diffusion Tube	BCC485	352654	177602	34	N/A	N/A
Diffusion Tube	BCC486	352785	177858	39.2	N/A	N/A
Diffusion Tube	BCC487	360243	174327	44.5	41.9	35.1
Diffusion Tube	BCC488	360205	174291	39.8	N/A	N/A
Diffusion Tube	BCC489	352634	177629	37.7	35.5	28.6
Diffusion Tube	BCC490	352683	177670	31	26.8	22.4
Diffusion Tube	BCC491	352722	177525	34.4	33.5	27.3
Diffusion Tube	BCC492	359445	176627	36.8	34.8	31.3
Diffusion Tube	BCC493	359677	176758	41.9	41.8	37
Diffusion Tube	BCC494	359558	176850	39.5	38.7	32
Diffusion Tube	BCC495	359353	177340	24.8	N/A	N/A
Diffusion Tube	BCC496	362296	173620	41.1	39.2	33.1
Diffusion Tube	BCC497	359268	174132	42.4	38	29.1
Diffusion Tube	BCC499	359522	173381	38.5	43.2	33.6
Diffusion Tube	BCC502	358640	173090	N/A	N/A	68.7
Diffusion Tube	BCC503	354977	176406	N/A	19.1	N/A
Diffusion Tube	BCC504	352204	177585	N/A	26.7	N/A
Diffusion Tube	BCC505	356352	179109	N/A	22	N/A
Diffusion Tube	BCC506	356387	178813	N/A	14.9	N/A
Diffusion Tube	BCC507	356744	178916	N/A	22	N/A
Diffusion Tube	BCC508	359881	177941	N/A	23.2	N/A
Diffusion Tube	BCC509	360050	176983	N/A	26.3	N/A
Diffusion Tube	BCC510	359556	176239	N/A	22.2	N/A

Monitoring Type	ID	X	Y	Monitored Annual Mean NO_2 Concentration (µg/m^3)		
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Diffusion Tube	BCC511	359717	175191	N/A	27	N/A
Diffusion Tube	BCC512	359026	174432	N/A	47.6	40.6
Diffusion Tube	BCC513	359674	173915	N/A	24.3	N/A
Diffusion Tube	BCC514	359707	174422	N/A	23.4	N/A
Diffusion Tube	BCC515	360333	174871	N/A	33.7	27.9
Diffusion Tube	BCC516	360411	175336	N/A	20.2	N/A
Diffusion Tube	BCC517	360922	175640	N/A	20.3	N/A
Diffusion Tube	BCC518	362989	175722	N/A	24.8	N/A
Diffusion Tube	BCC519	363854	175554	N/A	17.8	N/A
Diffusion Tube	BCC520	363517	175084	N/A	20.9	N/A
Diffusion Tube	BCC521	363251	175200	N/A	25.9	N/A
Diffusion Tube	BCC522	361362	174945	N/A	24.1	N/A
Diffusion Tube	BCC523	360764	174069	N/A	25.4	N/A
Diffusion Tube	BCC524	360990	173569	N/A	31.7	N/A
Diffusion Tube	BCC525	362455	173687	N/A	43.5	35.3
Diffusion Tube	BCC526	362436	173751	N/A	28	N/A
Diffusion Tube	BCC527	361732	173291	N/A	29.9	N/A
Diffusion Tube	BCC528	361564	173363	N/A	29.7	N/A
Diffusion Tube	BCC529	361132	173030	N/A	31.6	N/A
Diffusion Tube	BCC530	360838	172869	N/A	29.7	N/A
Diffusion Tube	BCC531	360345	173688	N/A	27.7	N/A
Diffusion Tube	BCC532	360025	173521	N/A	32.6	N/A
Diffusion Tube	BCC533	359814	172913	N/A	31	N/A
Diffusion Tube	BCC534	360412	171327	N/A	18.8	N/A
Diffusion Tube	BCC535	361532	170073	N/A	20.4	N/A
Diffusion Tube	BCC536	359291	172012	N/A	32.6	N/A
Diffusion Tube	BCC537	359145	171623	N/A	27.8	N/A
Diffusion Tube	BCC538	358681	171478	N/A	33.7	26.6
Diffusion Tube	BCC539	358599	171391	N/A	43.3	35.6
Diffusion Tube	BCC540	358017	171192	N/A	24.6	N/A
Diffusion Tube	BCC541	358437	171762	N/A	27.5	N/A
Diffusion Tube	BCC542	358078	171774	N/A	22.6	N/A
Diffusion Tube	BCC543	357791	171501	N/A	20.8	N/A
Diffusion Tube	BCC544	357345	171727	N/A	28.3	N/A
Diffusion Tube	BCC545	356379	171436	N/A	34.9	28.6
Diffusion Tube	BCC546	356927	172605	N/A	22.5	N/A
Diffusion Tube	BCC547	357979	172661	N/A	18.9	N/A
Diffusion Tube	BCC548	358473	173201	N/A	29.9	N/A
Diffusion Tube	BCC550	358353	172613	N/A	36.9	35.1
Diffusion Tube	BCC551	358981	178173	N/A	27.9	N/A
Diffusion Tube	BCC554	358812	173217	N/A	43.8	N/A
Diffusion Tube	BCC555	356679	172589	N/A	N/A	32.1
Diffusion Tube	BCC556	356827	172303	N/A	N/A	37
Diffusion Tube	BCC557	361171	170685	N/A	N/A	25.2
Diffusion Tube	BCC558	357294	171926	N/A	N/A	27.8
Diffusion Tube	BCC559	356485	171580	N/A	N/A	29
Diffusion Tube	BCC560	358665	173439	N/A	N/A	40.4
Diffusion Tube	BCC561	358688	173431	N/A	N/A	47
Diffusion Tube	BCC562	356960	168194	N/A	N/A	37.3
Diffusion Tube	BCC563	356606	168316	N/A	N/A	24.6
Diffusion Tube	BCC564	357173	177453	N/A	N/A	24.3
Diffusion Tube	BCC565	357227	179101	N/A	N/A	31.4
Diffusion Tube	BCC567	360728	175345	N/A	N/A	44
Diffusion Tube	BCC568	360178	175779	N/A	N/A	36.3
Diffusion Tube	BCC569	359855	176186	N/A	N/A	31.4
Diffusion Tube	BCC570	359847	176439	N/A	N/A	33.1
Diffusion Tube	BCC571	359848	176411	N/A	N/A	42.8

GBATS4M Model Update

METROWEST Highway Model Local Model Validation Report

Prepared for

West of England Authorities

08 October 2015

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Document History

GBATS4M Model Update

METROWEST Highway Model LMVR

West of England Authorities

This document has been issued and amended as follows:

Version	Date	Description	Created by	Verified by	Approved by
1.0	17.10.2014	Initial Draft Report	Pete Knightbridge		
1.1	14.4.2015	Draft Report	Pete Knightbridge	Katherine Williams	Chris Bushell
1.2	08.10.2015	Final Report	Pete Knightbridge	Katherine Williams	Chris Bushell

Contents

Section **Page**

Figures

Tables

SECTION 1
Introduction

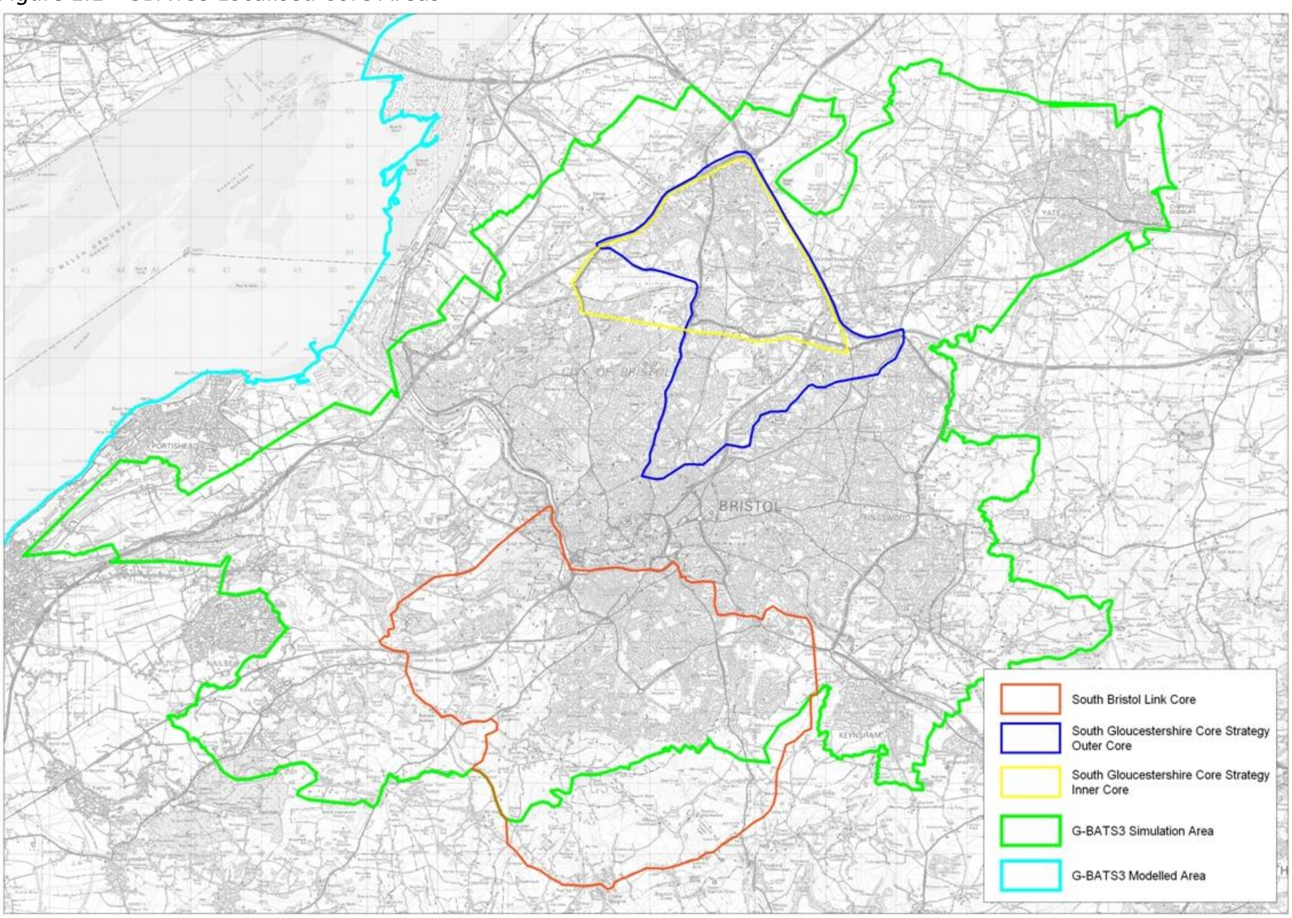
1.1 Background

This report has been prepared by CH2M Hill as part of their commission to update the Greater Bristol Area Transport Study (GBATS) modelling suite for Bristol City Council (BCC), on behalf of the West of England authorities.

The updated GBATS model has been specified to be suitable for assessing the MetroWest major scheme Phases 1 and 2. The Bristol Area Traffic Study (BATS) model was originally built and validated to a base year of 2001. Since then it has been updated to BATS2 as a part of the Greater Bristol Bus Network study in 2004 and further updated to the GBATS3 strategic model with a base year of 2006. The GBATS3 model was used as the starting point for four localised studies. In each case the model was updated, recalibrated and revalidated with the local study area core as its focus. Figure 1.1 shows the core areas of the localised models. The four studies are below:

- Ashton Vale to Temple Meads Rapid Transit (AVTM, 2006 Base year, 580 active zones);
- Northern Fringe to Hengrove Package (NFHP, 2009, 584);
- South Bristol Link (SBL, 2009 & 2012, 616); and
- South Gloucestershire Core Strategy (SGCS, 2011, 591).

Figure 1.1 - GBATS3 Localised Core Areas



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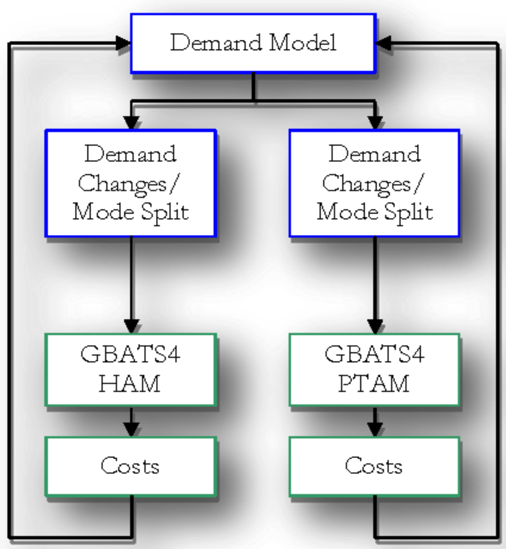
The updated model is called the GBATS4 Metro Model (GBATS4M). The GBATS4M model consists of:

- A Highway Assignment Model representing vehicle based movements across the Greater Bristol area for a 2013 autumn weekday morning peak hour (08:00-09:00), an average inter-peak hour (10:00-16:00) and an evening peak hour (17:00-18:00);
- A Public Transport (PT) Assignment Model representing bus and rail based movements across the same area and time periods; and
- A five-stage multi-modal incremental Variable Demand Model (VDM) that forecasts changes in trip frequency and choice of main mode, time period of travel, destination, and sub-mode choice, in response to changes in generalised costs across the 12-hour period (07:00 – 19:00).

The GBATS4M highway model is closely integrated with the GBATS4M PT model. The two models use different software packages (SATURN and EMME, respectively) but are identical in terms of road network structure, and zone system. The bus routes and frequencies in the PT model are used in the highway model.

The GBATS4M highway model is fully integrated within the GBATS4M VDM. The GBATS4M highway model provides highway transport costs to the GBATS4M VDM which, in turn, provides trip matrices for the GBATS4M highway model. The relationship between the elements of the modelling system is shown in Figure 1.2.

Figure 1.2 - GBATS4M Modelling Suite



1.2 Report Structure

This model development report consists of the following sections, after the Introduction:

- Section 2 – Model Usage and Design Considerations;
- Section 3 – Model Standards, Criteria and Acceptability Guidelines;
- Section 4 – Key Features of the model;
- Section 5 – Survey Data;
- Section 6 – Network Development;
- Section 7 – Trip Matrix Development;
- Section 8 – Network Calibration and Validation;
- Section 9 – Trip Matrix Calibration and Validation;
- Section 10 – Assignment Calibration and Validation and
- Section 11 – Conclusion

SECTION 2

Model Usage and Design Considerations

2.1 MetroWest

The GBATS4M modelling suite provides a tool with which to test the ability of future transport proposals to support forecast travel demand. At a general level this includes:

- Investigation of new development proposals; and
- Longer-term strategic planning of the transport network.

The specific purpose of the model is for assessing the MetroWest major scheme Phases 1 and 2. Figure 2.1 shows a schematic of the MetroWest scheme. The primary focus of GBATS4M highway model is the MetroWest scheme corridors.

2.2 Potential Further Uses

The GBATS4M modelling suite could (with further validation if necessary) also be used to forecast and assess a range of alternative potential interventions. While not a definitive list, the following future year schemes could potentially be assessed:

- Bristol Arena
- Temple Circus Roundabout / Redcliffe Way;
- Temple Quarter Enterprise Zone;
- Central Area Action Plan;
- Changes to bus operations;
- Park and Ride schemes;
- North Fringe VISSIM interface;
- Strategic wider area schemes; and
- Major development proposals in the wider urban area.

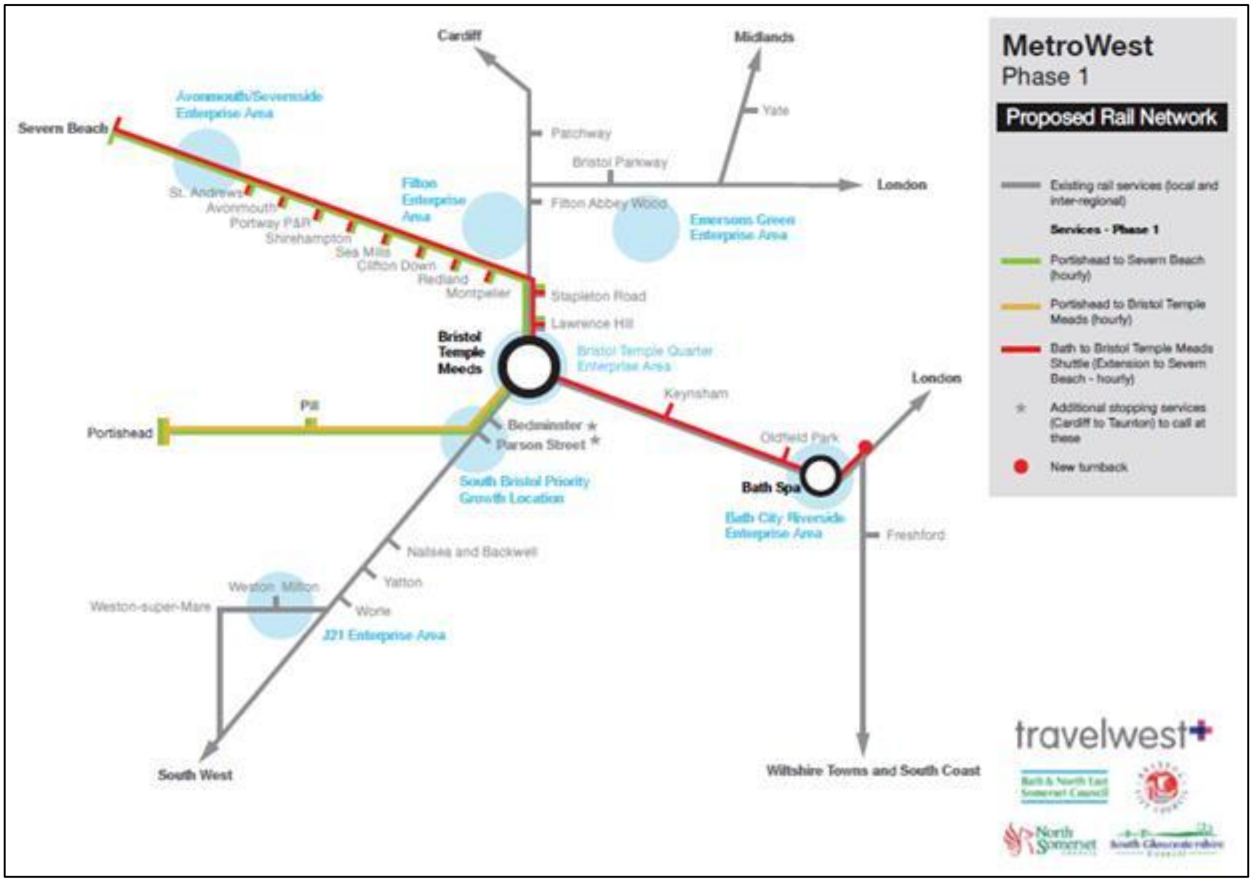
2.3 Model Design Considerations

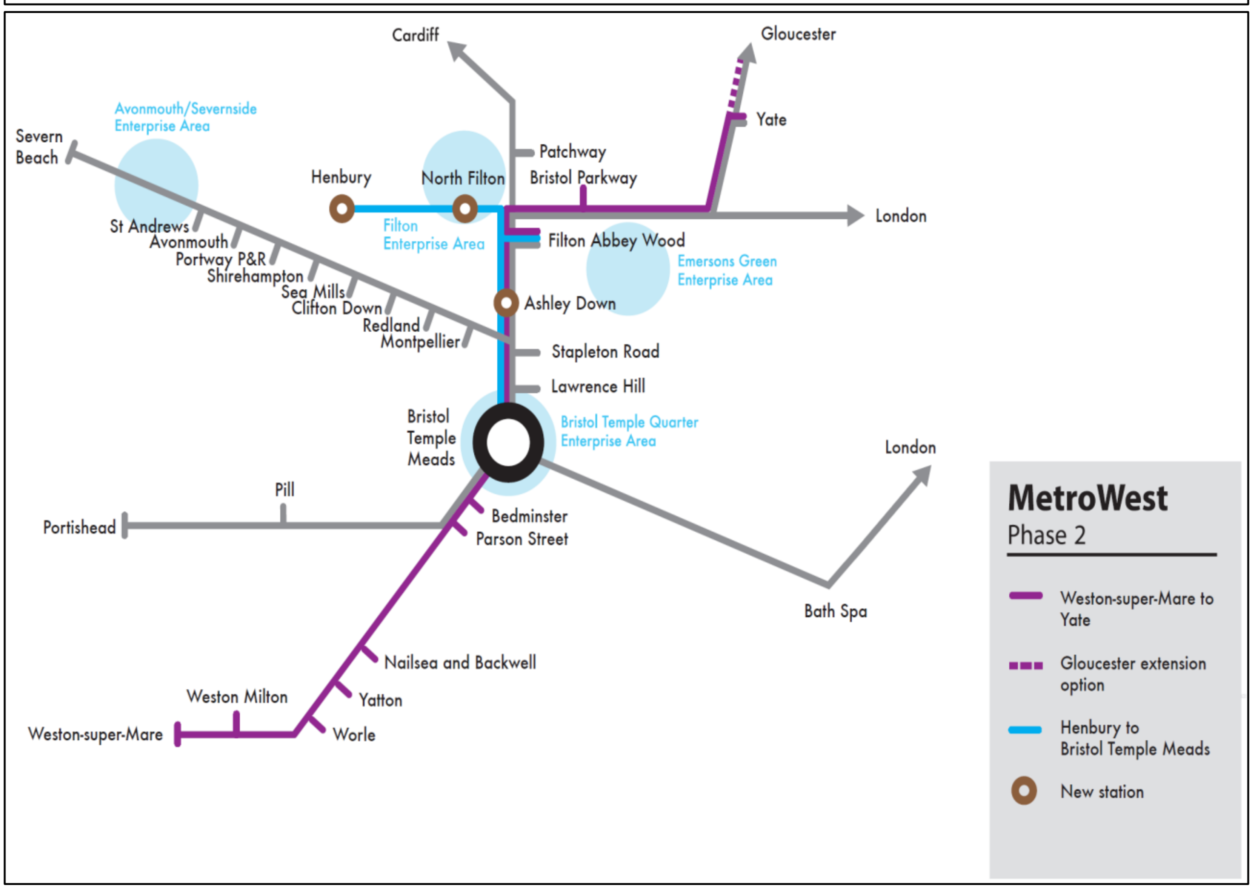
The principal objective of the GBATS4M highway model is to represent travel conditions on the highway network for the appraisal of the MetroWest scheme and should therefore provide:

- changes in the travel cost between the base year and forecast years for input to the GBATS4M VDM;
- changes in traffic flows along the MetroWest corridors for input to the appraisal; and
- changes in wider area travel costs for input to the economic appraisal.

The GBATS4M highway model is a SATURN model updated from the most recent versions of the GBATS3 highway model (South Bristol Link, 2012 and SGCS, 2011). In order to improve the model validation the focus has been to update the trip matrices and network along the routes most likely to be most affected by MetroWest. To facilitate this, a programme of traffic counts and trip pattern surveys were undertaken around Bristol. Where available, reliable existing survey data was also utilised. Details are provided in section 5.

Figure 2.1 - Metro Corridors





SECTION 3

Model Standards, Criteria and Acceptability Guidelines

3.1 Overview

The model has been designed and developed using the UK Department for Transport (DfT) Transport Analysis Guidance (TAG). The current, relevant guidance is DfT TAG UNIT M3.1 Highway Assignment Modelling, January 2014. Referenced throughout this report as: 'TAG M3.1'.

3.2 Validation Criteria and Acceptability Guidelines

Highway model validation acceptability guidelines are specified in TAG M3.1. However, TAG M3.1 states if these guidelines are not meet this does not necessarily mean the model is not 'fit for purpose', or indeed if they are met that the model is automatically deemed so. If these criteria cannot be fully met, the importance of the relevant locations to overall model validation and assessment of proposed schemes should be reviewed to ensure the model is still fit for purpose. Further, TAG M3.1 states if necessary the impact of matrix estimation should be reduced so that they do not become significant, and a lower standard of validation reported.

The validation criteria and acceptability guidelines as specified in TAG M3.1 are shown in Table 3.1 below. The observed flow and screenline flow criteria are applied to "all vehicles" and "cars/LGVs".

Table 3.1 - DMRB Acceptability Guidelines

Criteria and Measure		Acceptability Guideline	
Flow Difference Criteria			
1	Total screenline flows (normally > 5 links) to be within +/- 5%	All (or nearly all) screenlines	
2	Observed (individual) link flow < 700vph	Modelled flow within +/- 100vph	> 85% of links
	Observed (individual) link flow 700 to 2700vph	Modelled flow within +/- 15%	> 85% of links
	Observed (individual) link flow > 2700vph	Modelled flow within +/- 400vph	> 85% of links
GEH Criteria			
3	GEH statistic for individual link flows <5		> 85% of links
Journey Time Validation			
4	Modelled times along routes should be within 15% (or 1 minute, if higher)		> 85% of links

The GEH statistic, included in Table 3.1, is used as an indicator of the extent to which the modelled flows match the corresponding observed flows. This is recommended in the guidelines contained in TAG M3.1 and is defined as:

$$GEH = \sqrt{\frac{(M-C)^2}{0.5(M+C)}}$$

Where:

M = modelled flow; and

C = observed flow.

3.3 Convergence Criteria and Standards

SATURN is specifically designed to model congested networks which contain alternative routes between zones. The software uses algorithms which seek to achieve Wardrop's First Principle of Traffic Equilibrium and provides the following (TAG M3.1) recommended convergence indicators:

- The percentage of links on which flows or costs change by less than a fixed percentage between successive iterations;
- The difference between the costs along the chosen routes and those along the minimum cost routes, summed across the whole network, and expressed as a percentage of the minimum costs, usually known as 'Delta' or the '%GAP'.

To ensure a satisfactory model convergence, TAG M3.1 recommends the criteria shown in Table 3.2.

Table 3.2- TAG M3.1 Convergence Criteria

Criteria and Measure	Type	Acceptable values
Delta and %GAP	Proximity	Less than 0.1% or at least stable with convergence fully documented and all other criteria met
Percentage of links with flow change (P) < 1% or Percentage of links with cost change (P2) < 1%	Stability	Four consecutive iterations greater than 98%

TAG M3.1 (section 3.3.6 and 3.3.7) states the following:
"The percentages of links with small flow or cost changes both provide pragmatic views of the stability of the assignment, rather than the degree of convergence. The measures are necessary but not sufficient indicators of convergence. It is recommended that, in addition to satisfying the true convergence measures described below, assignment model iterations should continue until at least four successive values of 'P' or 'P2' in excess of 98% have been obtained. If this cannot be achieved, especially in a future year assignment, this may be an indication of instability caused by the level of traffic demand being higher than can be absorbed by the network capacity. "

"The Delta statistic or %GAP is a truer measure of convergence. Delta values generally decrease towards a minimum value as the number of iterations increases but will not do so monotonically….Delta should be used as the first choice measure of assignment convergence. "

The terminating criteria for the assignment-simulation iterative procedure used in the model are based on the %GAP criteria, with further checks on the "stability" criteria.

3.4 Trip Matrix Changes

The development of 'prior' matrices, using OD survey data for city centre trips and the use of the source highway models (SBL and SGCS) 'prior' matrices, has been undertaken. TAG M3.1 recommends that the changes brought about by matrix estimation should be carefully monitored by the following means:

- scatter plots of matrix zonal cell values, prior to and post matrix estimation, with regression statistics (slopes, intercepts and R2 values);
- scatter plots of zonal trip ends, prior to and post matrix estimation, with regression statistics (slopes, intercepts and R2 values);

- trip length distributions, prior to and post matrix estimation, with means and standard deviations; and
- sector to sector level matrices, prior to and post matrix estimation, with absolute and percentage changes.

The changes brought about by matrix estimation should not be significant. The criteria by which the significance of the changes brought about by matrix estimation may be judged are given in Table 3.3.

Table 3.3 - TAG M3.1 Significance of Matrix Estimation changes

Criteria and Measure	**Significance Criteria**
Matrix zonal cell levels	Slope within 0.98<Slope<1.02 , Intercept near zero , R^2 in excess of 0.95
Matrix zonal trip ends	Slope within 0.99<Slope<1.01, Intercept near zero , R^2 in excess of 0.98
Trip length distributions	Means within 5% , Standard deviations within 5%
Sector to sector level matrices	Differences within 5%

SECTION 4

Key Features of the Model

4.1 Source Models

The GBATS3 SBL 2012 model was the main source model used as a starting point for the initial parameters and majority network area of GBATS4M highway model. The SGCS 2011 model network and zone structure was used as the primary source for the North Fringe area of GBATS4M highway model by merging the two models.

The source models have been used as a starting point since they have been developed using TAG-compliant processes and successfully supported schemes through statutory processes which have been open to public scrutiny.

4.2 Modelling software

The GBATS4M highway model uses SATURN version 11.2.05 whilst both VDM and PT model use INRO EMME 4.11

4.3 Base Year

The GBATS4M modelling system has a 2013 base year and represents the travel conditions for a typical October weekday.

4.4 Model Network Area

The GBATS4M highway model area retains the same/similar geographical coverage as the GBATS3 source model, i.e. the 'simulation' (detailed) network extends to cover the Bristol urban area, roughly to the boundary of the West of England Partnership (WEP). Outside this area a 'buffer' network and zone system is used to cover the rest of the UK.

The focus of the improvements for the GBATS4M was primarily the corridors most likely to be impacted by MetroWest, the central area and key radial routes. This included a review / update of all bus routes and bus priority measures in the central area and radial routes approaching the centre. The red line in Figure 4.1 shows the area considered to be the central area in this regard. This corresponds to the middle cordon, used for data collection purposes as referred to in section 5.

Figure 4.2 shows the wider model area, including the extents of both the simulation and buffer network.

Figure 4.1 - GBATS4M Highway Model Central Modelled Area

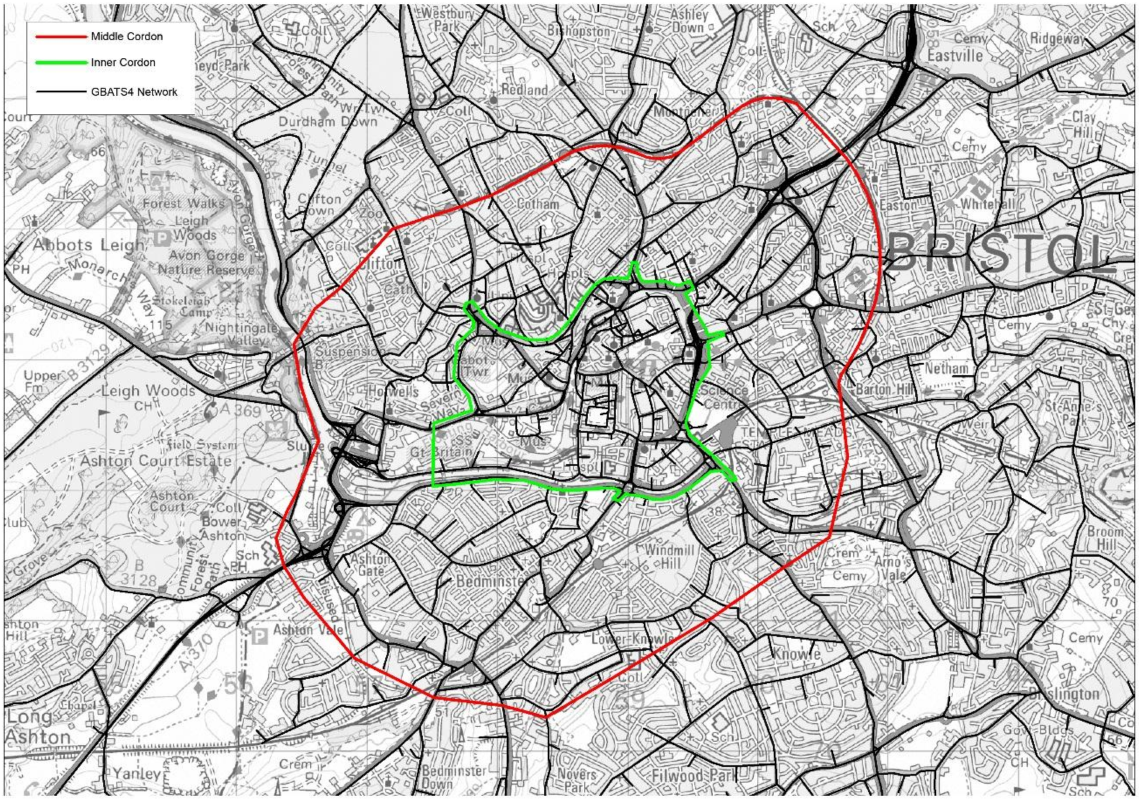
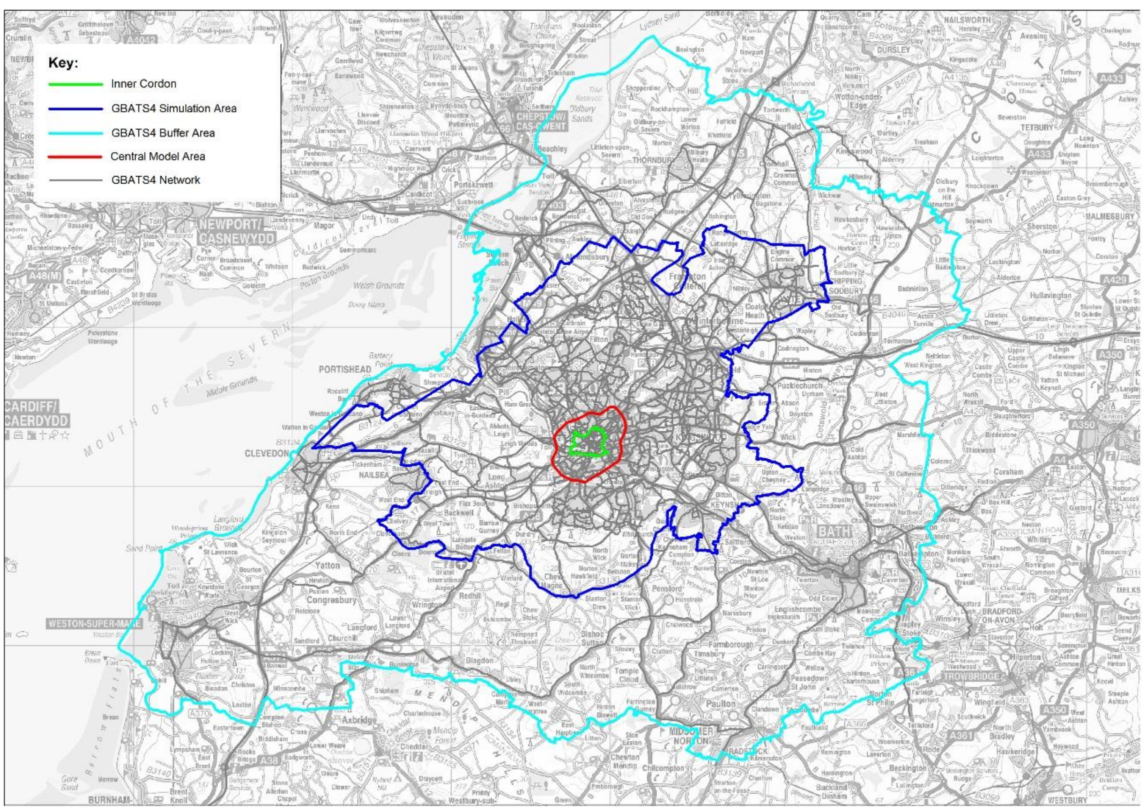


Figure 4.2 - GBATS4M Highway Model Fully Modelled Area



4.5 Time Periods

The GBATS4M highway model is based on trip making patterns on a typical October weekday in 2013. Data relating to other times was normalised to match this date.

Following a review of local traffic count data, the three modelled time periods have been retained from the source model as follows:

- AM peak, representing hourly traffic flow between 08:00 and 09:00;
- Inter peak, representing average hourly traffic flow between 10:00 and 16:00; and
- PM peak, representing hourly traffic flow between 17:00 and 18:00.

4.6 Pre Peak Queuing

For SATURN to adequately represent network performance in congested urban conditions, information on the amount of traffic queuing in the network at the start of the modelled hour is needed. The PASSQ option in SATURN enables this feature and requires information about queuing from the previous hour.

The PASSQ option has been used for the AM and PM peak models and has been derived from factoring the matrix for the relevant peak to represent the previous model hour; 07:00-08:00 for the AM peak and 16:00-17:00 for the PM peak. Initial factors have been developed based on averages of representative counts across the model area. PASSQ flows/queues passed to the peak have been checked to ensure they are not higher than observed flows for the peak hour. The pre-peak counts for both the AM and PM were sufficiently close to the peak hour, that 100% of the peak traffic was used in the pre-peak hours.

4.7 Zoning System

The GBATS4M highway model zone system and network structure exactly matches that of the PT model.

The GBATS4M modelling suite zoning system comprises 650 zones covering the whole of Great Britain. A detailed zoning system was developed to represent the Greater Bristol Urban area and its surroundings. This is shown in Figure 4.3 and 4.4.

Figure 4.3 - GBATS4M Central Model Area Zones

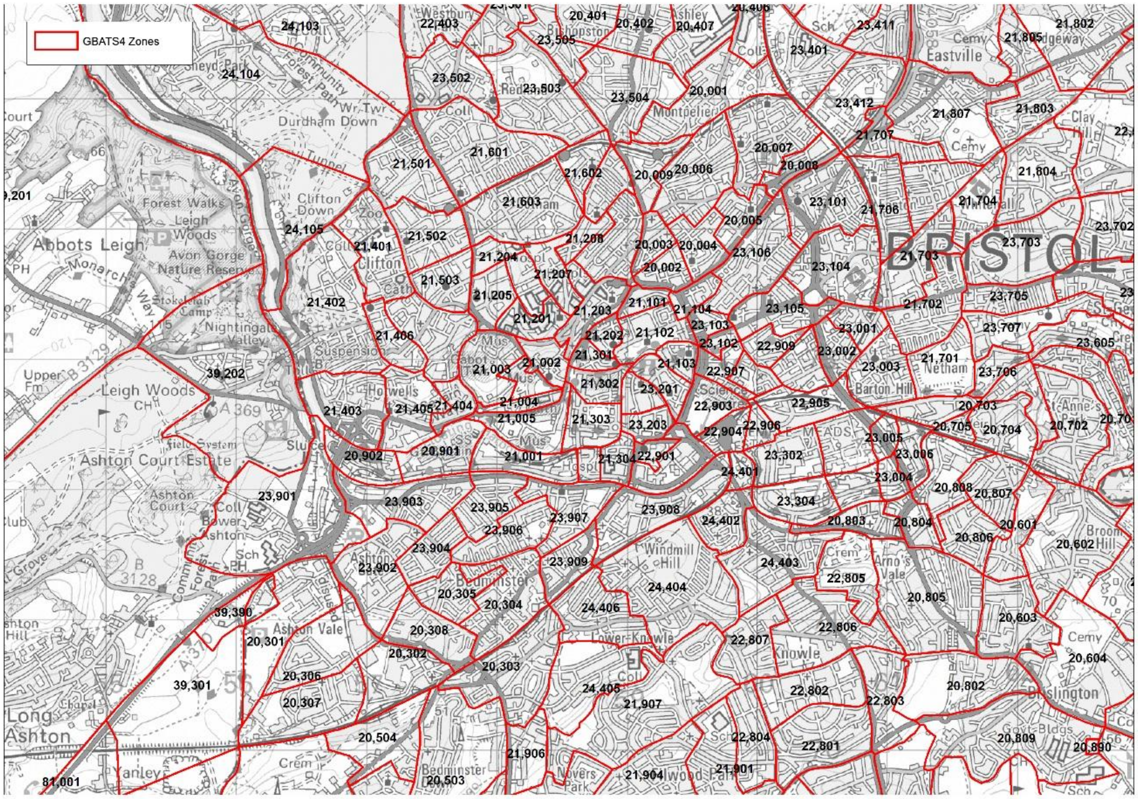
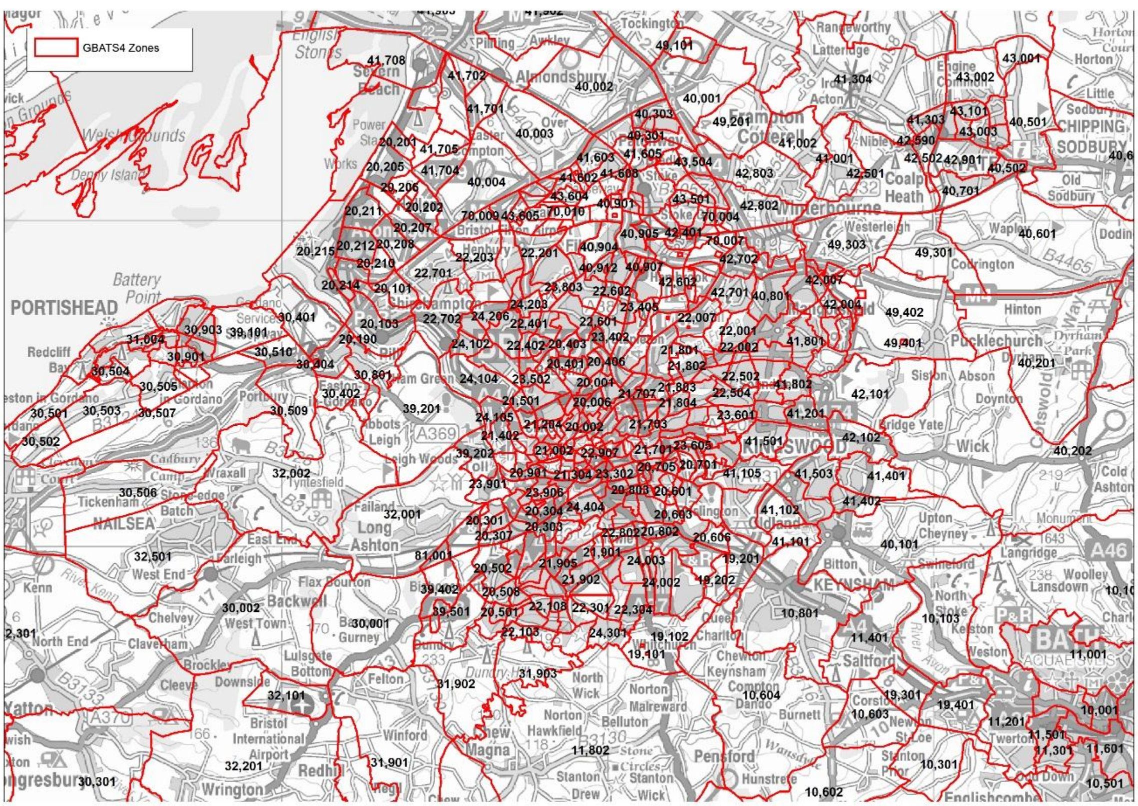


Figure 4.4 - GBATS4M Wider Model Area Zones



4.8 Signal Timings

Signal timings and staging were inherited from the GBATS3 models, thorough checks were undertaken to correct any anomalies along the MetroWest corridors and key junctions, such as the Hambrook interchange, using local knowledge, past experience and traffic flow data.

4.9 User Classes

The development of the GBATS4M highway model matrices initially incorporated two user classes, namely cars / light goods vehicles and heavy goods vehicles. PCU factors for the different classes in GBATS4M highway model are shown in Table 4.1.

Following validation of the two-user class model, the matrices were segmented to six user classes as follows for use in forecasting:

- Car, Non-business (low Income);
- Car, Non-business (medium Income);
- Car, Non-business (high Income);
- Car business;
- Light Goods Vehicles; and
- Heavy Goods Vehicles (HGVs).

TAG M3.1, App D, provides two PCU values for HGVs: 2.5 PCUs for motorways and all-purpose dual carriageways or 2.0 PCUs for all other road types. SATURN only allows for one value to be used within the model. It is assumed that the motorway network around the Bristol conurbation influences the distribution of through trips on the local road network so the higher value has been used throughout.

Table 4.1 - Vehicle to PCU Factors

Type	Car/LGV	HGV	Bus
Equivalent PCUs	1.0	2.5	3.0

4.10 Assignment Methodology

The GBATS4M highway model uses SATURN assignment software. SATURN uses the SATALL module to iterate between successive loops of SATASS module (which assigns the user class matrices to the network in accordance with Wardrop's First Principle of Traffic Equilibrium using the Frank-Wolfe algorithm) and SATSIM module (which takes the flows derived by SATASS and calculates the revised flow/delay relationships at each junction within the simulated area) until the resulting travel times and flows do not change significantly (that is, the process has 'converged').

The process starts with SATASS using the free-flow times (without any delays arising from vehicle interactions at the simulated junctions) from the network building program, SATNET. After the first set of path-builds in SATASS, the resulting flows are passed to SATSIM for the turn-based flow/delay curves representing the detailed interactions at each junction to be updated. These revised flow/delay relationships are passed back to SATASS for the travel time and flows to be recalculated. Further details may be found in the SATURN User Manual.

The choice of convergence algorithm used for the final GBATS4M assignment is detailed in the separate note: "GBATS4M Assignment Methodologies TN1 September 2014".

4.11 Representation of Car Parks

The highway model does not represent car parks explicitly. There is a fine zoning system within the central area, which covers some car parks. The trip matrix is based on ultimate origin or destination zone rather than the zone in which the vehicle is parked. As a result there are no associated car parking charges and parking capacities modelled within the highway model. However, average parking charges are reflected in the VDM, and hence reflected in the GBATS4M mode split and destination choice calculations.

4.12 Generalised Cost and Parameter Values

The generalised cost functions described in TAG M3.1 for trip routeing in the model are applied with parameters derived from TAG A1.3 (May 2014) "*User and provider impacts*" and the WebTAG Databook, May 2014. This relates travel costs to a combination of travel time and the cost per kilometre in terms of vehicle operating and maintenance. The value of time varies by purpose (either working or non-working time), vehicle type and occupancy levels. Similarly, operating and maintenance costs are journey purpose and vehicle dependent and vary by speed.

The speed assumed in the derivation of the generalised cost parameters is the average network speed in the source model.

All monetary values are calculated at 2013 prices.

4.12.1 Values of Time

Perceived values are used throughout. Note that, in the case of HGVs, and cars and LGVs in work time, the perceived and resource values are the same. The process is summarised below:

- equivalent 2013 values were calculated by applying the specified growth in working and non-working values of time, set at 2010 values, (Table A1.3.2 in the Databook) together with the change in prices using the RPI index;
- the relative proportions of Car Non-work for 'Other' and 'Commuting' were calculated from the RSI surveys;
- the equivalent values for vehicles were calculated by applying the occupancies obtained from the 2013 RSI surveys;
- HGV travel was assumed to be in work time with the split between OGV1 and OGV2 recorded from the RSI surveys; and
- The values were converted from £ per hour to p/min.

4.12.2 Vehicle Operating Costs

Vehicle Operating Costs were calculated using TAG A1.3 (May 2014) and defined separately for fuel and non-fuel elements before being combined for the use in the SATURN assignment. Non-fuel costs were only taken into consideration by travellers in work-time.

Fuel Costs

The consumption of fuel, adjusted by the fuel efficiency factors, was multiplied by the cost per litre to provide the cost per km in the model base year (2013), using the formula below from TAG A1.3.

$$L = (a + b.v + c.v^2 + d.v^3) / v$$

Where: L = consumption, expressed in litres per kilometre;
v = average speed in kilometres per hour; and
a, b, c, d are parameters defined for each vehicle category.

Fuel duty was included in the calculations as a perceived cost as businesses are not able to reclaim it. However, VAT was excluded because businesses are able to recover it. For non-work purposes, the perceived cost of the fuel Vehicle Operating Cost was the market price. LGV fuel costs were derived using the same work/non-work proportions used to calculate their average Value of Time.

Non-Fuel Costs

The non-fuel cost element was derived using the formula set out in TAG A1.3 and was a function of average network speed.

$$C = a_1 + b_1/v$$

Where: C = cost in pence per kilometre travelled;
a_1 is a parameter for distance related to costs defined for each vehicle category
b_1 is a parameter for vehicle capital saving defined for each vehicle category (only for work vehicles)
v = average link speed in kilometres per hour;

The cost was calculated using the same average network speeds from the source model and the fuel costs converted from 2010 to 2013 prices. No further adjustments were required as the non-fuel costs were assumed to remain constant, in real terms, over time. As noted above, the non-fuel cost element was only included for work trips.

Assignment Parameters

The resulting assignment parameters are summarised below in Table 4.2.

Table 4.2 - Generalised User Class - Value of Time and Distance

User Class	AM Peak		Inter Peak		PM Peak	
	Time (PPM)	**Distance (PPK)**	**Time (PPM)**	**Distance (PPK)**	**Time (PPM)**	**Distance (PPK)**
Car - Non Business Low Income	9.28	8.28	12.98	8.18	11.75	8.33
Car - Non Business Medium Income	12.95	8.28	16.38	8.18	15.25	8.33
Car - Non Business High Income	18.27	8.28	20.70	8.18	19.90	8.33
Car - Business	49.25	13.22	49.25	13.12	49.25	13.27
LGV	19.27	18.40	19.27	18.29	19.27	18.49
HGV	22.70	37.27	22.70	37.25	22.70	37.36

Note: All values in pence (2013 prices)

SECTION 5

Survey Data

5.1 Overview

The highway model matrix development included the use of new (2013) roadside interview (RSI) and count data. The model calibration and validation was undertaken using two types of survey data, namely traffic counts and journey times.

Traffic counts were required for expanding new RSI data, calibrating trip matrices and validating the model. Journey times were required for calibrating cruise speeds and validating the model.

Traffic count data was provided by local authorities and the Highways Agency (now Highways England) data from the TRADS website. Count data was available in a number of forms including:

- Manual classified counts (MCC);
- Temporary automatic traffic counts (ATC) on non-trunk/motorway roads;
- Permanent ATCs on non-trunk/motorway roads;
- Traffic signals (UTC);
- Junction turning counts; and
- TRADS counts on motorways.

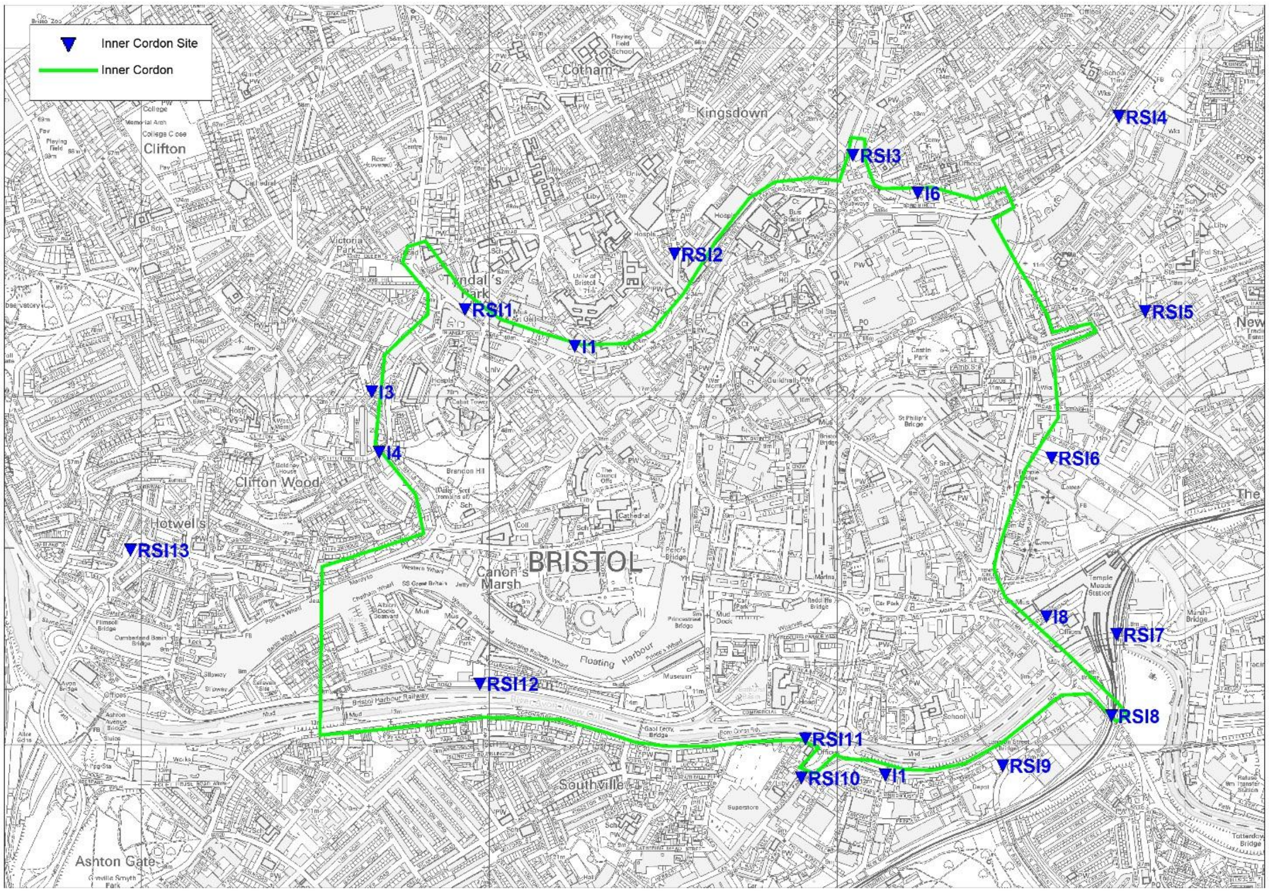
Observed Journey time data was examined using Trafficmaster™ journey time data supplied to the local authorities by the Department for Transport. Trafficmaster™ journey time data uses anonymised data for a large volume of vehicle types (cars, light and heavy vehicles) specially equipped with GPS devices. These devices record speed and location information which is collated, digitally mapped and matched to the Integrated Transport Network (ITN) layer. Any link that has been traversed by a Trafficmaster™ vehicle within each 15 minute time period within the day has a Trafficmaster record™. Separate records are created for each vehicle class.

Further details of surveys are reported in the 'GBATS4 Model Update - Report of Surveys and Existing Data Review'.

5.2 Roadside Interview Sites

A series of RSI surveys, which form the inner cordon of the GBATS4M highway model, were undertaken. They provided accurate origin/destination data for trips entering/exiting the city centre area. Figure 5.1 shows the location of the RSI sites (labelled RSI'n'), which cover the busiest routes across the inner cordon, and other locations. Minor roads were not covered by RSI surveys (labelled as I'n').

Figure 5.1 - City Centre RSI Locations



Sample Size and Logic Checks

The Design Manual for Roads and Bridges (DMRB) Volume 5, Section 1, Part 4, 'Traffic surveys by Roadside Interview'. Annex 8 contains advice on the sample size required to give results to a sufficient level of accuracy. The equation used to calculate the sample size required is as follows:

$$q = \frac{P\,(1-P)\,Q^3}{(E/1.96)^2\,(Q-1) + P\,(1-P)\,Q^2}$$

Where:
q = Sample size
P = Proportion of vehicles with a particular attribute
Q = Total traffic flow
E = Level of accuracy (expressed as a no. of vehicles)

The above equation requires an estimate to be made for the number of trips being made to a particular zone (P). Annex 8 states that "When data is being collected for a large multi-zoned modal, it is impossible to calculate this for every O-D pair for each RSI site as the origins and destinations are not yet known. Once a survey site has been established it is best practice to collect as much data as reasonably practical."

A total of 10007 surveys were conducted/received. Of these 9027 (90%) were flagged by the survey company as being "valid" while 980 were flagged as "invalid". Reasons for survey records being flagged as invalid include round trips, partial completion, complete refusal or illogical movements (where a stated trip origin or destination does not appear to match with the interview point). More detailed checks were then carried out during matrix development to assess whether any of the "invalid" survey records could be utilized and double checking the surveys deemed "valid". After this process 8324 (83%) were seen as "valid" trips to be used for updating the matrix.

The "valid" trips were determined by geocoding each RSI origin and destination record to a zone number based on its Ordinance Survey Grid Reference appended to it. Checks were undertaken to ensure that all characteristics of a trip fell within predefined ranges, such as specified ranges for vehicle type definition, occupancy and trip purpose. Logic checks were also undertaken and to assist in this process the 650 zone system was redefined as 22 sectors.

Full details of the sample rates achieved for each site and vehicle type are shown in the 'GBATS4 Model Update - Report of Surveys and Existing Data Review'.

5.3 Traffic Counts on Cordons and Screenlines

A wide range of traffic counts, forming a number of calibration and validation screenlines and cordons, across the area were conducted. Screenlines and cordons were selected to capture all the major trip movements. The screenlines were designed to be sufficiently long to show the quality of the matrix and the cordons were intended to be suitably 'watertight' and include all main roads in the network that intersect them.

The calibration screenlines were the inner cordon, South, East, North West Inner, River and Railway sections of the city as shown in Figure 5.2.

The validation screenlines were the Outer, Middle and North West Outer and North East cordons as shown in Figure 5.3.

Any data not collected in October 2013 was adjusted using the using factors described in the next section. Tables and figures summarise the count locations as follows:

- Tables 5.1 and 5.2 provide details of the various counts used for calibration and validation.
- Figure 5.2 shows the location of all Calibration traffic count sites.
- Figure 5.3 shows the location of all Validation traffic count sites.

Further details of Highways Agency TRADS count sites (from October 2013), Wider Area and Central area sites can be found in **Appendix A**.

Table 5.1 - Calibration Traffic Count Data

	Ref No.	Source	Road	Location	Available Data	Date
Inner Cordon	RSI1	CH2M	A4018 Whiteladies Road	south of Queens Avenue	MCC/ATC	9/10/2013
	I5	CH2M	Woodland Rd	north of Park Row	ATC	22/06/2013
	RSI2	CH2M	Horfield Road	south of St Michaels Hill	MCC/ATC	11/10/2013
	RSI3	CH2M	A38 North Road	north of St James Barton roundabout	MCC/ATC	9/10/2013
	I6	CH2M	York Street	north of A4044 Newfoundland St	ATC	19/06/2013
	RSI4	CH2M	A4032 Newfoundland Street	at gyratory signals	MCC/ATC	9/10/2013
	RSI5	CH2M	A420 Old Market Street	east of Old market roundabout	MCC/ATC	9/10/2013
	RSI6	CH2M	Avon Street	east of Temple Way	MCC/ATC	9/10/2013
	I8	CH2M	Station Approach Rd	in/out of Temple Meads	ATC	19/06/2013
	RSI7	CH2M	Feeder Road	north of Bath Bridge roundabout	MCC/ATC	9/10/2013
	RSI8	CH2M	A4 Bath Road	south of Bath Bridge roundabout	MCC/ATC	11/10/2013
	RSI9	CH2M	St Lukes Road	south of railway	MCC/ATC	9/10/2013
	I1_I2	CH2M	Whitehouse Street/Spring Street	south of A370 York Rd	ATC	18/06/2013
	RSI10	CH2M	Bedminster Parade	south of Bedminster Bridge	MCC/ATC	9/10/2013
	RSI11	CH2M	A370 Coronation Road	west of Bedminster Bridge	MCC/ATC	9/10/2013
	RSI12	CH2M	Cumberland Road	west of Bedminster Bridge	MCC/ATC	9/10/2013
	RSI13	CH2M	Hotwell Road	west of Jacobs Well roundabout	MCC/ATC	15/10/2013
	I4	CH2M	Constitution Hill	west of Jacob's Wells Rd	ATC	19/06/2013
	I3	CH2M	Lower Clifton Hill (one way)	west of Jacob's Wells Rd	ATC	19/06/2013
East Screenline	E1	SGC	A4174	east of Bristol Rd	ATC	3/06/2013
	E2	CH2M	Downend Rd	west of Stanbury Av	ATC	6/03/2014
	E3	CH2M	Staplehill Rd	west of Lewington Rd	ATC	19/03/2014
	E4	CH2M	Lodge Hill	west of Cotteral Av	ATC	1/03/2014
	E5	CH2M	Two Mile Hill Rd	west of New Queens Way	ATC	1/03/2014
	E6	CH2M	Nags Head Hill	south of Nicholas Lane	ATC	1/03/2014
	E7	BCC	Crews Hole Road	north of Troopers Hill Road	MCC	29/03/2011
	E9	BCC	Bath Rd	east of Ironmould Lane	ATC	23/07/2012
Noth West InnerScreenline	NWI2	BCC	Shirehampton Rd	south of Kings Weston Rd	ATC_perm, MCC	24/07/2011
	NWI3	CH2M	Henbury Rd	south of Hyland Grove	ATC	1/03/2014
	NWI4	BCC	A4018 Passage Rd	south of Eastover Close	ATC_perm	10/07/2011
	NWI5		Grey Stoke Av	south of Concorde Drive	MCC	15/02/2011
	NWI7	CH2M	Southmead Rd	south of Charis Av	ATC	1/03/2014
	NWI8	BCC	Kellaway Av	south of Abbotts Way	ATC_perm, MCC	23/10/2011
	NWI9		Gloucester Rd	south of Wellington Hill	MCC	21/03/2011
	NWI10	CH2M	Muller Rd	north of Stottbury Rd	ATC	1/03/2014
	NWI11	CH2M	Coldhabour Lane	north of M32	ATC	1/03/2014
	NWI12	SGC	Filton Rd	west of M32	ATC_perm, MCC	30/09/2013
	NWI13	SGC	Hambrook Rd	north of Curtis Lane	ATC	30/09/2013
	NWI14	SGC	Winterbourne Rd	west of Old Gloucester Rd	ATC_perm, MCC	25/02/2013
	NWI15	TRADS	M4	J20-J19	TRADS	2014

	Ref No.	Source	Road	Location	Available Data	Date
South Screenline	S1	CH2M	Bridgewater Rd	north of Winford Grove	ATC	1/03/2014
	S2	BCC	Bishopsworth Rd	btw Wrington Close	ATC_perm	3/02/2012
	S3	CH2M	St Peters Rise	south of Headley Park	ATC	27/03/2014
	S4	CH2M	Hengrove Way	east of Cater Rd	ATC	19/03/2014
	S5	CH2M	Hawkfield Rd	south of Baiscoes Av	ATC	6/03/2014
	S6	CH2M	Whitchurch Lane	south of Hawkfield Way	ATC	19/03/2014
	S7	BCC	Bamfield	north of Oatfields Av	MCC	3/02/2011
	S8	CH2M	Wells Rd	north of Hengrove Lane	ATC	19/03/2014
	S9	CH2M	Bath Rd	south of A4174	ATC	19/03/2014
	S10	CH2M	School Road	south of Allison Rd	ATC	6/03/2014
	S11	BCC	Allison Rd	btw Allison Av	MCC	13/01/2010
River Screenline	R1	TRADS	M5	J18-J19	TRADS	2013
	R3	CH2M	A3029 Brunel Way (N)	south of Bennett Way	MCC	20/06/2013
	R4	BCC	A3029 Brunel Way (S)	north of Jessops underpass	MCC	13/10/2011
	R5	BCC	Princes Street Bridge	south of The Grove	MCC	23/11/2011
	R6	CH2M	Bedminster Bridge	north of Bedminster Parade	MCC	26/06/2013
	R7	CH2M	Redcliffe Way	east of Welsh Back	MCC	26/06/2013
	R8	BCC	Bristol Bridge, Victoria Street	south of Baldwin Street	MCC	24/11/2011
	R9	BCC	Passager Street	north of Temple Back	MCC	04/11/2011
	R10	BCC	Temple Way	north of Temple Back	MCC	04/11/2011
	R11	CH2M	Bath Bridge	south of Temple Gate	MCC	27/06/2013
	R12	CH2M	Avon Street	north of Feeder Road	ATC	19/06/2013
	R13	BCC	Albert Road	north of A4 Bath Road	MCC	25/11/2011
	R15	CH2M	St Phillips Causeway	north of Whitby Road	MCC	25/06/2013
	R16	BCC	Marsh Lane	north of Feeder Road	MCC	17/02/2011
	R17	BCC	Nethan Road	north of Feeder Road	MCC	13/07/2009
	R18	BCC	Feeder Road	north of Whitby Road	MCC	17/11/2011
Railway Screenline	RW1	CH2M	A4176 Portway	south of Roman Way	MCC	20/06/2013
	RW5	CH2M	Clifton Down	west of Pembroke Road	ATC	19/06/2013
	RW22	CH2M	Kingsland Road	south of Day's Rd	ATC	19/06/2013
	RW2	CH2M	Avon Street	east of New Kingsley Road	ATC	9/10/2013
	RW26	CH2M	B3021 St Johns Lane	south of A38 Sheene Road	ATC	18/06/2013
	RW27	BCC	A38 Parsons Street	south of A38 West Street	MCC	20/10/2010
	RW28	BCC	A38 Bedminster Down Road	south of A3029 Winterstoke Road	MCC	17/06/2009
	RW30	CH2M	Whitby Road	south of Feeder Road	ATC	19/06/2013
	RW34	SGC	A4174	north of A4 Keynsham By-Pass	ATC	23/01/2012
	RW35	CH2M	A4175 Keynsham Road	between The Ave and Chandos Rd	ATC	19/06/2013
	RW36	CH2M	Muller Road	Shaldon Rd and Petherbridge Way	ATC	18/06/2013
	RW37	BCC	Lockleaze Road		MCC	23/09/2009
	RW38	CH2M	Bonnington Walk	east of Wordsworth Rd	ATC	19/06/2013
	RW39	SGC	A4174 Station Road	east of Filton Avenue	ATC	30/09/2013
	RW40	SGC	Gipsy Patch Lane	west of Station Road	ATC	30/09/2013
	RW41	SGC	A38 Gloucester Road	south of Stoke Lane	MCC	6/12/2013
	RW42	TRADS	M5	J16-J17	TRADS	2014
	M5J19	CH2M	M5J19	All Movements	FURNESS	1/04/2013

Table 5.2 - Validation Traffic Count Data

	Ref No.	Source	Road	Location	Available Data	Date
Outer Cordon	O1	NS	A38 Bridgewater Road	south of Kings Head Lane	ATC	2013
	O2	NS	A370 Long Ashton Bypass	south of B3128	ATC	2013
	O3	NS	B3128 Ashton Road	east of Long Ashton Rd	ATC	2013
	O4	CH2M	A369 Clanage Road	north of Kennel Lodge Road	ATC	01/03/2014
	O5	NS	B3129 Clifton Suspension Bridge	Leigh Woods	ATC	25/09/2013
	O6	CH2M	A4 Portway	west of Sylvan Way	ATC	19/03/2014
	O7	BCC	B4054 Shirehampton Road	east of Penpole Lane	MCC	28/11/2011
	O8	CH2M	Kings Weston Lane	north of Campbells Farm Drive	ATC	01/03/2014
	O9	CH2M	Hallen Road	north of Marissal Road	ATC	01/03/2014
	O10	SGC	A4018 Cribbs Causeway	west of Hollywood Lane	ATC	27/05/2013
	O11	SGC	Merlin Road	south of Highwood Lane	ATC	30/09/2013
	O12	SGC	Highwood Lane	east of Merlin Road	ATC	04/11/2013
	O13	SGC	A38 Gloucester Rd	north of Bradley Stoke Way	ATC	30/09/2013
	O14	SGC	B4427 Old Gloucester Road	north of Trench Lane	ATC	26/08/2013
	O15	SGC	B4057 Beacon Lane	east of M4	ATC	30/09/2013
	O16	TRADS	M32	M4 - M32 J1	TRADS	October 2013
	O17	SGC	B4058 Bristol Road	east of Old Gloucester Road	ATC	30/09/2013
	O18	SGC	A432 Badminton Road	north of Cuckoo Lane	ATC	30/09/2013
	O19	SGC	Westerleigh Road	south of M4	ATC	30/09/2013
	O20	SGC	Shortwood Road	east of Siston Lane	ATC	30/09/2013
	O21	SGC	A420 London Rd	east of Nashcombe Hill	ATC	26/08/2013
	O22	SGC	A431 Bath Road	east of A4175 Cherry Garden	ATC	30/09/2013
	O23	B&NES	A4 Bath Road	east of Keynsham By-Pass	ATC	2013
	O24	B&NES	B3116 Wellsway	south of Courtenay Rd	ATC	2013
	O25	B&NES	A37 Bristol Road	south of Norton Lane, Whitchurch	ATC	2013
	O26	CH2M	Queens Rd	south of Bearbridge Road	ATC	05/03/2014
Middle cordon	M2	CH2M	A4176 Portway	south of Bridge Valley Road	ATC	18/06/2013
	M4	BCC	College Road	south of Clifton Down	MCC	20/06/2011
	M5	CH2M	Pembroke Road	south of Clifton Down	MCC	19/06/2013
	M7	BCC	Whiteladies Road	north of Cotham Hill	MCC	17/06/2011
	M8	BCC	Hampton Road	north of Waverley Road	MCC	17/06/2011
	M9	BCC	Redland Grove	south of South Road	MCC	17/06/2011
	M10	BCC	Redland Road	south of Zetland Road	MCC	23/06/2011
	M11	CH2M	A38 Cheltenham Road	north of Cotham Brow	ATC	18/06/2013
	M12	CH2M	North Road	north of Cheltenham Rd	ATC	14/03/2014
	RW14	BCC	Ashley Hill	south of Hurlington Road	MCC	27/06/2011
	MM12	BCC	Glenfrome Road	Railway Line	MCC	27/06/2011
	M13	BCC	M32	north of Jct 3	MCC	21/06/2011
	M14	BCC	Stapleton Road	south of Berwick Road	MCC	14/06/2011
	M15	BCC	Easton Road	west of Whitehall Road	MCC	16/06/2011
	M16	CH2M	A420 Lawrence Hill	east of Croydon St	ATC	19/06/2013
	M17	BCC	Ducie Road	North of Morton Street	ATC	11/09/2011
	M18	CH2M	Barrow Road	south of Lincoln St	ATC	19/06/2013
	M19	CH2M	A4320 St Phillips Causeway	south of Day's Rd	ATC	19/06/2013
	M20	BCC	Feeder Road	west of St Phillips Causeway	MCC	24/06/2011
	M21	BCC	Albert Road	west of St Phillips Causeway	MCC	30/06/2011
	M22	BCC	Bath Road	east of Park Street	MCC	13/06/2011
	M23	BCC	Wells Road	south of School Road	MCC	13/06/2011
	MM23	CH2M	Redcatch Road	north of Axbridge Road	MCC	27/06/2013
	M24	CH2M	Wedmore Vale	north of Glynn Vale	ATC	18/06/2013
	M25	BCC	Novers Hill	South of Parson Street	MCC	16/02/2010
	M26	CH2M	A4174 Hartcliffe Way	south of Parson St	ATC	18/06/2013
	M27	CH2M	A38 Bedminster Down Road	north of Bishopsworth Rd	ATC	18/06/2013
	M28	CH2M	South Liberty Lane	west of Nelson St	ATC	18/06/2013
	M29	CH2M	Ashton Drive	near rail bridge	ATC	18/06/2013
	M30	CH2M	A370 Ashton Road	east of B3128 merge	ATC	18/06/2013
NorthWest Outer	NWO1	TRADS	M5	J17-18a	TRADS	2012
	NWO2	SGC	A4018 Cribbs Causeway	s/o The Laurels	ATC	3/06/2013
	NWO4	SGC	Gloucester Rd North	south of Filton Avenue	ATC-perm	30/09/2013
	NWO5	SGC	Great Stoke Way	north of Filton Rd	ATC-perm	30/09/2013
	NWO6	TRADS	M32	M32 J1 Within	TRADS	October 2013
	NWO7	CH2M	Bristol Rd	north of A4174	ATC	06/03/2014
Northeast Screenline	NE1	CH2M	Frenchay park Rd	east of Ham Lane	ATC	01/03/2014
	NE2	BCC	Blackberry Hill	east of Small Lane	MCC	15/03/2011
	NE3	BCC	Fishponds Road	west of Alcove Rd	MCC	19/01/2011
	NE4	BCC	Berkley Rd	south of Lodge Causeway	ATC	16/10/2011
	NE5	CH2M	Charlton Road	south of King Johns Rd	ATC	01/03/2014
	NE6	CH2M	Lodge Rd	south of Britton Gardens	ATC	01/03/2014
	NE7	CH2M	Downend Rd	north of Cross St	ATC	01/03/2014
	NE8	CH2M	Syston Way	west of Northend Rd	ATC	06/03/2014
	NE9	CH2M	Lees Hill	south of High View Road	ATC	06/03/2014
	NE10	CH2M	Pound Rd	south of High View Road	ATC	06/03/2014
	NE12	SGC	Station Rd	south of Chiphouse Rd	ATC Temp	01/03/2014

Figure 5.2- Calibration Traffic Count Sites

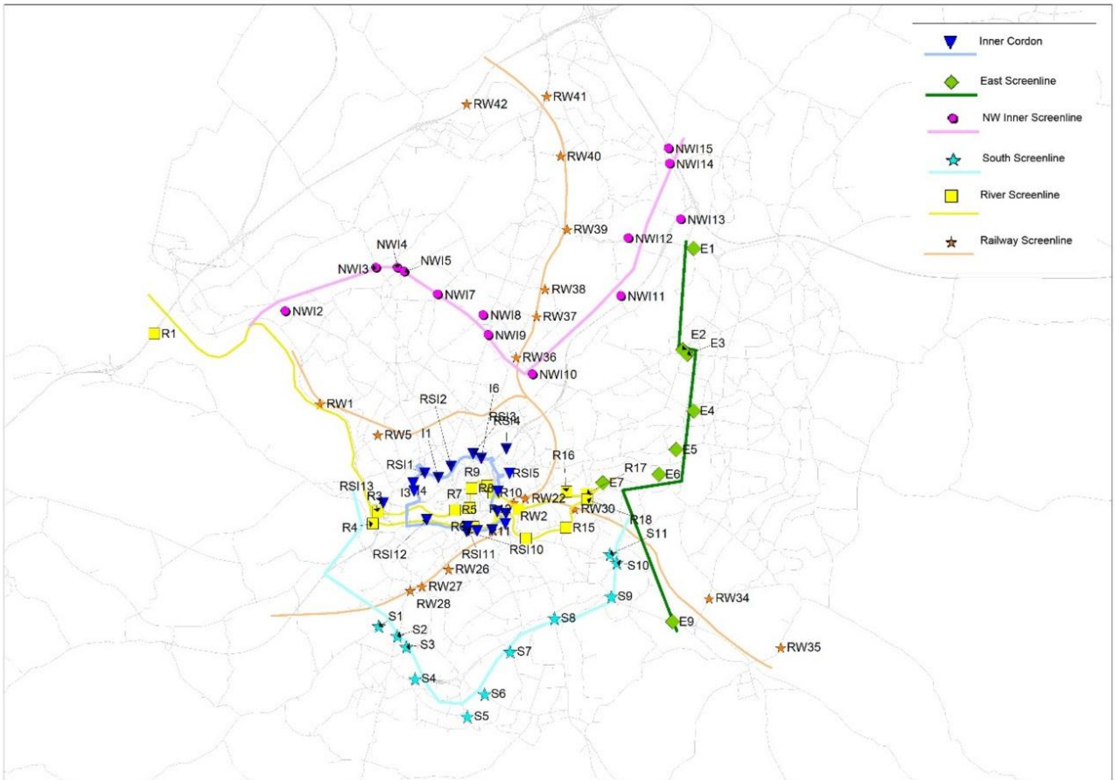
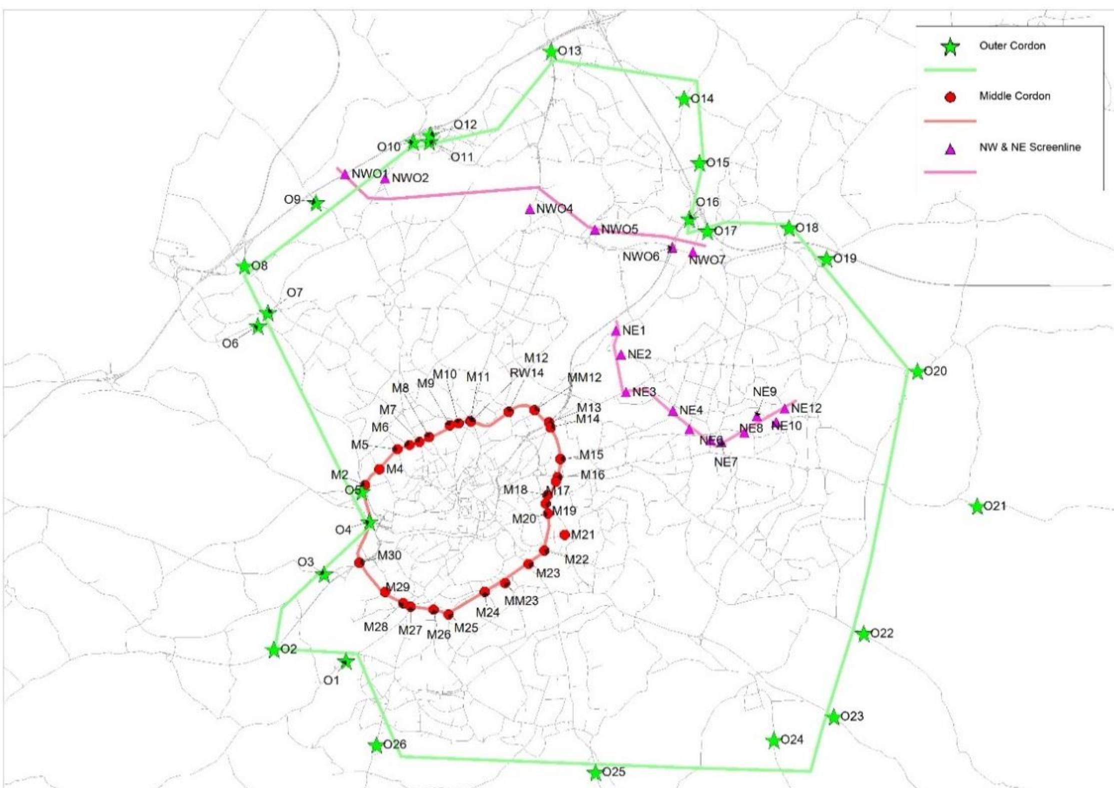


Figure 5.3- Validation Traffic Count Sites



5.4 Data Processing

The model represents a typical weekday in October 2013. The traffic data used in the model was collected over a range of different sources (see Tables 5.1 and 5.2). Therefore, factors were needed to account for monthly variations, as shown in Table 5.3.

Table 5.3 – Monthly Traffic Flow Factors

Site	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
883	Temple Way Underpass	11391	11410	11613	11946	11990	12124	12125	11947	11681	11342	11091	11171
886	Brunel Way	12055	12605	12395	12390	12570	12397	12363	12192	12410	12396	12336	12234
20702071	A4320 Easton Way	16105	16931	17082	16996	16776	16617	16850	16064	17002	17501	17417	17144
32033204	A4174 Avon Ring Road	11214	11676	12029	12464	12960	12998	14936	14738	14757	14497	13704	12066
40000044	A4018 Queen's Road	12930	16293	17393	18226	18311	18153	17877	17505	17769	17882	17430	16671
50000002	A4174 Callington Road	7271	7505	7908	7105	7229	7299	7333	7484	7090	7031	7128	7205
80000179	A4018 Park Street	4966	5180	5286	5358	5352	5333	5312	5111	5302	5377	5252	5296
80000200	A4320 St Philips C'way	8356	7395	8874	8517	8539	8513	8732	8493	8854	9148	8746	8685
80000330	A4 Anchor Road	6322	6678	6796	6731	6743	6672	6709	6766	6667	6679	6765	6722
80000403	A4162 Sylvan Way	4696	4927	5717	5923	5917	5805	5765	5490	5752	5841	5935	5827
80003010	Kings Weston Ln	2023	2144	2216	2303	2303	2313	2240	2244	2298	2270	2234	2132
Total		97330	102744	107310	107961	108690	108225	110243	108034	109580	109964	108037	105153
Factor		**1.13**	**1.07**	**1.02**	**1.02**	**1.01**	**1.02**	**1.00**	**1.02**	**1.00**	**1.00**	**1.02**	**1.05**

Local annual data collected (located in South Gloucestershire, as BCC data was not available) suggested that growth was relatively flat between 2009 (generally the oldest available data) and 2013, as shown in Table 5.4. Therefore no annual adjustment factors were applied.

Table 5.4 - Annual Traffic Flow Factors

Year	South Glos Counts	Index	% Change from 2013
2009	289240	132	0.990
2010	288658	131	0.991
2011	288055	131	0.992
2012	286865	131	0.996
2013	285479	130	1.000

5.5 Journey Time Surveys

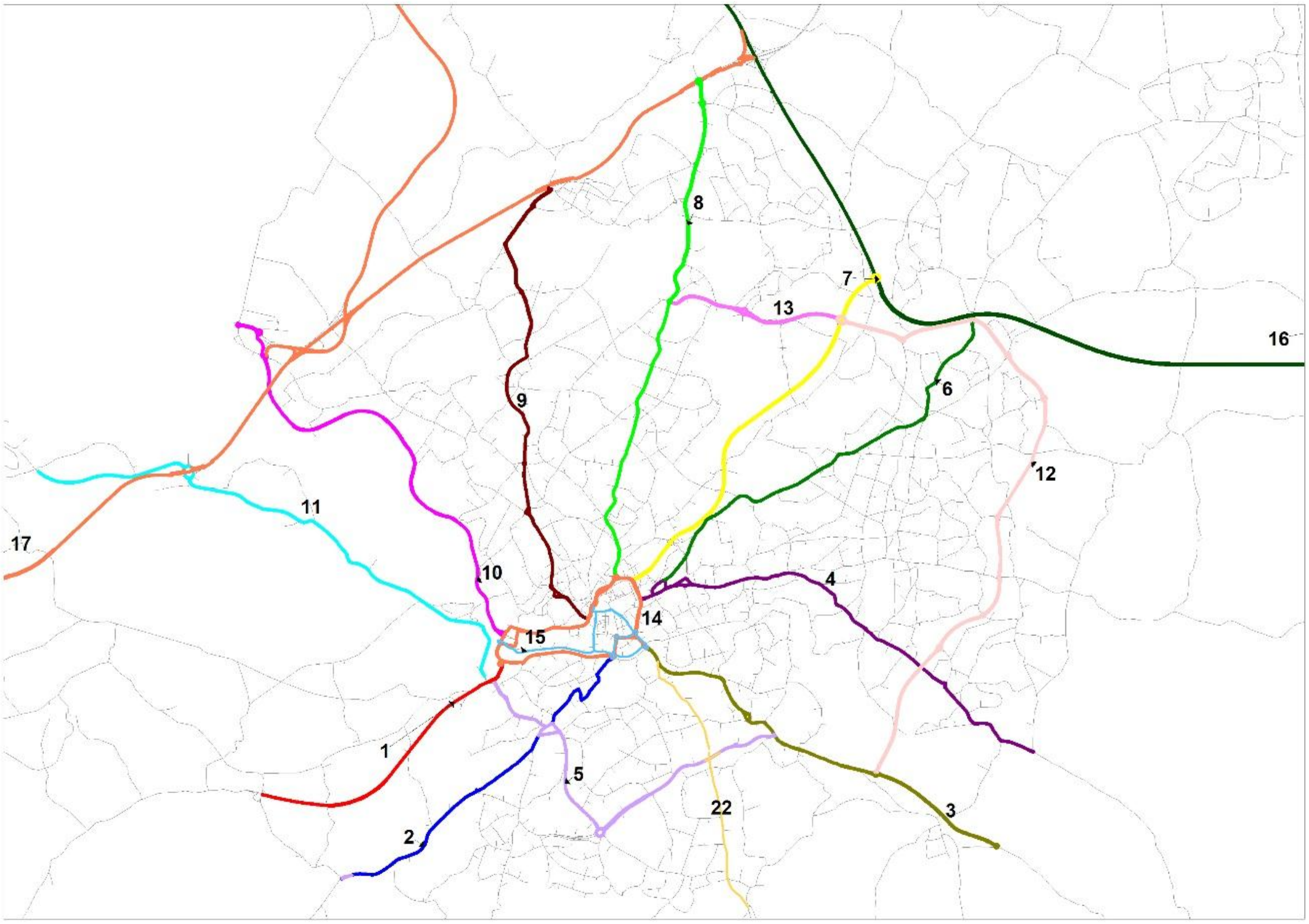
Observed Journey time data was examined using Trafficmaster™ journey time data supplied to the local authorities by the Department for Transport. TAG M3.1 recommends that *"journey time routes should cover as wide a range of route types as possible and cover the Fully Modelled Area as evenly as possible. For models developed for the appraisal of specific interventions, routes should include those from which it is expected traffic will be affected by the scheme, as well as covering the scheme itself as appropriate."*

TAG M3.1 underlines the importance of setting accurate cruise speeds. Although not a specific TAG requirement, Trafficmaster™ journey time data was used to check model cruise times. The cruise speed by link type was estimated by calculating the between-junction link speed on all links during the 7am to 7pm period. During this period, the highest average speed (in 15 minute intervals) recorded for each link was considered to be a reasonable approximation of link cruise time; which in the highway model is the link journey time, excluding junction delay.

The journey time routes are shown in Figure 5.4.

The journey time data used represents mean values from all weekdays in October 2013, filtered to exclude school holidays. During this time period the main road through Barrow Gurney was shut due to repairs to a water main. This had a substantial impact on travel times through both routes 1 and 2. Therefore May 2013 data was used as an alternative for these routes during the morning and evening peaks.

Figure 5.4 - GBATS4M Highway Model Journey Time Survey Routes



5.6 Accuracy of Journey Time Surveys

Table 5.5 summarises the number of runs undertaken for each route by time period, and the resulting standard deviation and accuracy. The accuracy values are a measure of the variability of the journey time surveys and were calculated following the advice given in DMRB guidance (Volume 13, Section 1, Part 5, Chapter 11 'Economic Assessment of Road Schemes').

$$m = \frac{\sum X_i}{n} \qquad s = \sqrt{\frac{\sum (X_i - m)^2}{n-1}} \qquad a = t.\frac{s}{m.\sqrt{n}}$$

Where :
n = the number of observations of journey time
m = the estimate of true mean journey time
s = the estimate of the standard deviation of true mean journey time
t = t-distribution, which depends on (n-1) number of degrees of freedom, and the confidence level (95%)
a = accuracy

The guidance recommends that, as a general rule, it should be realistic to aim for an accuracy of ±10% in the estimate of observed journey time on the existing route, at the 95% confidence level. On individual links the level of accuracy need not be so great.

For all observed routes, the mean values are shown to meet TAG M3.1 guidelines and standards.

Table 5.5 - Accuracy of Journey Time Data

	Route Description	Mean No. Vehs in Sample (Weighted by Distance)			Standard Deviation			Accuracy (95% Confidence)		
		AM	IP	PM	AM	IP	PM	AM	IP	PM
1	A370 Inbound (Backwell to Ashton Gate)	46	300	18	1.7	1.7	0.5	4.9%	1.8%	2.7%
1	A370 Outbound (Jessop Underpass to Backwell)	27	464	53	1.2	1.8	0.9	5.0%	1.6%	2.4%
2	A38 Inbound (Barrow Gurney to Bedminster Bridge)	44	382	48	1.9	2.2	2.2	3.3%	1.2%	3.4%
2	A38 Outbound (Bedminster Bridge to Barrow Gurney)	39	420	51	1.7	1.4	2.2	4.1%	1.0%	3.8%
3	A4 Inbound (Keynesham to Bath Bridge)	82	673	78	4.4	1.8	2.1	3.1%	0.9%	2.5%
3	A4 Outbound (Bath Bridge to Keynesham)	100	551	70	3.0	0.7	1.9	3.1%	0.4%	2.5%
4	A431 Inbound (Willsbridge to Old Market St)	54	284	44	2.6	0.6	1.6	2.3%	0.3%	2.2%
4	A431 Outbound (Old Market St Jct to Willsbridge)	45	289	48	1.4	0.8	2.0	2.1%	0.4%	2.2%
5	A38 Eastbound (Ashton Gate to Brislington)	92	447	64	4.3	2.2	3.1	3.1%	1.1%	3.0%
5	A38 Westbound (Brislington to Ashton Gate)	72	435	55	3.0	1.8	2.2	3.0%	0.9%	2.7%
6	A432 Inbound (A4174 Badminton Rbt to Old Market St)	48	220	30	3.3	1.7	1.7	2.7%	1.0%	2.7%
6	A432 Outbound (West St to A4174 Badminton Rbt)	28	212	35	2.5	1.6	1.9	3.7%	0.9%	2.5%
7	M32 Inbound (M32 J1 to Cabot Circus)	205	1560	203	2.2	0.7	1.4	2.3%	0.7%	3.0%
7	M32 Outbound (Cabot Circus to M32 J1)	266	1686	222	0.9	0.4	1.0	2.0%	0.5%	2.7%
8	A38 Inbound (M5 J16 to St James Barton Rbt)	70	398	49	3.3	1.8	2.3	2.4%	0.7%	2.2%
8	A38 Outbound (St James Barton Rbt to M5 J16)	57	389	45	2.9	2.5	2.9	2.4%	1.0%	2.5%
9	A4018 Inbound (M5 J17 Cribbs to Clifton Triangle)	75	412	64	3.4	1.5	2.1	2.6%	0.9%	2.3%
9	A4018 Outbound (College Green to M5 J17 Cribbs)	58	417	57	1.6	1.5	1.5	2.3%	0.9%	2.1%
10	A4 Portway Inbound (Avonmouth to Hotwells)	73	475	52	1.7	1.1	1.9	1.9%	0.7%	2.8%
10	A4 Portway Outbound (Hotwells to Avonmouth)	57	452	53	1.0	1.1	0.7	2.1%	0.9%	1.7%
11	A369 Inbound (Portishead to A4 Bristol Gate)	90	459	82	4.2	1.0	1.4	3.6%	0.7%	1.8%
11	A369 Outbound (A4 Bristol Gate to Portishead)	78	497	73	1.2	0.7	1.5	1.6%	0.4%	1.9%
12	A4174 Eastbound (Filton Rbt to A4)	132	990	140	3.7	1.0	3.6	2.3%	0.3%	1.9%
12	A4174 Westbound (A4 to Filton Rbt)	126	898	147	3.8	1.1	3.0	2.1%	0.3%	1.9%
14	City Centre Outer Loop (Clockwise)	63	518	57	3.5	1.6	3.9	2.5%	0.6%	2.5%
14	City Centre Outer Loop (Anti-Clockwise)	67	466	51	3.4	0.7	2.8	2.5%	0.3%	2.5%
15	City Centre Inner Loop (Clockwise)	31	227	33	2.7	1.7	2.6	3.3%	1.1%	3.1%
15	City Centre Inner Loop (Anti-Clockwise)	48	270	34	2.1	1.6	2.4	3.2%	1.4%	4.7%
16	M4 Mainline Eastbound (J22 to J18)	304	1816	300	3.0	0.6	1.6	1.2%	0.1%	0.9%
16	M4 Mainline Westbound (J18 to J22)	264	1901	314	1.9	0.8	1.6	1.1%	0.2%	0.9%
17	M5 Mainline Northbound (J20 to M4)	427	2256	381	0.8	0.7	2.4	0.6%	0.2%	1.4%
17	M5 Mainline Southbound (M4 to J20)	346	2443	352	0.9	0.7	1.5	0.7%	0.2%	1.0%

SECTION 6

Network Development

6.1 Source Networks

As a starting point, the GBATS3 2012 South Bristol Link (SBL) model was the primary source model for the majority of the network area of the GBATS4M highway model. The 2011 SGC Core Strategy Model (CSM) model was used as the primary source for the North Fringe area of the GBATS4M highway model. The two networks were merged and a thorough check of the network was undertaken to ensure that the model coding is representative of the October 2013 Bristol area road network. This included checks as outlined below.

6.2 Link Coding

The network development process involved checking and adjusting the highway network principally along the journey time routes, and other routes where necessary to calibrate the model.

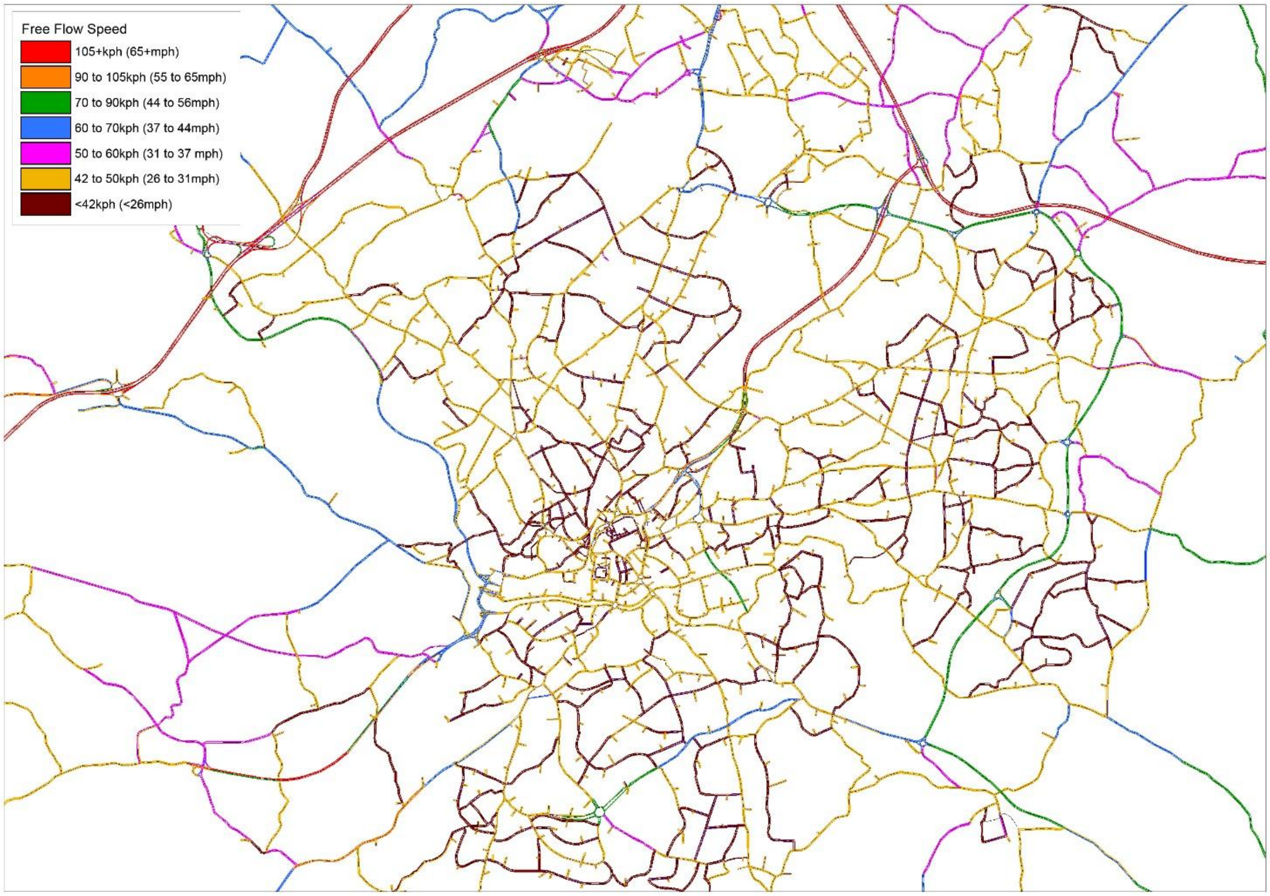
All links in simulated area were allocated distances derived from a detailed GIS based analysis of mapping to provide an estimation of road lengths.

The road classification system and local network speed limits were used to apply free-flow speed limits to individual links in the network. Speed/flow curves on specific links in the simulation area have been included to a) represent interactions on links which are otherwise not directly modelled, such as in busy retail/high street areas which are impacted by on-street parking, bus stops, pedestrians and non-modelled junctions and b) high speed inter-urban roads (i.e roads with a speed limit greater than or equal to 50 mph) which have been defined using the using the standard Cost Benefit Analysis (COBA) speed/flow classification.

The Trafficmaster™ journey time data was used to validate the cruise speed of the inter-peak model (see section 10).

The free flow speeds used in the simulation area are shown in Figure 6.1.

Figure 6.1 - GBATS4M Free Flow Speed



6.3 Junction Coding

The coding of junctions within SATURN requires a range of information. This included the use of web-based imagery and site visits. The following checks were undertaken for all the key nodes within the simulation area, including all nodes on MetroWest corridors, with corrections where required:

- Junction type, layout, lane usage and flare length;
- Junction geometry and turn capacities;
- Signal stages and timings;
- Junction delay, and particularly junctions with highest delay, as identified by the SATURN software.

6.4 Centroid Connectors

The allocation of centroid connectors for internal zones were examined to verify that trips are loading onto the network at locations that are both sensible and realistic. Centroid connectors for external zones were also checked and corrected where required. Internal zones are those in the simulation network and external zones are those in the buffer network.

Summary details of the network coding standards utilised are found in **Appendix B**.

SECTION 7

Trip Matrix Development

7.1 Matrix Development process

The development of GBATS4M 'prior' trip matrices involved new RSI OD survey data for city centre trips and the use of the 2012 SBL model and the 2011 SGC CSM 'prior' matrices. The source model prior matrices were used rather than the validated assignment matrices so that any matrix estimation effects were not incorporated into the new GBATS4 model. The matrix development process for light vehicles was undertaken as described below. Due to the relatively low sample rate for heavy goods vehicles (HGVs) in the 2013 RSI surveys, a check of trip patterns for HGVs for the central area in the source model matrices was undertaken in relation to Trafficmaster™ OD data. This showed a reasonable fit in terms of trip lengths and spatial patterns. Hence no adjustment was made to the OD data for HGVs in the development of prior matrices.

7.2 GBATS3 Matrix Merge

The SBL 2012 model was deemed the most appropriate starting point for the updated GBATS4M Metro Model, however the northern part of the model was out of date as the CSM model of this area had been developed to test schemes to the north of the city. Therefore, the two models needed to be merged, both network and matrices, to fully update the GBATS4M model. The SBL 2012 and CSM 2011 model matrices were merged using the following process:

- Expand SBL and CSM matrices to have a consistent zoning system (650 zones) – (total trips remained the same);
- Expand SBL and CSM networks to have a consistent zoning system (650 zones);
- Assign both models using the updated networks and matrices;
- Undertake a select link on both model assignments for each time period, at each RSI location used in the development of the CSM model, but not used in the SBL model (see Table 7.1 for sites);
- Remove the SBL select link matrices from the SBL prior matrices and replace with the SGCS select link matrices; and
- Assign GBATS3 merged 'prior' matrices to the SBL 2012 network.

Table 7.1 – CSM RSI Locations Used

Site Location	Year
Aztec West	2011
Bradley Stoke Way	2011
Hayes Way	2011
Highwood Lane	2011
Merlin Road	2011
Lysander Road	2011
A38 Gloucester Road	2009
Hatchet Road	2009
B4427 Old Gloucester Road	2009
Great Stoke Way	2009
A432 Badminton Road	2009
A4174 Avon Ring Road	2009
B4057 Beacon Lane	2006

B4058 Bristol Road	2006
A369 Portbury Hundred	2009

7.3 RSI Data

The 2013 RSI data was used to develop an observed matrix of trip movements to/from the city centre, i.e. the part of the matrix based on 2013 fully observed data. It was assumed that the level of vehicular trips with both origin and destination within the inner cordon was not significant.

The RSI data was processed as follows:

- Range and logic checks to determine the data was 'sensible';
- Allocate trips to 'super-zones', defined based on groups of nearby model assignment zones;
- Disaggregate trips to assignment zones within each super-zone based on residential and/or employment demographic data to produce a 'smoothed' distribution of trips within super zones;
- Expand origin/destination trips to the manual classified count (MCC) collected on the day of interview, by time period and vehicle type; and
- Correct to the automatic traffic count (ATC) collected over a two week period, to remove any bias with the day of interview.

The use of a super-zone system, combined with demographic-based trip allocation to assignment zones removed any 'unevenness' (as far as possible) from the RSI data collected.

For example, if a trip was observed at an RSI site between two assignment zones this would be identified as a trip between the super-zones containing these assignment zones. Trips would then be disaggregated back to the assignment zone level pro rata using demographic data for each zone. This effectively smoothed the observed trips across nearby zones. This was undertaken in line with DMRB matrix building guidance; specifically Vol 12 Section 1 Chapter 8 as referenced by TAG M3.1.

The creation of the non-interview direction matrices was undertaken by transposing the AM, Inter-Peak and PM interview direction matrices. The AM transpose was used for the PM non-interview direction and the PM transpose was used for the AM non-interview direction. This meant that the trips seen travelling (interview direction) into the city in one time period travelled back in the other time period, i.e. 'home to work' trips in the AM become 'work to home' trips in the PM. For the inter-peak model it is assumed that trips enter and leave within the same time period. This approach was applied to trips of all purposes. The resulting purpose split for transposed trips in each time period was controlled to the purpose split for observed trips in each time period. The factors required to control the purpose splits were reviewed to ensure best use was made of the observed data.

7.4 Merging RSI Data

Once hourly trip purpose matrices for each site were developed, the RSI data was 'merged' to create observed RSI matrices. To avoid double counting of trips passing through the area enclosed by the inner cordon, interview direction data was used in preference to transposed data.

The hourly observed matrices were then used to replace the OD trips within the source model highway matrices, using the following methodology:

- Undertaken a select link on the GBATS3 merged 'prior' matrices / SBL 2012 network assignment, at each RSI location and output an OD matrix;
- Remove all RSI OD trips from the original matrix; and
- Add the RSI observed matrices to the matrices created in the step above.

The merged observed and updated source model trip matrices then became the initial prior matrices for the model matrix development process.

7.5 Calibration of the Initial Trip Matrices

TAG M3.1 recommends that the 'prior' trip matrix should be validated by comparing total screenline and cordon model flows and counts. If screenline and cordon totals are not within 5%, then remedial action should be considered.

Table 7.2 shows the model screenline output when the initial prior matrices were assigned to the network and the model flows were compared to the count for each screenline and cordon. Where the difference in the total screenline count was greater than 5%, then appropriate OD pairs (which crossed the screenline) were factored to match the observed flow. This iterative process was continued until an appropriate 'prior' matrix was created, which fulfilled the TAG M3.1 criteria. This process did not disaggregate light and heavy vehicles.

Table 7.2 - Initial Trip Matrix Comparison

		AM Peak		Inter Peak		PM Peak	
Screenlines and Cordon	No. Links observed	Observed Total (PCUs)	Initial Matrix vs Obs % Diff	Observed Total (PCUs)	Initial Matrix vs Obs % Diff	Observed Total (PCUs)	Initial Matrix vs Obs % Diff
Calibration Total	163	144,654	-2%	122,397	-5%	149,598	-3%
Inner (In)	19	14,232	-1%	10,216	-6%	11,030	-4%
Inner (Out)	18	10,975	-9%	10,461	-5%	14,527	-6%
East (In)	8	6,612	4%	5,053	1%	5,342	0%
East (Out)	8	4,963	25%	5,456	-1%	7,917	3%
NW Inner (In)	13	13,434	-3%	11,192	-9%	13,488	-8%
NW Inner (Out)	13	12,330	10%	9,984	-6%	13,851	1%
South (In)	11	6,063	11%	5,655	2%	6,321	3%
South (Out)	11	6,042	-1%	5,703	4%	6,835	7%
River (WBSB)	16	18,175	-8%	17,279	-3%	22,218	-3%
River (EBNB)	16	23,640	-4%	17,640	-2%	19,778	-6%
RW (ALL)	30	28,188	-8%	23,759	-12%	28,291	-2%
Validation Total	146	119,970	-7%	93,005	-8%	122,986	-9%
Outer (In)	26	25,522	-5%	16,282	-4%	21,238	-12%
Outer (Out)	26	19,660	-15%	15,827	-5%	24,825	-7%
Middle (In)	30	23,785	-7%	17,425	-8%	19,770	-8%
Middle (Out)	30	18,054	-5%	17,360	-8%	23,120	-8%
NW Outer (In)	6	10,937	-9%	8,744	-3%	12,082	-8%
NW Outer (Out)	6	11,634	0%	9,006	1%	11,666	-1%
NE (In)	11	4,889	-6%	4,215	-30%	5,320	-25%
NE (Out)	11	5,490	-12%	4,147	-35%	4,964	-11%
All	**309**	**264,624**	**-4%**	**215,403**	**-6%**	**272,584**	**-5%**

SECTION 8

Network Calibration and Validation

8.1 Network Calibration

Highway network calibration was undertaken to ensure that the model fully replicated the observed traffic characteristics in terms of speeds, throughputs and delays. This was done by systematically reviewing model assignments and modifying the network parameters to improve the model's fit against observed calibration data. Checks were made to ensure:

- Link speeds on the network are realistic and speed/flow calculations are operating as expected; and
- Delay calculations at junctions are realistic.

Modelled speeds, traffic flows and journey times were compared to observed data. Any significant differences were subsequently reviewed and the network updated accordingly.

A large number of checks were iteratively undertaken, throughout the process, to calibrate the models. This included:

- Reviewing the warnings produced by SATNET;
- Inspecting excessive junction delays to check network coding;
- Monitoring where model flows were too high or low and checking the coding of the principle route and alternate competing routes.

All output data for route choice calibration and validation is found in **Appendix D**.

8.2 Route Choice Calibration

Network calibration focuses on adjusting the network to perform to replicate the observed data. However, it is generally not considered a cost effective use of resources to check all modelled routes against travel time data. Therefore, checking of the routes chosen by traffic travelling through the network is used to calibrate the parts of the network not directly observed. In line with TAG M3.1, the selected origins and destinations focused on important centres of population and employment or key intersections. These were chosen so that the routes:

- relate to significant numbers of trips;
- are of significant length or cost (e.g. 20+ minutes);
- pass through areas of interest (e.g. scheme impacted areas);
- include both directions of travel (to sense check differences);
- link different compass areas (e.g. north to south, east to west, etc.); and
- coincide with journey time routes as appropriate.

TAG M3.1 suggests the number of pairs of zones to be examined and displayed should be at least:

Number of OD pairs = (number of zones)$^{0.25}$ x the number of user classes.

There are 650 zones and the model was developed and calibrated using 2 user classes equating to 10 routes (note the model was validated using 6 user classes). The OD routes selected to check are below:

1. Portishead – Bristol City Centre
2. Avonmouth – Bristol City Centre
3. Wales – Bristol City Centre
4. Yate – Bristol City Centre

5. Bath – Bristol City Centre
6. Weston-super-Mare – Bristol City Centre
7. Lawrance Weston – Hanham
8. Stoke Gifford – Bedminster
9. Clifton – Emerson Green
10. Filton - Brislington

8.3 Route Choice Validation

There are no validation criteria or prescribed mechanisms for route choice validation. Therefore, common practice is to provide plots of the trees (the paths from an origin to all destinations) chosen by the model from a number of locations. Routeings were checked in key corridors through and around the city centre to ensure plausible and realistic routeing of traffic, as above.

The following locations (by zone) for plotting trees, include: Wales, Gloucester, Yate, Bath, Weston-super-Mare, Portishead, Pill, Avonmouth, Westbury-on-Trym, Bradley Stoke, Filton, Stoke Gifford, Emersons Green, Fishponds, Kingswood, Brislington, Bedminster, St Phillips, City Centre and Clifton.

All output is found in **Appendix D**. Note: this output is based on the final version of the model, post matrix Estimation, with 6 user classes, see following section.

SECTION 9

Trip Matrix Calibration and Validation

9.1 Prior Trip Matrix

The prior matrix was assigned to the model network to ensure that it produced trip patterns across the network that reasonably replicates the origins and destinations of trips in the model area. This was done by comparing modelled movements to observed independent counts and total screenline flows. This showed that whilst screenline and cordon totals showed a better fit to observed data than assignment of the initial trip matrices, the resulting flows still did not meet the model validation requirements. As such, matrix estimation was applied to the prior trip matrix to improve the matrix calibration.

9.2 Application of Matrix Estimation

The SATURN modules SATME2 and SATPIJA were used for matrix estimation. In combination they attempt to match assigned link flows in the model with observed traffic counts. The matrix estimation process forms part of the calibration process and is designed to modify the origin-destination volumes by reference to the observed traffic counts. Trips are adjusted in the prior matrix to produce the estimated matrix, which is most likely to be consistent with the traffic counts. The equation used may be written as:

$$T_{ij} = t_{ij} \prod aXaP_{ij}a$$

Where:

T_{ij} = the output estimated matrix of OD pairs $_{ij}$; t_{ij} = the prior matrix of OD pairs $_{ij}$;
∏a = the product over all counted links a; Xa = the balancing factor associated with counted link;

$P_{ij}a$ = the fraction of trips from i to j using link a.

Matrix estimation was undertaken on both light and heavy vehicles and was limited to the calibration sites shown in Figure 5.2.

9.3 Changes due to Matrix Estimation

TAG M3.1 advises that it is important that the process of matrix estimation does not significantly alter the characteristics of the prior matrix. The relevant criteria are described in section 3. The checks undertaken are shown as follows:

- Table 9.1 shows the regression analysis;
- Table 9.2 shows the total mean trip length check and;
- Table 9.3 shows the changes comparing the ‘prior’ and ‘final post ME2’ sector matrix totals;
- Figure 9.1 shows the corresponding sector plan.
- Additional output (including scatter plots and trip length distribution checks) is found in **Appendix C**.

An analysis of the output shows that the regression analysis guidance has been met with the exception of the R^2 value for AM cells, which is within rounding error tolerances. The mean trip length changes are well within the criteria. The total matrix change are each within 1% and individual sector changes are generally less than the recommended 5%, with the exception of only a few sectors which are all within 10%, and only marginally higher than 5%.

Table 9.1 - Matrix Estimation (Prior vs Post ME2 matrix) Regression Analysis Summary

Measure	Cells							Trips Ends						
	Criteria	AM		IP		PM		Criteria	AM		IP		PM	
Intercept	near 0	0.005	✓	0.005	✓	0.004	✓	near 0	5.886	✓	3.267	✓	3.483	✓
Slope	0.98<X<1.02	0.98	✓	0.98	✓	0.97	×	0.99<X<1.01	0.99	✓	0.99	✓	0.98	✓
R^2	>0.95	0.947	×	0.960	✓	0.960	✓	>0.98	0.989	✓	0.996	✓	0.993	✓

Table 9.2 - Matrix Estimation (Prior vs Post ME2 matrix) Total Mean Trip Length

Time Period / Criteria	AM Peak			Inter Peak			PM Peak		
	Prior	Final	% Diff	Prior	Final	% Diff	Prior	Final	% Diff
Mean Distance (kms)	23,555	23,555	0.0%	23,467	23,472	0.0%	23,642	23,668	-0.1%
Standard Deviation	26,547	26,547	0.0%	26,432	26,433	0.0%	26,525	26,537	0.0%

Figure 9.1 - GBATS4M Sector Plan

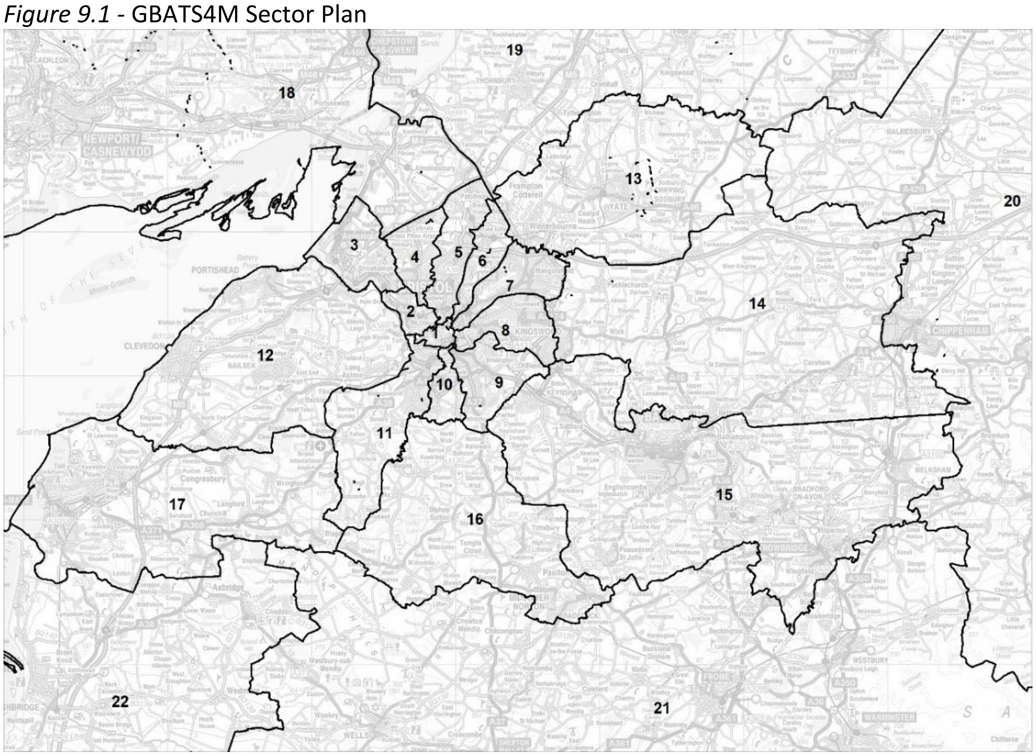


Table 9.3 - Matrix Estimation (Prior vs Post ME2 matrix) Sector Matrix Changes

Time / Sector	AM Peak			Inter Peak			PM Peak		
	Prior (2UC)	ME (6UC)	% Diff	Prior (2UC)	ME (6UC)	% Diff	Prior (2UC)	ME (6UC)	% Diff
1	5239	5211	-1%	6165	6242	1%	7858	7773	-1%
2	4829	4818	0%	4420	4500	2%	4959	4906	-1%
3	5247	5230	0%	4592	4641	1%	4789	4516	-6%
4	4827	4854	1%	5136	5206	1%	6104	5986	-2%
5	11939	12033	1%	10412	10578	2%	12343	12772	3%
6	3578	3589	0%	4708	4730	0%	7386	7182	-3%
7	10164	10169	0%	8316	8201	-1%	8057	8294	3%
8	13569	13499	-1%	10589	10762	2%	12398	12400	0%
9	8281	8274	0%	6536	6710	3%	8386	8622	3%
10	5091	5150	1%	4334	4469	3%	5265	5337	1%
11	7388	7241	-2%	6644	6862	3%	7956	7923	0%
12	8310	8456	2%	4861	5074	4%	7109	7183	1%
13	4833	4843	0%	3362	3390	1%	3612	3485	-3%
14	2935	2935	0%	1781	1806	1%	2152	2161	0%
15	3675	3698	1%	2542	2659	5%	3363	3535	5%
16	1091	1140	5%	1018	1057	4%	1319	1295	-2%
17	4360	4383	1%	3650	3782	4%	4511	4456	-1%
18	4990	4868	-2%	3673	3698	1%	3873	3876	0%
19	7044	7014	0%	4440	4512	2%	5487	5454	-1%
20	3679	3669	0%	3547	3395	-4%	3968	3994	1%
21	2055	2099	2%	1776	1789	1%	1747	1741	0%
22	2436	2457	1%	2581	2499	-3%	2383	2476	4%
Total	**125561**	**125630**	**0%**	**105084**	**106561**	**1%**	**125059**	**125406**	**0%**

9.4 Park and Ride Matrices

There are three park and ride sites in Bristol and each of the sites were surveyed. On bus origin-destination surveys were carried out at Brislington and Portway, Long Ashton was surveyed by BCC in 2013. This obtained OD data to provide both the car and bus leg of the journey. The car leg of the journey was added to the 'post-ME2' matrices for each of the sites.

9.5 Further Trip Matrix Segmentation

The models were developed, matrix estimation undertaken and calibrated using two-user classes. Further matrix segmentation was undertaken to include six user classes, detailed in Section 4. This segmentation was undertaken using income and purpose data obtained in the RSI surveys. The light vehicle user class was firstly split into 3 user classes using the percentage splits in Table 9.4.

Table 9.4 - RSI Light Vehicle User Class Splits

Purpose / Veh Type	AM	IP	PM
Car Non Business	78.6%	69.5%	84.8%
Car Business	8.6%	12.9%	5.1%
LGVs	12.7%	17.6%	10.1%

The Car Non Business trips were then split by income, on a sector basis to account for spatial variation. Table 9.5 shows the income split percentages by sector, based on the following criteria:

- Low (Less than £23,000)
- Medium (Between £23,000 and £46,000)
- High (More than £46,000)

Table 9.5 - RSI Light Vehicle User Class Splits

	Origin End - AM and IP			Destination End - PM			Sector	Origin End - AM and IP			Destination End - PM		
Sector	Low	Med	High	Low	Med	High		Low	Med	High	Low	Med	High
1	25%	42%	34%	28%	40%	32%	11	37%	47%	16%	35%	42%	22%
2	27%	44%	29%	27%	42%	31%	12	19%	43%	38%	32%	48%	20%
3	27%	42%	30%	55%	35%	10%	13	17%	43%	39%	15%	51%	34%
4	21%	46%	33%	38%	44%	18%	14	11%	18%	71%	27%	38%	36%
5	40%	37%	23%	31%	52%	17%	15	30%	41%	29%	19%	46%	35%
6	26%	40%	34%	36%	43%	21%	16	17%	59%	23%	15%	60%	26%
7	33%	43%	24%	31%	51%	18%	17	28%	46%	26%	28%	40%	31%
8	36%	45%	19%	37%	45%	18%	18	22%	36%	43%	19%	50%	31%
9	41%	42%	17%	29%	45%	26%	19	21%	32%	47%	31%	42%	27%
10	35%	53%	12%	35%	47%	19%	20	12%	42%	46%	21%	48%	31%

Assignment Calibration and Validation

10.1 Overview

The final assignment was undertaken with the final (post ME) matrix and calibrated network, using the processes previously described. Validation checks were made on comparing model cruise time, traffic flow on links and net journey time. The output from the models, compared against observed data, is found in the following section. The final section presents results from model convergence.

10.2 Cruise Times

Output from the Trafficmaster™ journey time database was used to check the cruise time of the inter-peak model. The observed cruise time was estimated by calculating the lowest time (in 15 minute intervals) during the 7am to 7pm period. This was considered to be a reasonably accurate reflection of actual cruise time.

Inter peak model output is shown in Table 10.1. The location of the journey time routes is shown in Figure 5.4. A check of just one time period was undertaken since the coding of model speeds is consistent between time periods. Further this is not a TAG requirement but merely an additional model check to confirm appropriate generation of delays between links and junctions.

62% of modelled routes are within 5% of observed times. 82% of routes are within 10%. All routes are within 15%. The model is therefore considered sufficient to present an accurate representation of observed cruise speeds.

Table 10.1 – Inter-Peak Model Cruise Time Check

Route Description		Dist (km)	Cruise Time (mins)			Av Cruise Speed (kph)
			Obs	Model	% Diff	
1	A370 Inbound (Backwell to Ashton Gate)	9.6	8.1	9.1	12%	71
1	A370 Outbound (Jessop Underpass to Backwell)	9.5	8.6	8.9	4%	67
2	A38 Inbound (Barrow Gurney to Bedminster Bridge)	7.6	11.3	9.8	-13%	40
2	A38 Outbound (Bedminster Bridge to Barrow Gurney)	7.6	9.7	9.9	3%	47
3	A4 Inbound (Keynesham to Bath Bridge)	8.3	11.4	10.6	-6%	44
3	A4 Outbound (Bath Bridge to Keynesham)	8.3	10.4	10.3	-1%	48
4	A431 Inbound (Willsbridge to Old Market St)	9.2	14.6	14.7	1%	38
4	A431 Outbound (Old Market St Jct to Willsbridge)	9.6	13.7	15.3	12%	42
5	A38 Eastbound (Ashton Gate to Brislington)	8.0	12.4	12.6	1%	39
5	A38 Westbound (Brislington to Ashton Gate)	8.6	13.2	13.7	4%	39
6	A432 Inbound (A4174 Badminton Rbt to Old Market St)	9.4	15.2	16.3	8%	37
6	A432 Outbound (West St to A4174 Badminton Rbt)	9.4	15.4	15.7	2%	37
7	M32 Inbound (M32 J1 to Cabot Circus)	6.2	4.9	4.3	-11%	77
7	M32 Outbound (Cabot Circus to M32 J1)	6.0	3.8	3.6	-7%	94
8	A38 Inbound (M5 J16 to St James Barton Rbt)	10.3	16.3	17.0	4%	38
8	A38 Outbound (St James Barton Rbt to M5 J16)	10.3	16.6	16.7	0%	37
9	A4018 Inbound (M5 J17 Cribbs to Clifton Triangle)	8.2	12.3	11.9	-4%	40
9	A4018 Outbound (College Green to M5 J17 Cribbs)	8.2	12.5	12.7	1%	39
#	A4 Portway Inbound (Avonmouth to Hotwells)	9.8	10.8	10.8	0%	55
#	A4 Portway Outbound (Hotwells to Avonmouth)	9.7	9.8	9.6	-2%	59
#	A369 Inbound (Portishead to A4 Bristol Gate)	11.5	11.6	12.1	4%	59
#	A369 Outbound (A4 Bristol Gate to Portishead)	12.8	13.2	13.4	2%	58
#	A4174 Eastbound (Filton Rbt to A4)	17.1	17.3	17.1	-1%	59
#	A4174 Westbound (A4 to Filton Rbt)	17.1	17.6	16.6	-6%	58
#	City Centre Outer Loop (Clockwise)	9.3	17.2	17.0	-1%	32
#	City Centre Outer Loop (Anti-Clockwise)	8.1	14.5	13.9	-4%	34
#	City Centre Inner Loop (Clockwise)	7.0	13.8	14.0	1%	31
#	City Centre Inner Loop (Anti-Clockwise)	3.7	8.0	8.6	7%	28
#	M4 Mainline Eastbound (J22 to J18)	34.5	18.9	18.3	-3%	109
#	M4 Mainline Westbound (J18 to J22)	34.6	18.5	18.4	0%	112
#	M5 Mainline Northbound (J20 to M4)	24.1	14.2	12.7	-10%	102
#	M5 Mainline Southbound (M4 to J20)	24.2	14.0	12.5	-11%	103

	<5%	**<10%**	**<15%**
% All routes within x% of observed	62%	82%	100%

10.3 Traffic Flows

Tables 10.2 (AM), 10.3 (IP) and 10.4 (PM) present a summary of the link flow validation on all the cordons and screenlines. The location of the calibration and validation screenlines is shown in Figures 5.2 and 5.3. Detailed individual link outputs are found in **Appendix E**.

The flow validation criteria and acceptability guidelines (as specified in TAG M3.1, see Table 3.1) have been met for all screenline and cordon links in all modelled time periods for both calibration and validated links in relation to checks for "all vehicles". Additional checks have been undertaken for light vehicles (LVs), i.e. cars/LGVs. For LVs the traffic flow criteria has been met for both GEH values and DMRB flow criteria for calibration and validation screenlines for all time periods with the exception of validation screenlines in the AM and PM peaks, which are very close to the criteria, both with a value of 84%. When the model fit is considered as a whole this is deemed to be acceptable since the corresponding value against GEH criteria is 86% and 85% for each peak respectively and the value across all screenlines is 86% for both peaks. All (or nearly all) screenlines are within 5% of the observed data.

Figures 10.1 to 10.3 show the GEH values in graphical form. Note that GEH values have been assigned a negative value where model flow is lower than observed.

Table 10.2 – AM Peak Link Flow Validation Summary

Screenlines and Cordon	No. Links	% Links GEH (PCUs)		% links DMRB flow (PCUs)	Observed Total (PCUs)	Model vs Obs Total (PCUs)	Model vs Obs % Diff (PCUs)	% Links GEH (LVs)	% links DMRB Flow (LVs)
		<5	<7					<5	
Calibration total	163	88%	98%	88%	144,654	-1,614	-1%	87%	89%
Inner (In)	19	84%	95%	79%	14,232	384	3%	79%	84%
Inner (Out)	18	94%	100%	83%	10,975	94	1%	83%	94%
East (In)	8	88%	100%	88%	6,612	-142	-2%	75%	75%
East (Out)	8	100%	100%	100%	4,963	-142	-3%	100%	100%
NW Inner (In)	13	92%	100%	85%	13,434	-402	-3%	92%	92%
NW Inner (Out)	13	85%	92%	92%	12,330	238	2%	100%	100%
South (In)	11	91%	91%	82%	6,063	37	1%	91%	91%
South (Out)	11	82%	100%	91%	6,042	55	1%	82%	91%
River (WBSB)	16	81%	100%	81%	18,175	168	1%	75%	69%
River (EBNB)	16	88%	100%	94%	23,640	-869	-4%	88%	88%
RW (ALL)	30	87%	97%	93%	28,188	-1,035	-4%	90%	93%
Validation total	146	92%	98%	88%	119,970	-368	0%	86%	84%
Outer (In)	26	88%	100%	77%	25,522	-463	-2%	81%	73%
Outer (Out)	26	96%	96%	96%	19,660	-170	-1%	96%	88%
Middle (In)	30	93%	93%	87%	23,785	-386	-2%	87%	87%
Middle (Out)	30	90%	100%	90%	18,054	106	1%	87%	90%
NW Outer (In)	6	83%	100%	83%	10,937	730	7%	67%	50%
NW Outer (Out)	6	100%	100%	83%	11,634	-217	-2%	83%	100%
NE (In)	11	91%	100%	91%	4,889	-46	-1%	82%	91%
NE (Out)	11	100%	100%	100%	5,490	79	1%	91%	73%
All	**309**	**90%**	**98%**	**88%**	**264,624**	**-1,982**	**-1%**	**86%**	**86%**

Figure 10.1 - AM Peak Traffic Flow Validation and Calibration Screenlines

Table 10.3 – Inter Peak Link Flow Validation Summary

Screenlines and Cordon	No. Links observed	% Links GEH (PCUs)		% links DMRB Flow (PCUs)	Observed Total (PCUs)	Model vs Obs Total (PCUs)	Model vs Obs % Diff (PCUs)	% Links GEH (LVs)	% links DMRB Flow (LVs)
		<5	<7					<5	
Calibration Total	163	87%	96%	88%	122,397	-3,444	-3%	89%	93%
Inner (In)	19	79%	89%	79%	10,216	-496	-5%	79%	84%
Inner (Out)	18	78%	94%	83%	10,461	-253	-2%	83%	94%
East (In)	8	88%	88%	88%	5,053	-383	-8%	75%	88%
East (Out)	8	88%	100%	100%	5,456	-276	-5%	100%	100%
NW Inner (In)	13	92%	100%	92%	11,192	-185	-2%	100%	100%
NW Inner (Out)	13	100%	100%	100%	9,984	-126	-1%	100%	100%
South (In)	11	100%	100%	100%	5,655	30	1%	91%	91%
South (Out)	11	100%	100%	100%	5,703	47	1%	100%	100%
River (WBSB)	16	88%	88%	88%	17,279	-241	-1%	88%	94%
River (EBNB)	16	75%	100%	75%	17,640	-457	-3%	81%	81%
RW (ALL)	30	83%	97%	87%	23,759	-1,105	-5%	90%	93%
Validation Total	146	90%	99%	89%	93,005	-2,096	-2%	92%	93%
Outer (In)	26	100%	100%	92%	16,282	-856	-5%	100%	96%
Outer (Out)	26	92%	100%	88%	15,827	-356	-2%	92%	92%
Middle (In)	30	80%	97%	80%	17,425	-921	-5%	90%	93%
Middle (Out)	30	87%	100%	93%	17,360	-762	-4%	100%	100%
NW Outer (In)	6	83%	100%	100%	8,744	282	3%	83%	100%
NW Outer (Out)	6	67%	100%	83%	9,006	274	3%	100%	100%
NE (In)	11	100%	100%	91%	4,215	173	4%	73%	64%
NE (Out)	11	100%	100%	91%	4,147	71	2%	82%	91%
All	**309**	**88%**	**97%**	**89%**	**215,403**	**-5,540**	**-3%**	**91%**	**93%**

Figure 10.2 - Inter Peak Traffic Flow Validation and Calibration Screenlines

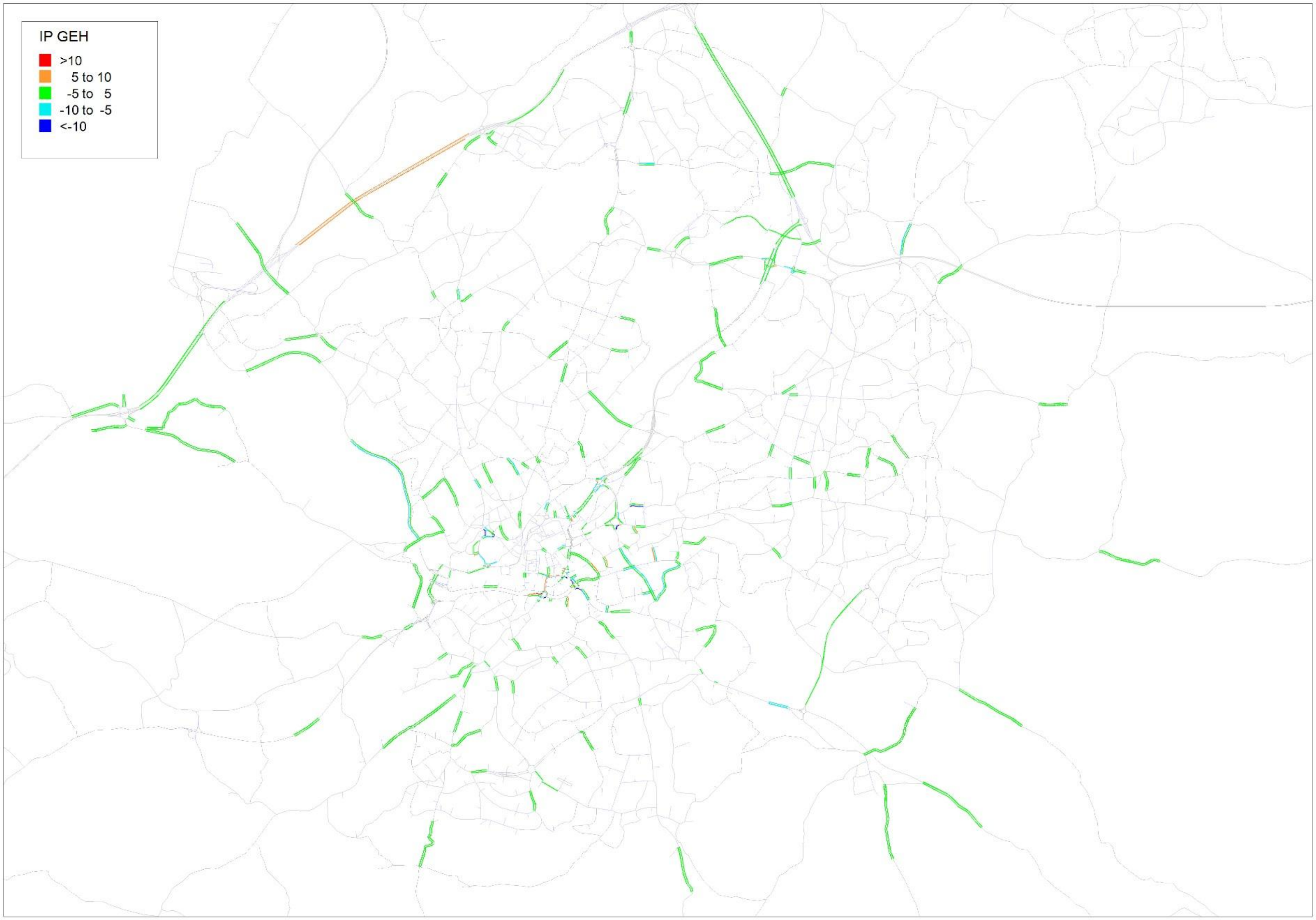


Table 10.4 – PM Peak Link Flow Validation Summary

Screenlines and Cordon	No. Links observed	% Links GEH (PCUs)		% links DMRB Flow (PCUs)	Observed Total (PCUs)	Model vs Obs Total (PCUs)	Model vs Obs % Diff (PCUs)	% Links GEH (LVs)	% links DMRB Flow (LVs)
		<5	<7					<5	
Calibration Total	163	85%	91%	88%	149,598	-311	0%	88%	88%
Inner (In)	19	84%	89%	89%	11,030	65	1%	84%	89%
Inner (Out)	18	67%	78%	78%	14,527	-263	-2%	72%	72%
East (In)	8	100%	100%	100%	5,342	-275	-5%	100%	100%
East (Out)	8	88%	100%	100%	7,917	-225	-3%	100%	100%
NW Inner (In)	13	85%	92%	85%	13,488	-544	-4%	85%	85%
NW Inner (Out)	13	92%	92%	77%	13,851	-254	-2%	92%	92%
South (In)	11	100%	100%	100%	6,321	32	1%	100%	100%
South (Out)	11	82%	82%	82%	6,835	403	6%	82%	73%
River (WBSB)	16	94%	100%	94%	22,218	753	3%	94%	94%
River (EBNB)	16	75%	81%	75%	19,778	455	2%	69%	75%
RW (ALL)	30	87%	97%	93%	28,291	-457	-2%	97%	97%
Validation Total	146	89%	97%	91%	123,001	-1,800	-1%	85%	84%
Outer (In)	26	96%	100%	92%	21,239	-316	-1%	85%	81%
Outer (Out)	26	88%	96%	88%	24,827	-533	-2%	85%	85%
Middle (In)	30	87%	100%	93%	19,779	-470	-2%	90%	90%
Middle (Out)	30	87%	87%	87%	23,123	140	1%	73%	73%
NW Outer (In)	6	67%	100%	83%	12,082	-522	-4%	83%	83%
NW Outer (Out)	6	100%	100%	100%	11,667	228	2%	83%	100%
NE (In)	11	91%	100%	100%	5,320	-189	-4%	91%	100%
NE (Out)	11	91%	100%	91%	4,964	-139	-3%	100%	82%
All	**309**	**87%**	**94%**	**89%**	**272,599**	**-2,111**	**-1%**	**86%**	**86%**

Figure 10.3 - PM Peak Traffic Flow Validation and Calibration Screenlines

10.4 Journey Times

All observed data is from October 2013 (excluding school half term), using output from the Trafficmaster™ journey time database, with the exception of Routes 1 & 2, where local roadworks in Barrow Gurney were underway, hence May 2013 data was utilised. The location of the routes is shown in Figure 5.4. Table 10.5 shows a good model fit to observed journey times in all time periods. **Appendix F** shows distance-time graphs.

Table 10.5 - GBATS4M Net Journey Time (mins) Validation

Route Description		AM Peak			Inter Peak			PM Peak		
		Obs	Model	% Diff	Obs	Model	% Diff	Obs	Model	% Diff
1	A370 Inbound (Backwell to Ashton Gate)	*10.1*	10.5	4%	10.8	9.5	-12%	*9.8*	9.7	-1%
1	A370 Outbound (Jessop Underpass to Backwell)	*9.7*	9.6	-1%	10.3	9.5	-7%	*10.2*	11.7	15%
2	A38 Inbound (Barrow Gurney to Bedminster Bridge)	*17.6*	15.6	-11%	18.2	16.2	-11%	*18.8*	17.3	-8%
2	A38 Outbound (Bedminster Bridge to Barrow Gurney)	*13.6*	14.0	3%	12.7	13.9	9%	*16.6*	18.0	9%
3	A4 Inbound (Keynesham to Bath Bridge)	30.9	26.5	-14%	15.1	16.1	7%	19.2	21.3	11%
3	A4 Outbound (Bath Bridge to Keynesham)	19.2	20.1	5%	14.4	14.9	4%	18.6	20.6	10%
4	A431 Inbound (Willsbridge to Old Market St)	30.7	33.5	9%	20.4	21.2	4%	22.8	22.6	-1%
4	A431 Outbound (Old Market St Jct to Willsbridge)	20.7	23.0	11%	20.9	22.4	7%	25.8	28.6	11%
5	A38 Eastbound (Ashton Gate to Brislington)	29.2	25.1	-14%	18.8	21.4	14%	26.1	29.6	14%
5	A38 Westbound (Brislington to Ashton Gate)	23.3	23.0	-1%	17.9	20.7	16%	21.8	24.6	13%
6	A432 Inbound (A4174 Badminton Rbt to Old Market St)	35.6	34.0	-4%	23.0	25.1	9%	23.6	26.0	10%
6	A432 Outbound (West St to A4174 Badminton Rbt)	26.3	28.8	9%	23.4	26.7	14%	26.0	25.7	-1%
7	M32 Inbound (M32 J1 to Cabot Circus)	13.1	12.5	-5%	5.1	5.7	11%	6.2	6.8	10%
7	M32 Outbound (Cabot Circus to M32 J1)	5.6	5.3	-6%	4.1	4.3	5%	4.8	4.2	-12%
8	A38 Inbound (M5 J16 to St James Barton Rbt)	33.6	36.2	8%	24.7	25.9	5%	30.4	31.2	2%
8	A38 Outbound (St James Barton Rbt to M5 J16)	32.2	31.2	-3%	24.9	24.8	-1%	35.3	29.9	-15%
9	A4018 Inbound (M5 J17 Cribbs to Clifton Triangle)	29.7	21.4	-28%	16.7	16.0	-4%	22.9	19.6	-14%
9	A4018 Outbound (College Green to M5 J17 Cribbs)	18.1	18.4	2%	16.3	17.5	7%	18.9	19.4	3%
10	A4 Portway Inbound (Avonmouth to Hotwells)	20.8	17.5	-16%	13.7	14.4	5%	18.3	18.8	3%
10	A4 Portway Outbound (Hotwells to Avonmouth)	12.0	12.6	5%	10.9	11.6	6%	11.9	12.3	3%
11	A369 Inbound (Portishead to A4 Bristol Gate)	24.2	21.8	-10%	13.2	14.9	13%	16.6	16.4	-1%
11	A369 Outbound (A4 Bristol Gate to Portishead)	16.7	17.6	5%	15.3	16.4	7%	19.0	19.8	4%
12	A4174 Eastbound (Filton Rbt to A4)	28.0	26.4	-5%	22.1	23.5	7%	31.5	27.3	-13%
12	A4174 Westbound (A4 to Filton Rbt)	31.7	36.2	14%	21.1	22.2	5%	26.1	25.3	-3%
14	City Centre Outer Loop (Clockwise)	35.5	34.5	-3%	24.0	27.3	14%	41.5	39.9	-4%
14	City Centre Outer Loop (Anti-Clockwise)	32.2	31.1	-4%	20.3	22.3	10%	32.4	37.6	16%
15	City Centre Inner Loop (Clockwise)	30.5	26.7	-12%	20.9	21.8	4%	29.4	29.1	-1%
15	City Centre Inner Loop (Anti-Clockwise)	19.4	19.5	0%	13.6	14.4	6%	17.9	20.0	11%
16	M4 Mainline Eastbound (J22 to J18)	28.0	24.4	-13%	19.6	19.8	1%	21.0	20.6	-2%
16	M4 Mainline Westbound (J18 to J22)	20.5	20.4	-1%	20.2	20.2	0%	20.9	20.4	-3%
17	M5 Mainline Northbound (J20 to M4)	14.4	14.2	-2%	14.8	13.7	-7%	17.5	14.0	-20%
17	M5 Mainline Southbound (M4 to J20)	14.9	13.4	-10%	14.5	13.3	-8%	14.9	14.0	-6%
% All routes within x% of observed		*10%*	*15%*	*20%*	*10%*	*15%*	*20%*	*10%*	*15%*	*20%*
		69%	**94%**	97%	72%	**97%**	100%	56%	**91%**	100%

10.5 Model Convergence

The convergence for each model period is summarised in Table 10.6 and shows that the three models have achieved TAG M3.1 proximity %GAP criteria (the first choice measure of assignment convergence, see section 3.2). The stability criteria is achieved, based on change in delay (used as a proxy for cost) but has not for flow change. TAG M3.1 states that the convergence criteria must be met for either flow or cost and hence overall the convergence criteria is met.

Table 10.6 - GBATS4M Convergence Summary

Measure		**AM Peak**		**Inter Peak**		**PM Peak**	
No. Loops till termination		16		20		44	
Final 4 Loops Mean	Gap %	0.08	✓	0.01	✓	0.05	✓
	% Flow change (P <1%)	91	×	96	×	96	×
	% Delay change (P2 <1%)	98	✓	100	✓	99	✓

10.6 Stress Test

After achieving a near-fully validated model a ‘stress test’ of the Base AM and PM models was undertaken by increasing the total numbers of trips in the matrices by 30% and reassigning. This revealed some minor network faults which previous checks had not detected. The changes were made and feed back into the iterative model development process.

SECTION 11

Conclusion

11.1 Overview

The model has been validated using the guidance, measures and criteria recommended in TAG M3.1. The following comparisons between modelled and observed data have been reported:

- Total flows for cordons and screenlines;
- Traffic Flows on individual links; and
- Journey times (both cruise and net) for a range of key routes.

The analysis shows that the three models meet the acceptability guidelines:

- Regarding matrix estimation changes;
- For traffic flows on links across the total cordon and screenlines and at the individual calibration, and independent validation sites; and
- For journey times.

All three models achieve acceptable levels of convergence and are stable based on delay/cost.

Stress test confirmed the network is fit for future year testing, in particular the MetroWest Phase 1 and 2 schemes.

Appendix A: Other Traffic Count Sites

Figure A1: Highways Agency TRADS Sites and Wider Area counts

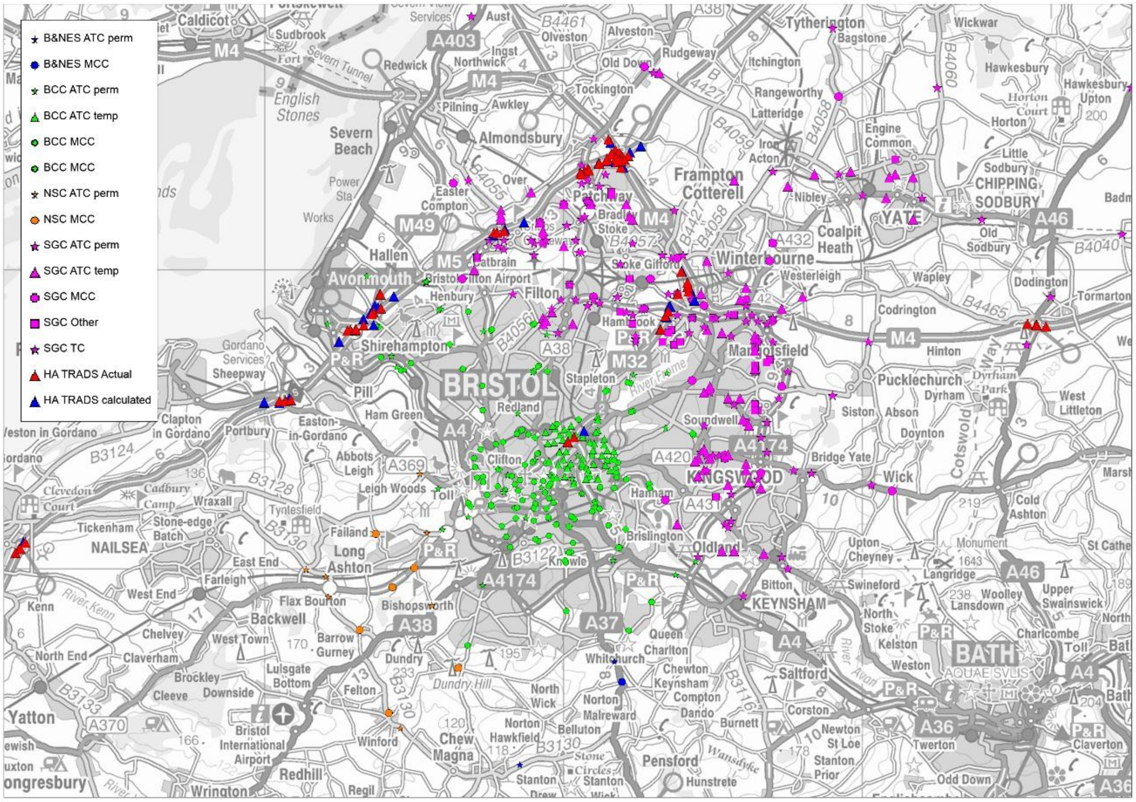
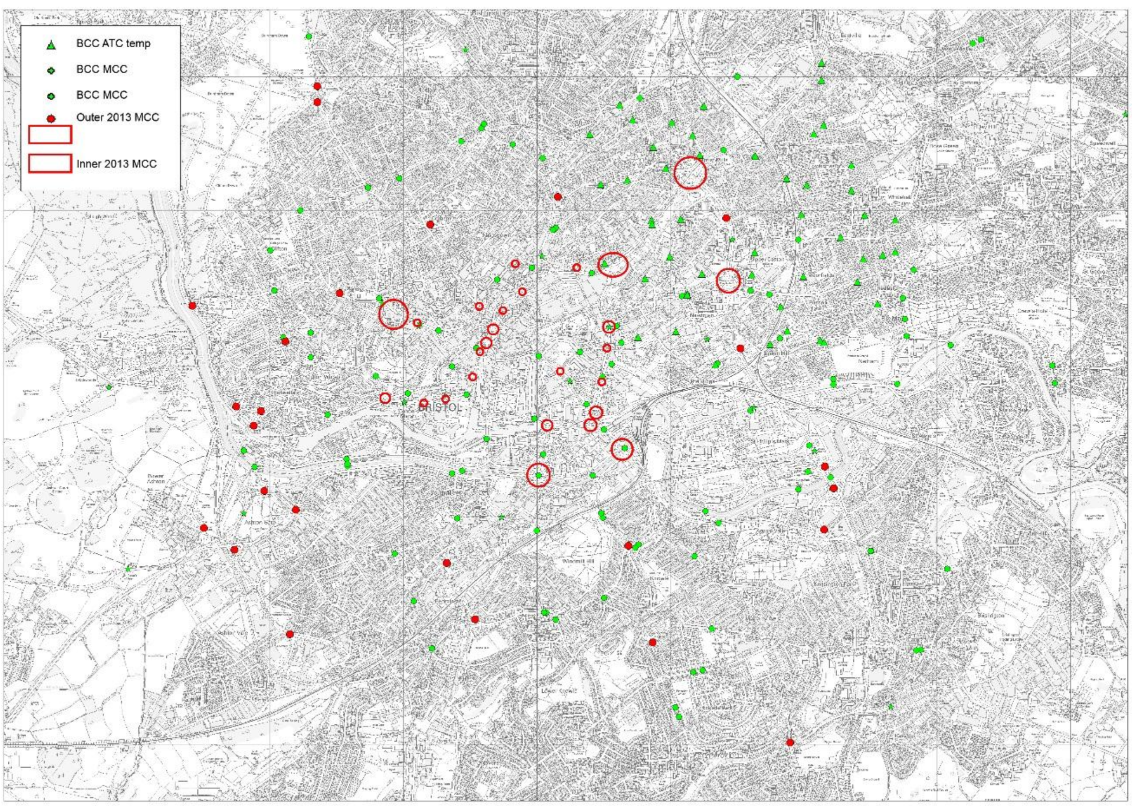


FIGURE A2
Central Area Count Sites



Appendix B: Network Coding Standards

Roundabouts

Roundabouts have entry and circulating saturation flows defined in the SATURN coding. The main factors determining the values of these are entry lane approach width / degree of flaring and the inscribed circle diameter.

TABLE B2

Roundabout saturation flows and GAP

Entry Arm Type	Mini	Small	Medium	Large	Very Large
Inscribed Diameter	~20m	~40m	~60m	~80m	~100m
Single Lane Narrow <3m, No Flare	900	950	1000	N/A	N/A
Single Lane Narrow <3m, Flare To 2 Lanes	1225	1325	1400	N/A	N/A
Single Lane Normal 3.5m, No Flare	1050	1075	1150	1200	1250
Single Lane Normal 3.5m, Flare To 2 Lanes	1475	1550	1625	1700	1800
Dual No Flare	N/A	2325	2400	2475	2525
Dual Flare To 3 Lanes	N/A	2725	2850	2950	3075

Entry Arm Type		Mini	Small	Medium	Large	Very Large
All Single	Cir	1950	2100	2500	N/A	N/A
	Gap	1.8	1.7	1.5	N/A	N/a
Mixed Single/Dual	Cir	N/A	2300	2650	3100	3300
	Gap	N/A	1.6	1.4	1.2	1.1
All Dual But No Flares To 3 Lanes	Cir	N/A	N/A	3550	4200	4500
	GAP	N/A	N/A	1.0	0.9	0.8
All Dual And Flared To 3 Lanes	Cir	N/A	N/A	3850	4500	4800
	GAP	N/A	N/A	0.9	0.8	0.8

Geometry	Mini	Small	Medium	Large	Very Large
Inscribed Diameter	~20m	~40m	~60m	~80m	~100m
Circulation Time (Seconds)	6	11	17	23	28

Signalised Junction Saturation flows

Signalised junctions typically have saturation flows per lane of between 1600 and 2050 depending on the lane width and the turn radii of left/right turns.

TABLE B1

Signalised junction saturation flows

Entry Arm Type	Left Turn	Straight	Right Turn
Single Lane Narrow <3m	1650	1900	1700
Single Lane Normal ~ 3.5m	1750	1950	1800
2 Lanes Narrow <6m	3500	3950	3600
2 Lanes Normal ~7m	3600	4100	3700
3lanes ~10m	N/A	6200	N/A

Priority Junctions

Unopposed Movements:

- Straight ahead 1700 to 1950;
- Left Turn 1650 to 1800;

TABLE B3

Priority junction saturation flows – opposed movements:

Visibility	Right Major	Left Minor	Straight Minor	Right Minor
Poor (<50m)	575	600	500	500
Average (50-120m)	615	625	575	575
Good (120-240m)	675	700	675	675

Gap acceptance at priority junctions is usually of the order of 1.5 to 2.5 seconds depending on the junction geometry.

EMME – SATURN Linkage for Bus Lanes

The coding of bus priority measures within the SATURN network needs to be accessed by EMME3 to ensure that travel time improvements from such measures are incorporated into the mode choice model. The coding of bus priority is based on the 'B-Code' method used in SATURN which allocates lanes on the main carriageway to exclusive bus usage. This method allows the bus lane to be allocated to either adjacent to the kerb or adjacent to the centre line.

Appendix C: Matrix Estimation Checks

FIGURE C1
AM Matrix Zonal Cells Scatterplot

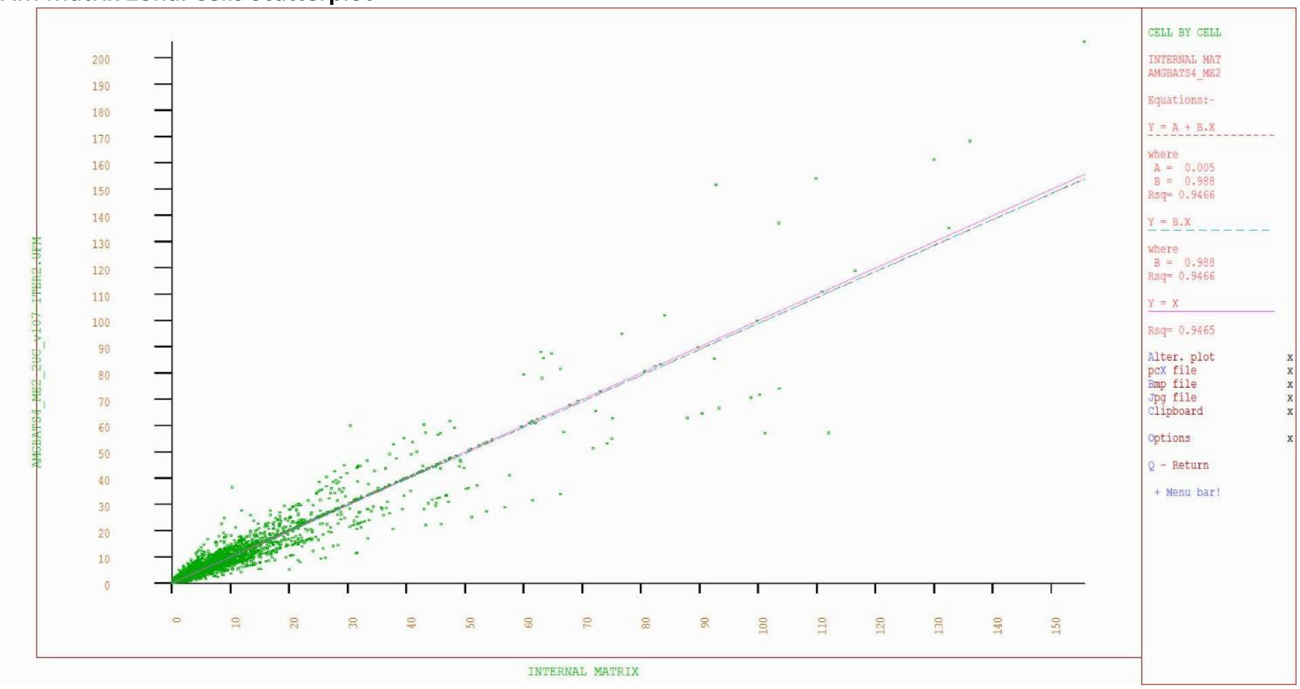


FIGURE C2
AM Matrix Zonal Trip Ends Scatterplot

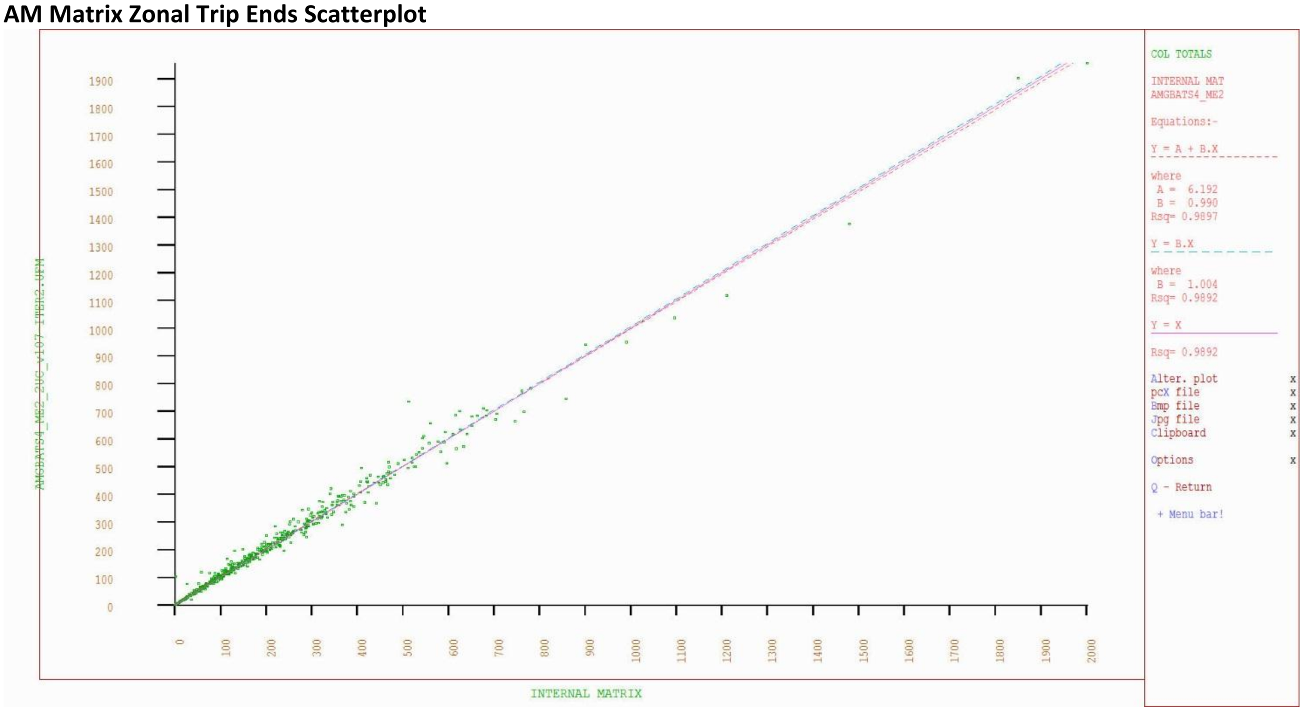


FIGURE C3

IP Matrix Zonal Cells Scatterplot

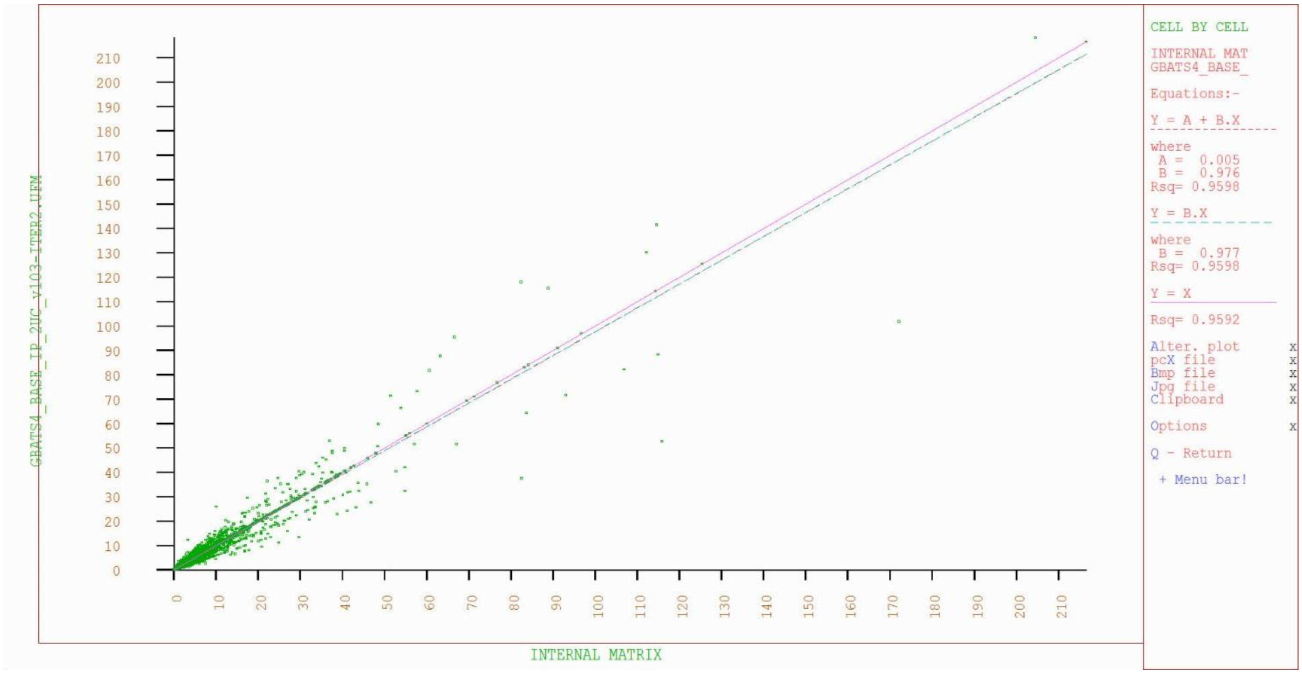


FIGURE C4

IP Matrix Zonal Trip Ends Scatterplot

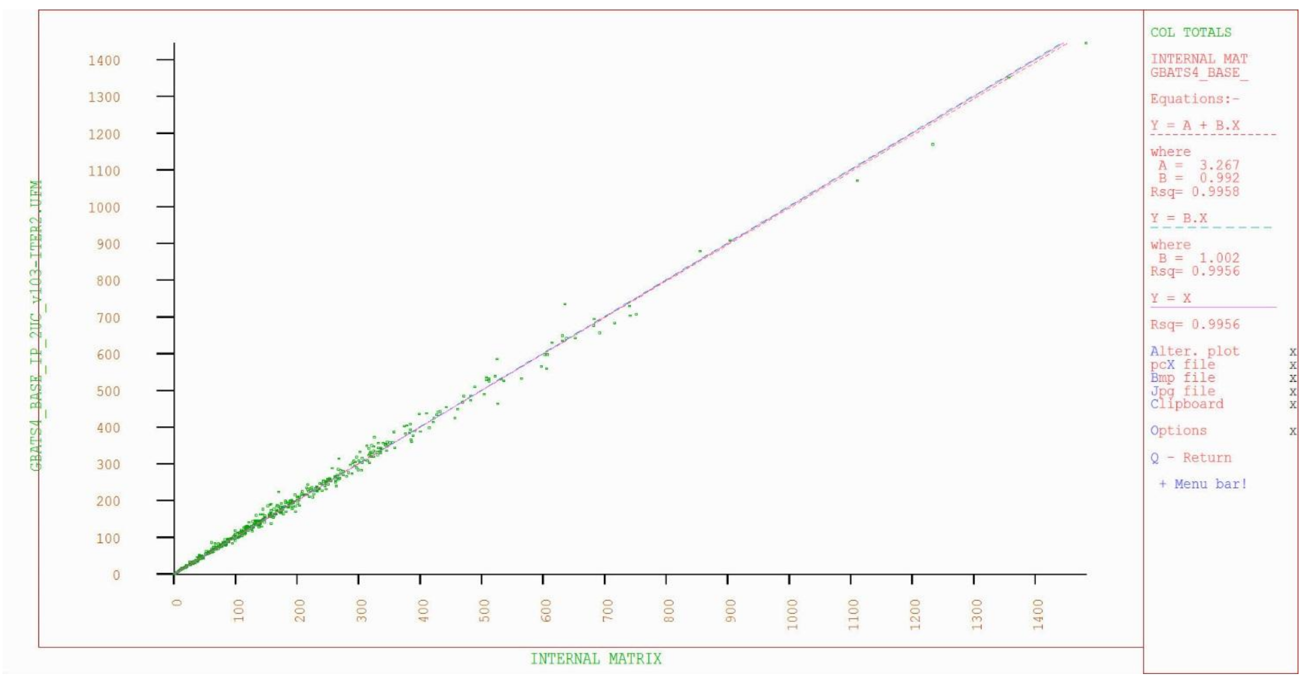


FIGURE C5
PM Matrix Zonal Cells Scatterplot

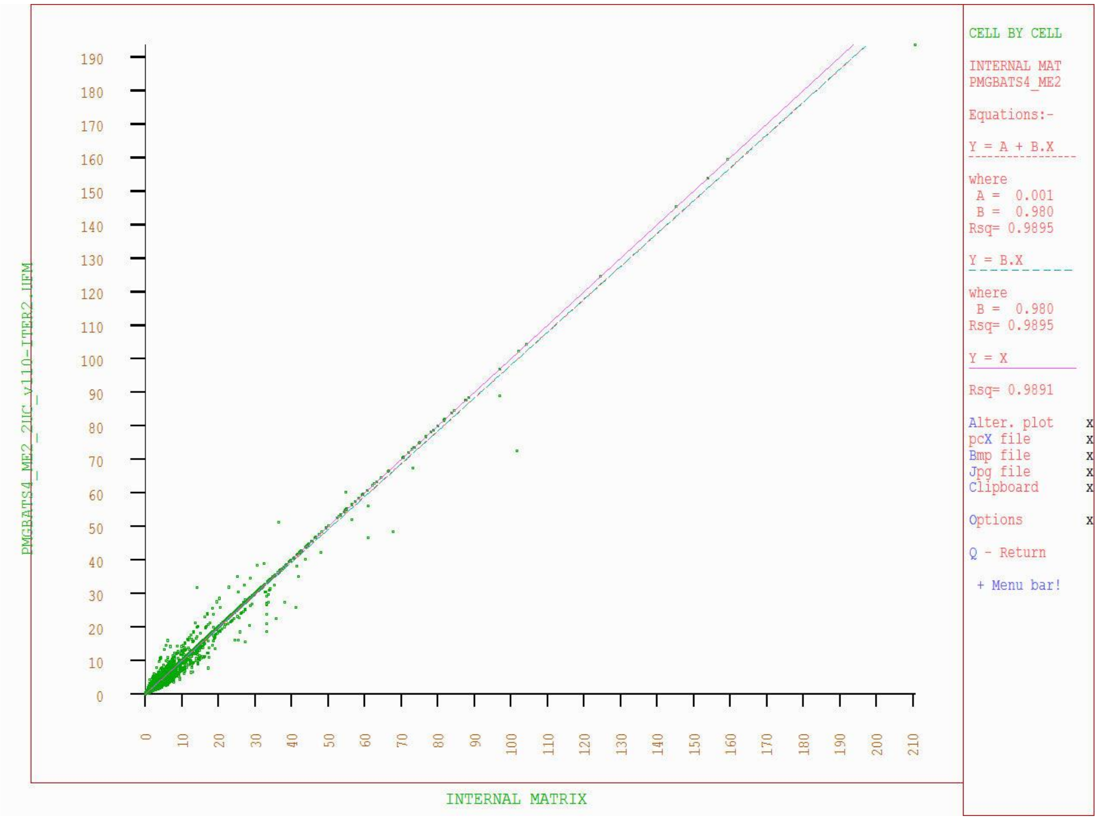


FIGURE C6
PM Matrix Zonal Trip Ends Scatterplot

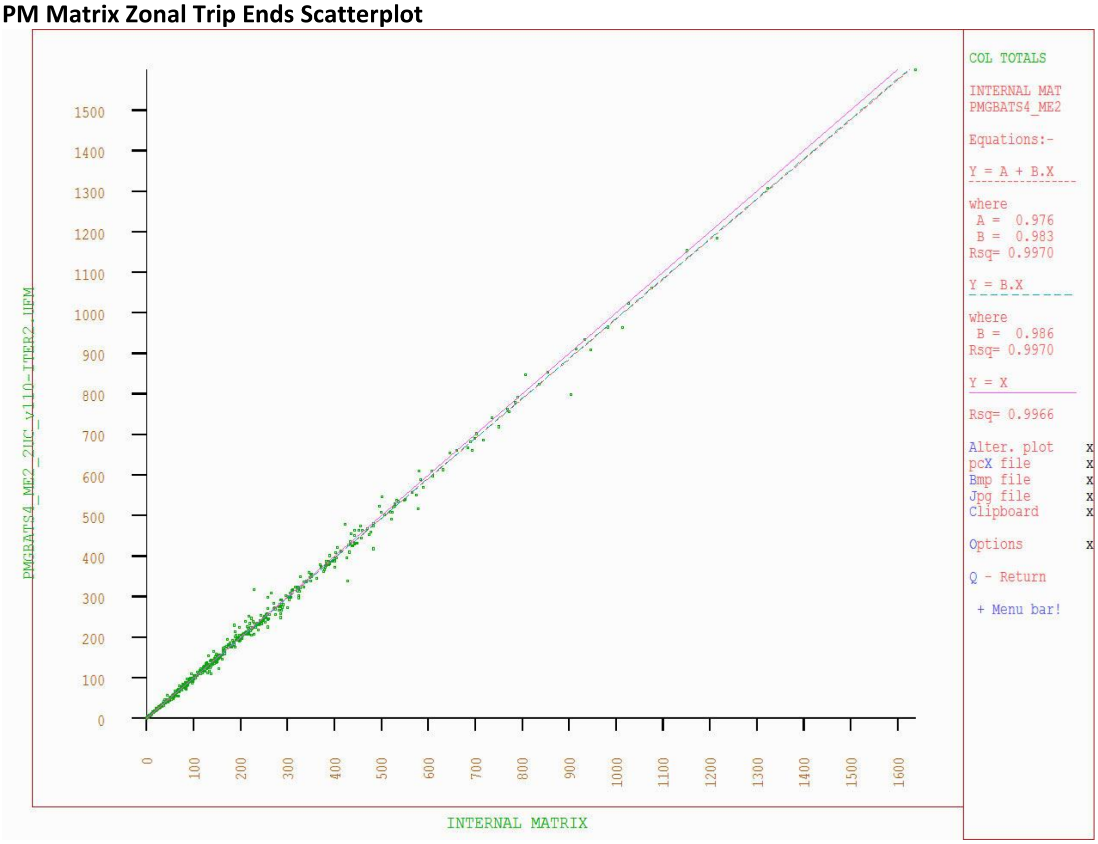


FIGURE C7
AM Trip Length Distribution

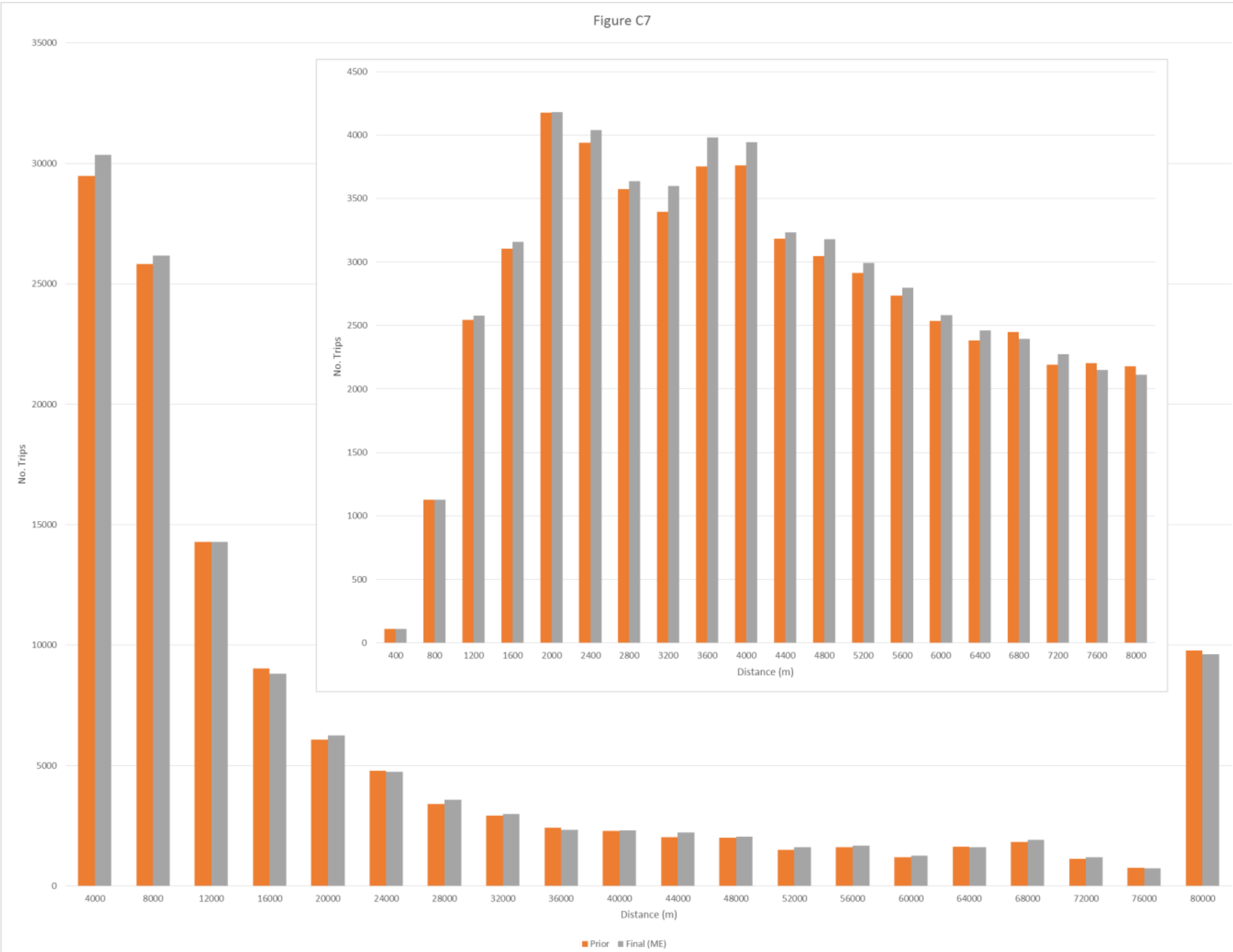


FIGURE C8
IP Trip Length Distribution

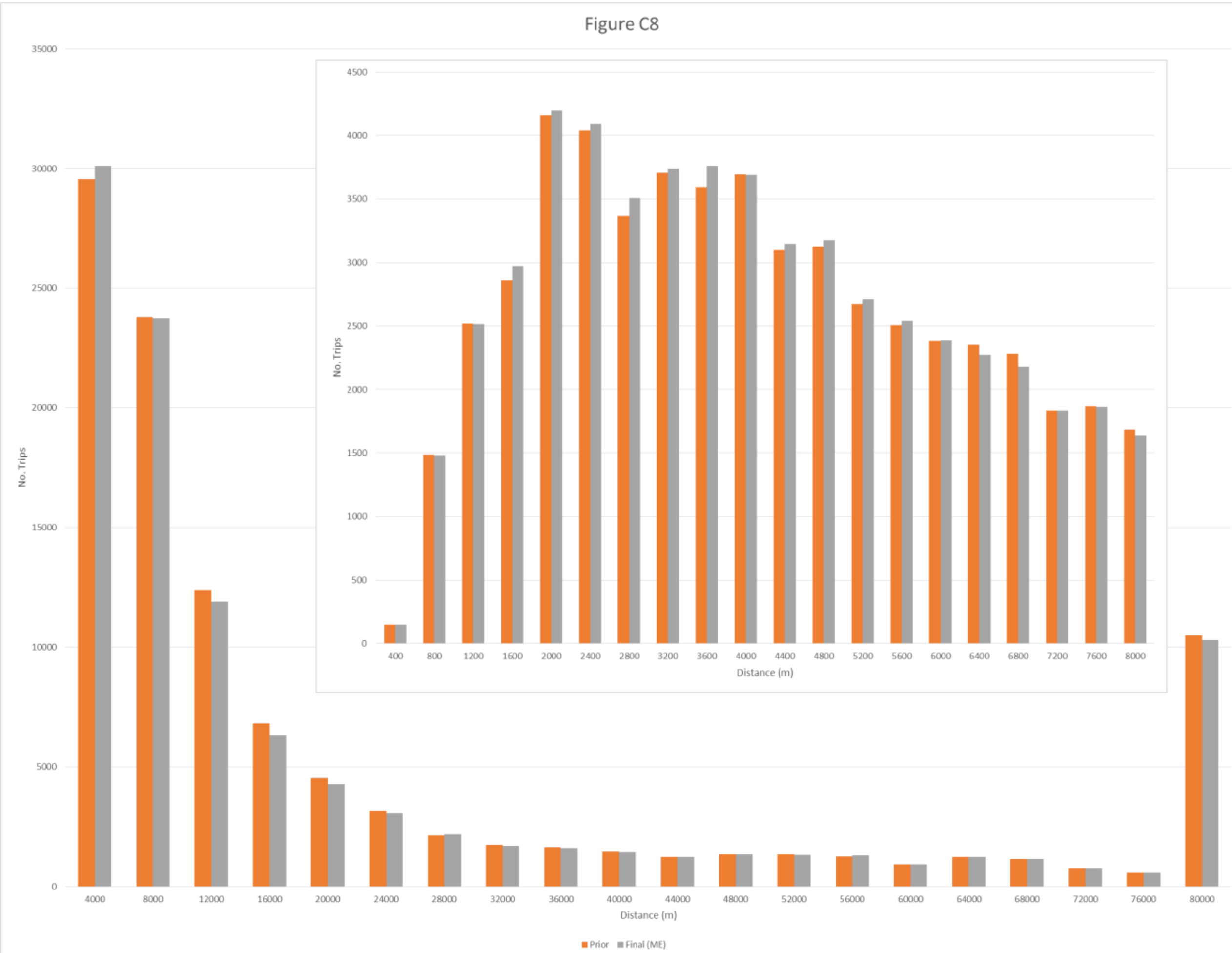
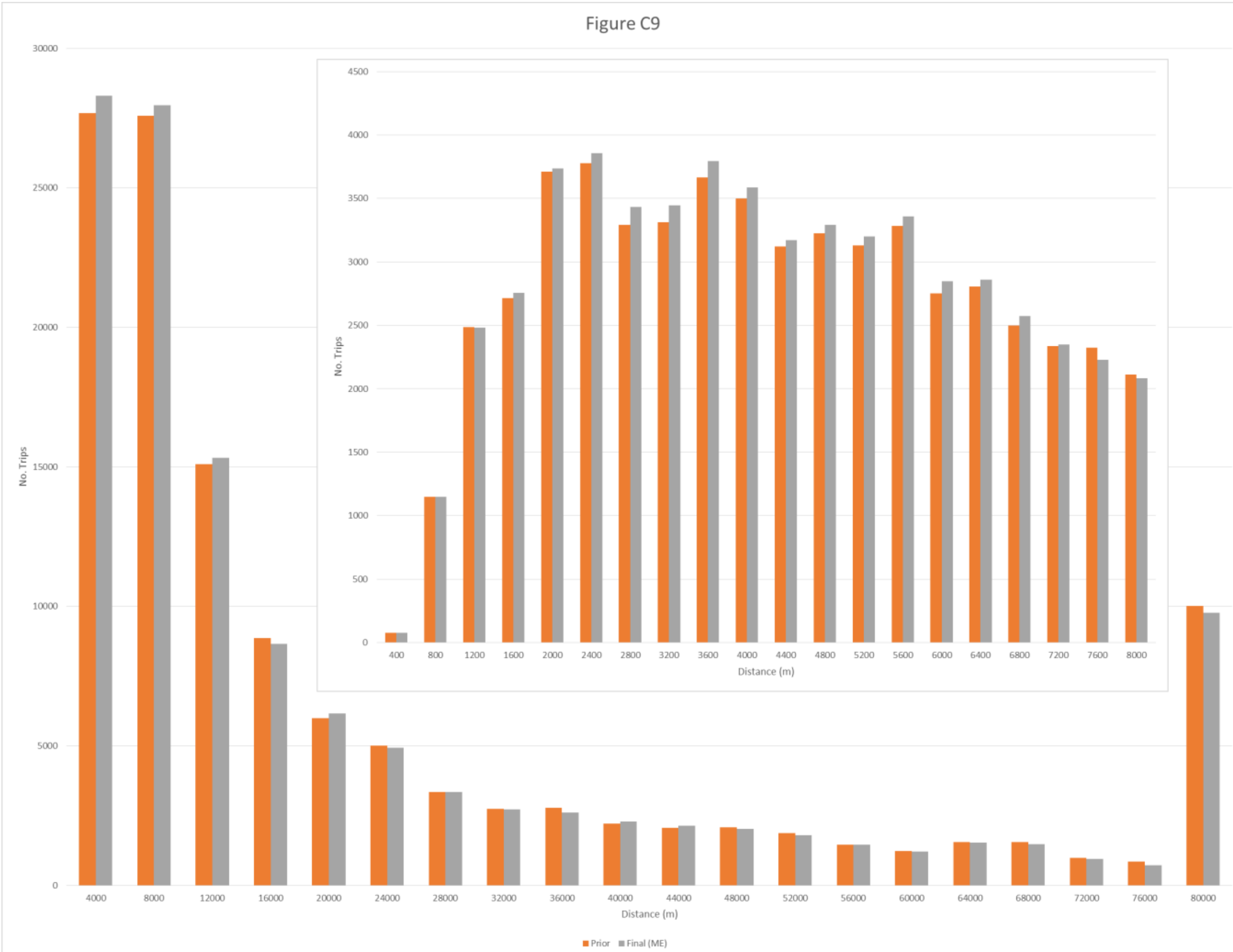
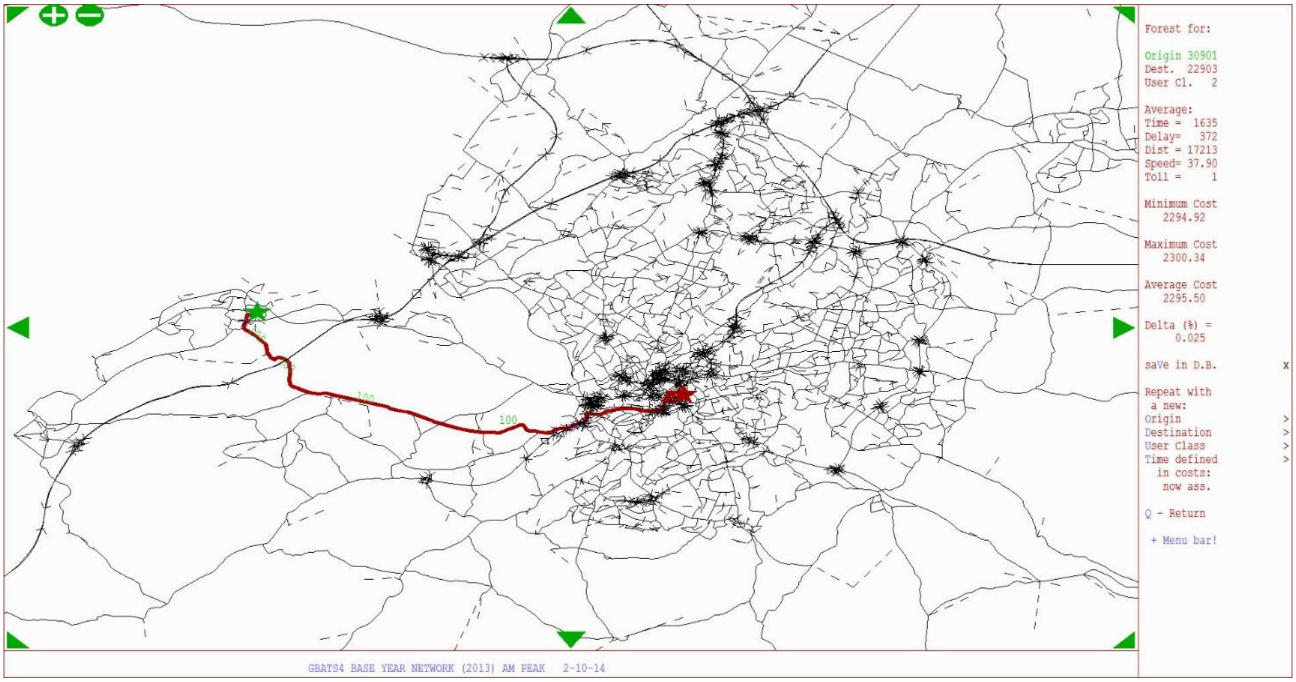


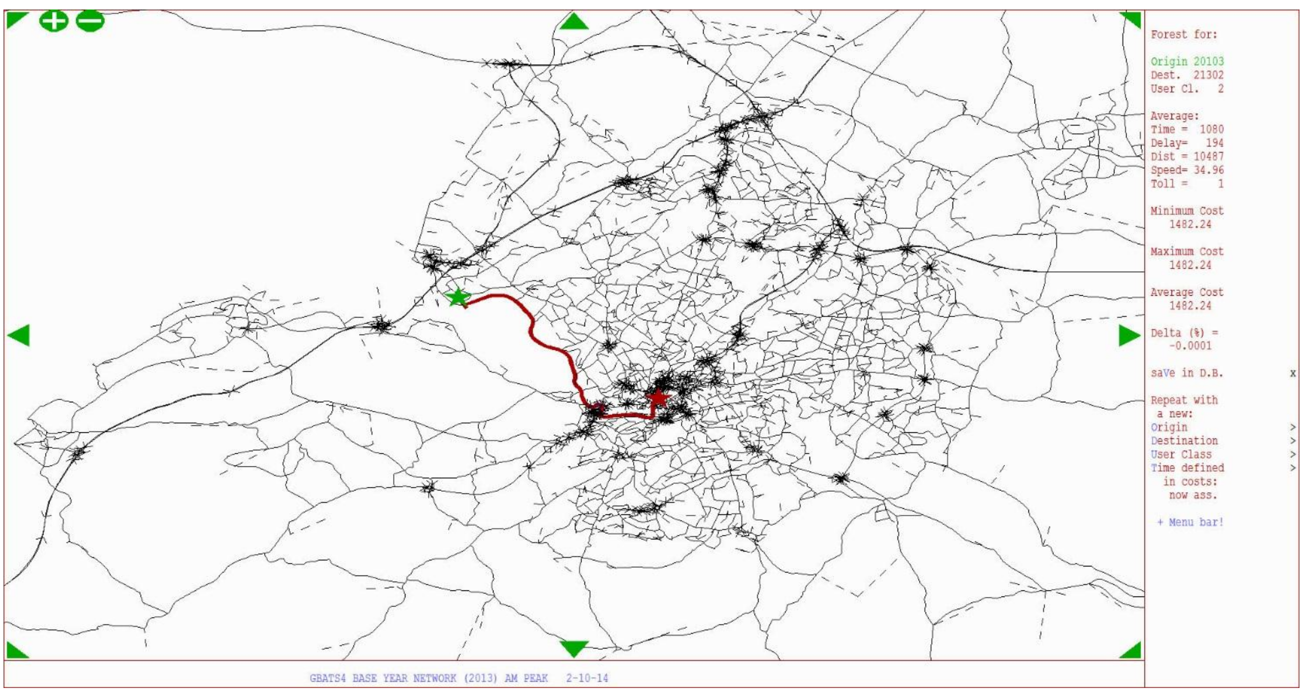
FIGURE C9
PM Trip Length Distribution

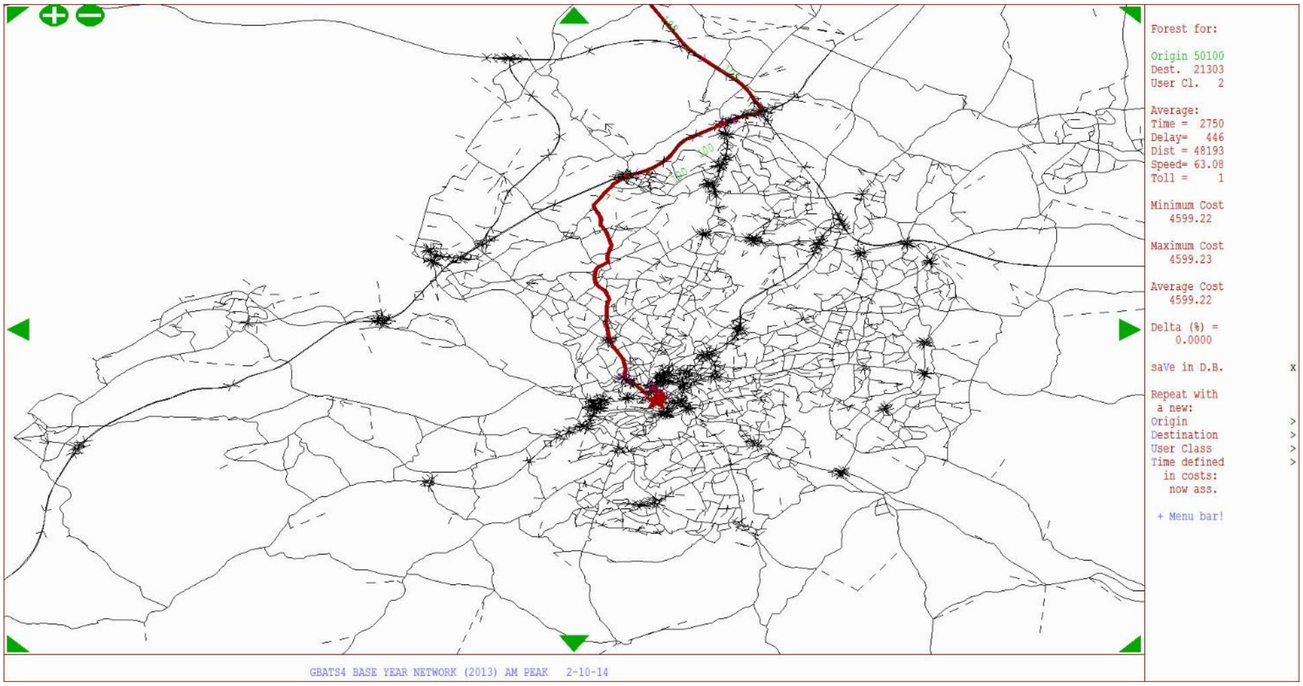


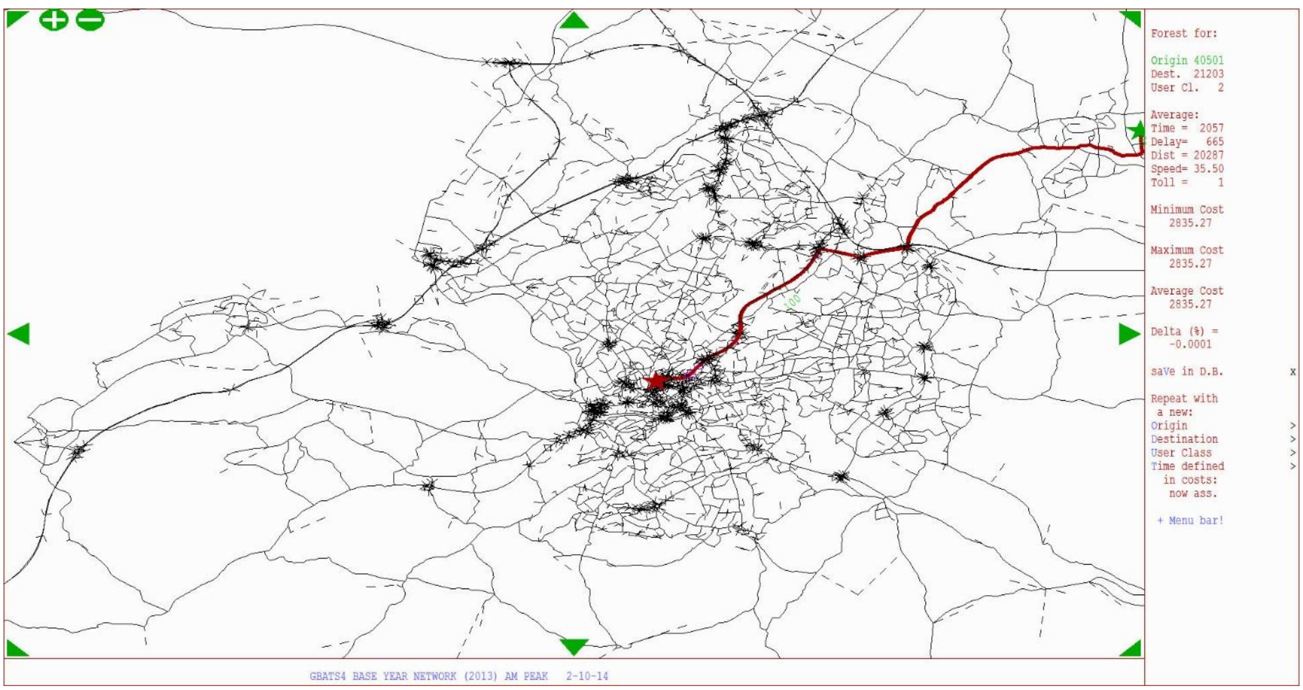
Appendix D: Route Choice Calibration

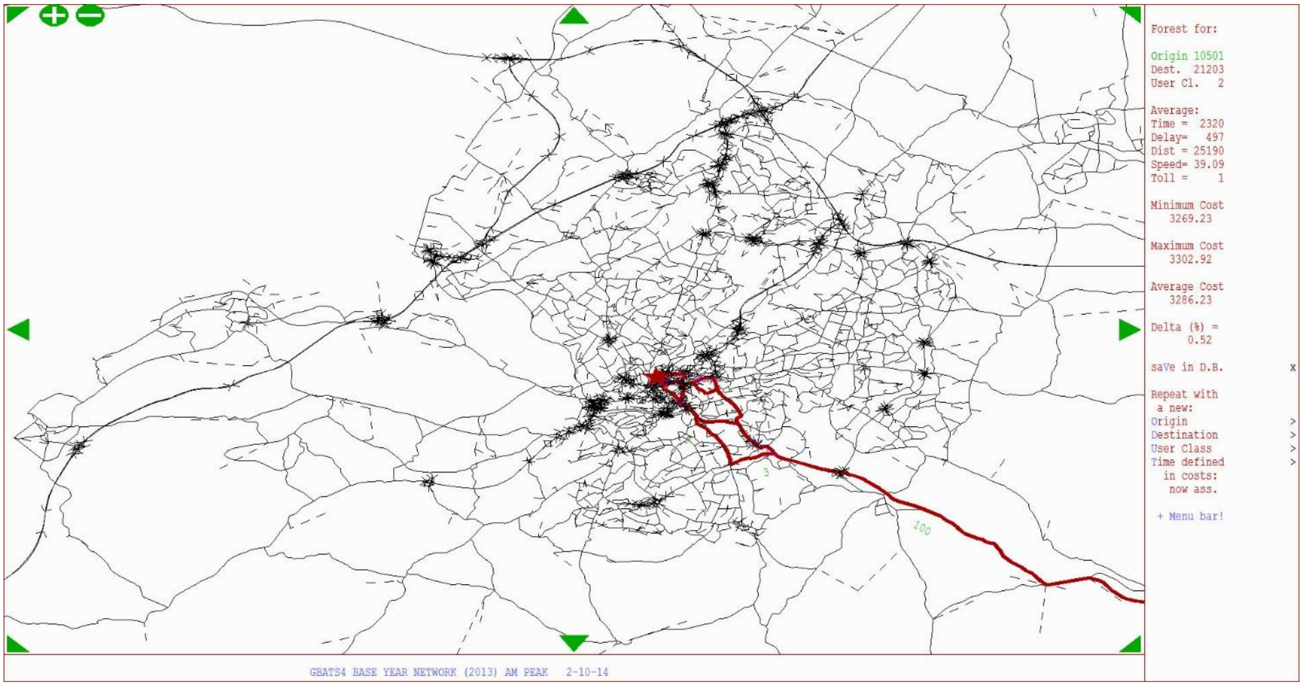
Part 1: Route Choice Path Plots

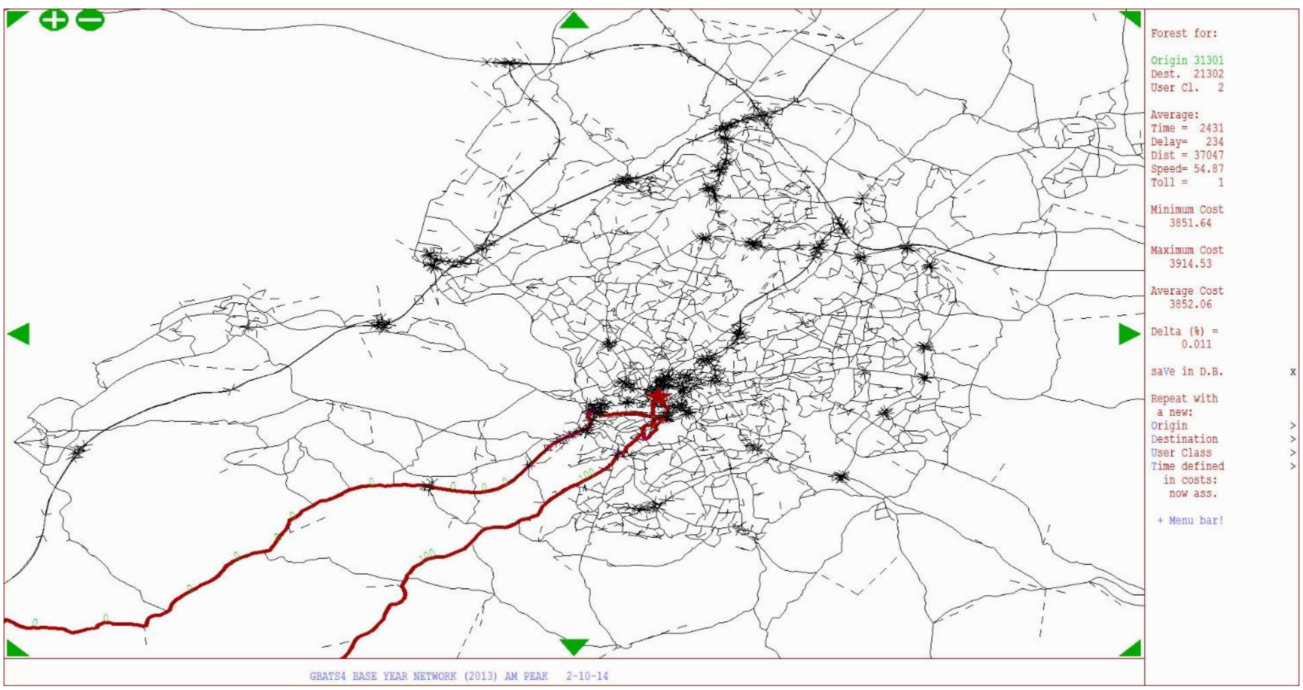


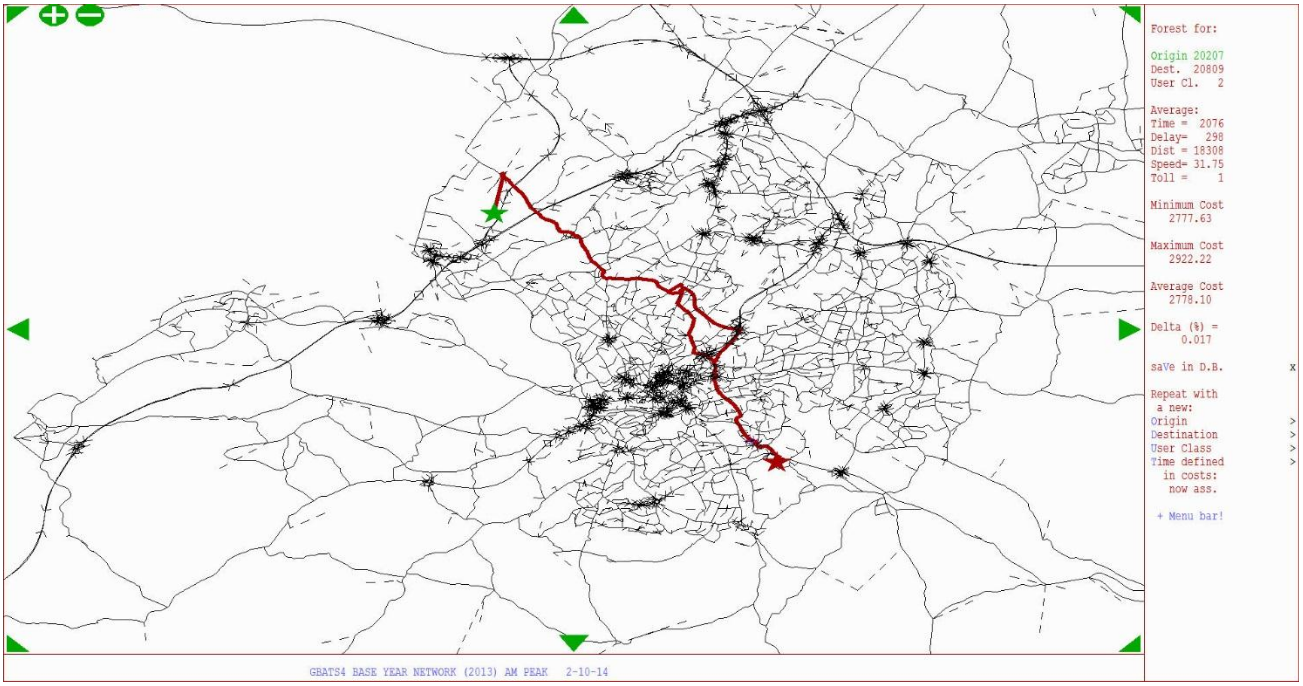


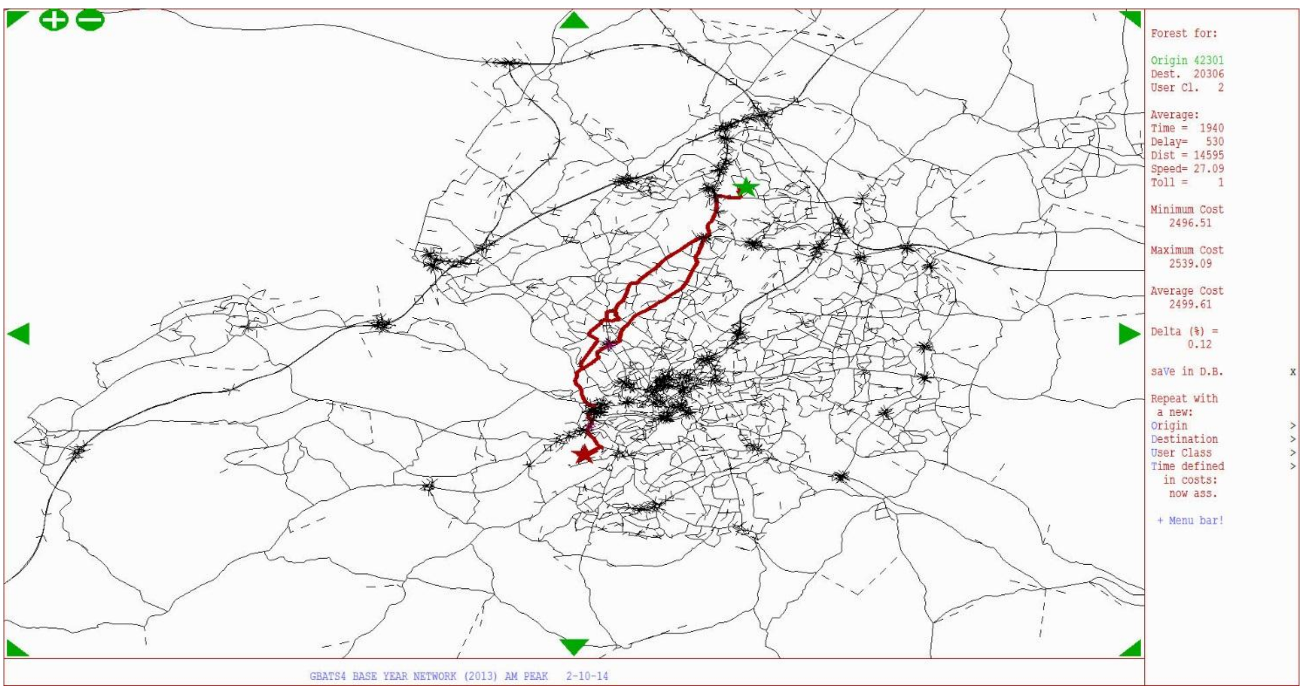

Forest for:
Origin 50100
Dest. 21303
User Cl. 2
Average:
Time = 2750
Delay= 446
Dist = 48193
Speed= 63.08
Toll = 1
Minimum Cost
4599.22
Maximum Cost
4599.23
Average Cost
4599.22
Delta (%) =
0.0000
saVe in D.B.
Repeat with
a new:
Origin
Destination
User Class
Time defined
in costs:
now ass.
+ Menu bar!
GBATS4 BASE YEAR NETWORK (2013) AM PEAK 2-10-14

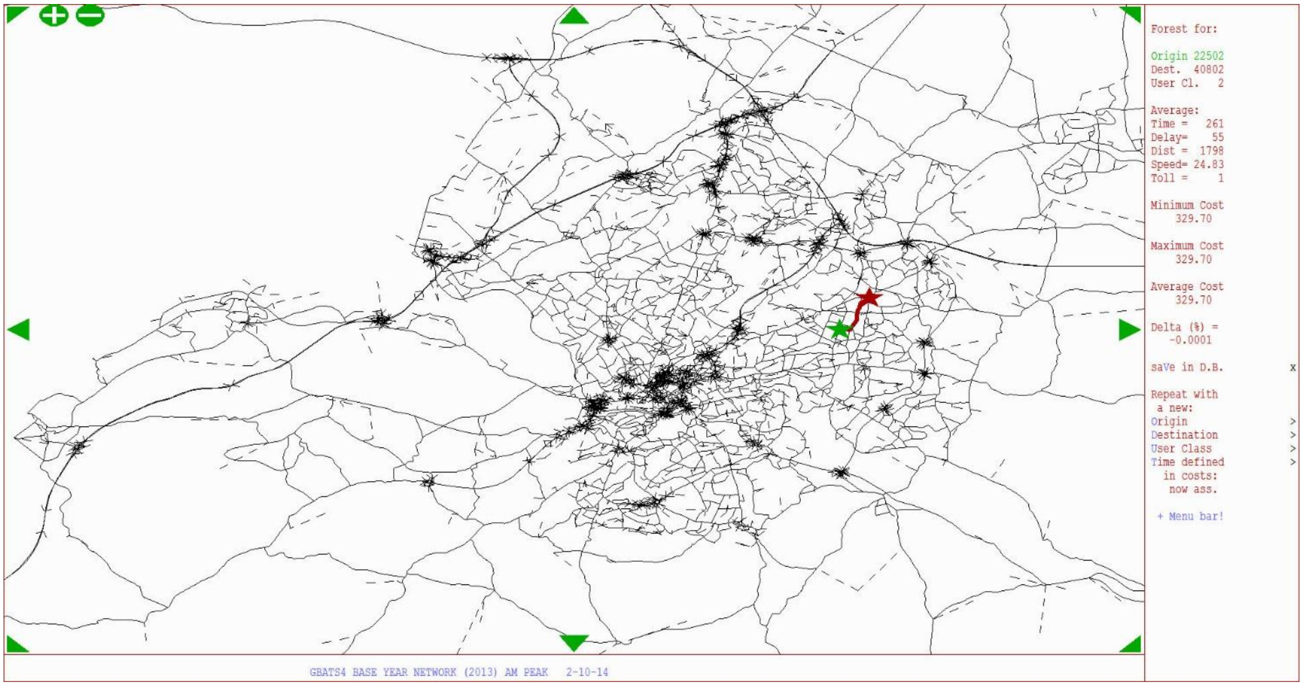

Forest for:
Origin 40501
Dest. 21203
User Cl. 2
Average:
Time = 2057
Delay= 665
Dist = 20287
Speed= 35.50
Toll = 1
Minimum Cost
2835.27
Maximum Cost
2835.27
Average Cost
2835.27
Delta (%) =
-0.0001
saVe in D.B.
Repeat with
a new:
Origin
Destination
User Class
Time defined
in costs:
now ass.
+ Menu bar!
GBATS4 BASE YEAR NETWORK (2013) AM PEAK 2-10-14

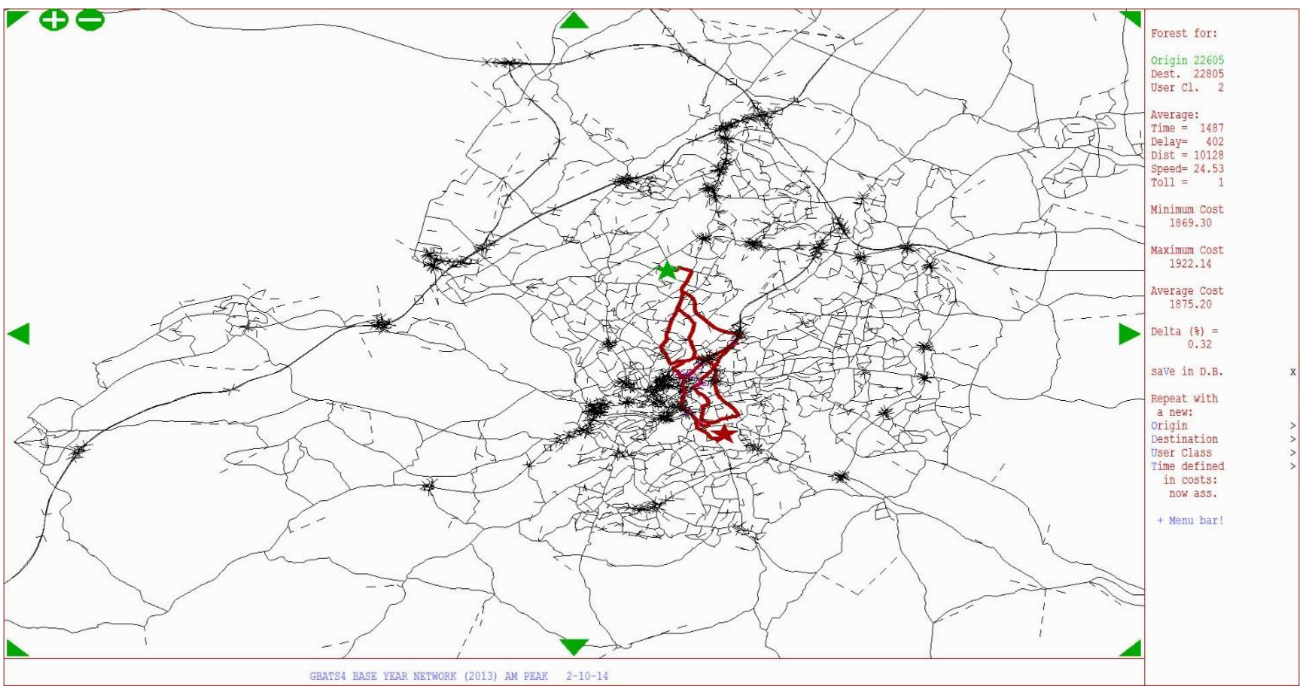

Forest for:
Origin 10501
Dest. 21203
User Cl. 2
Average:
Time = 2320
Delay= 497
Dist = 25190
Speed= 39.09
Toll = 1
Minimum Cost
3269.23
Maximum Cost
3302.92
Average Cost
3286.23
Delta (%) =
0.52
saVe in D.B. x
Repeat with
a new:
Origin >
Destination >
User Class >
Time defined >
in costs:
now ass.
+ Menu bar!
GBATS4 BASE YEAR NETWORK (2013) AM PEAK 2-10-14


Forest for:
Origin 31301
Dest. 21302
User Cl. 2
Average:
Time = 2431
Delay= 234
Dist = 37047
Speed= 54.87
Toll = 1
Minimum Cost
3851.64
Maximum Cost
3914.53
Average Cost
3852.06
Delta (%) =
0.011
saVe in D.B. x
Repeat with
a new:
Origin >
Destination >
User Class >
Time defined >
in costs:
now ass.
+ Menu bar!
GBATS4 BASE YEAR NETWORK (2013) AM PEAK 2-10-14


Forest for:
Origin 20207
Dest. 20809
User Cl. 2
Average:
Time = 2076
Delay= 298
Dist = 18308
Speed= 31.75
Toll = 1
Minimum Cost
2777.63
Maximum Cost
2922.22
Average Cost
2778.10
Delta (%) =
0.017
saVe in D.B.
x
Repeat with
a new:
Origin
Destination
User Class
Time defined
in costs:
now ass.
+ Menu bar!
GBATS4 BASE YEAR NETWORK (2013) AM PEAK 2-10-14


Forest for:
Origin 42301
Dest. 20306
User Cl. 2
Average:
Time = 1940
Delay= 530
Dist = 14595
Speed= 27.09
Toll = 1
Minimum Cost
2496.51
Maximum Cost
2539.09
Average Cost
2499.61
Delta (%) =
0.12
saVe in D.B.
x
Repeat with
a new:
Origin
Destination
User Class
Time defined
in costs:
now ass.
+ Menu bar!
GBATS4 BASE YEAR NETWORK (2013) AM PEAK 2-10-14


Forest for:
Origin 22502
Dest. 40802
User Cl. 2
Average:
Time = 261
Delay= 55
Dist = 1798
Speed= 24.83
Toll = 1
Minimum Cost
329.70
Maximum Cost
329.70
Average Cost
329.70
Delta (%) =
-0.0001
saVe in D.B.
Repeat with
a new:
Origin
Destination
User Class
Time defined
in costs:
now ass.
+ Menu bar!
GBATS4 BASE YEAR NETWORK (2013) AM PEAK 2-10-14


Forest for:
Origin 22605
Dest. 22805
User Cl. 2
Average:
Time = 1487
Delay= 402
Dist = 10128
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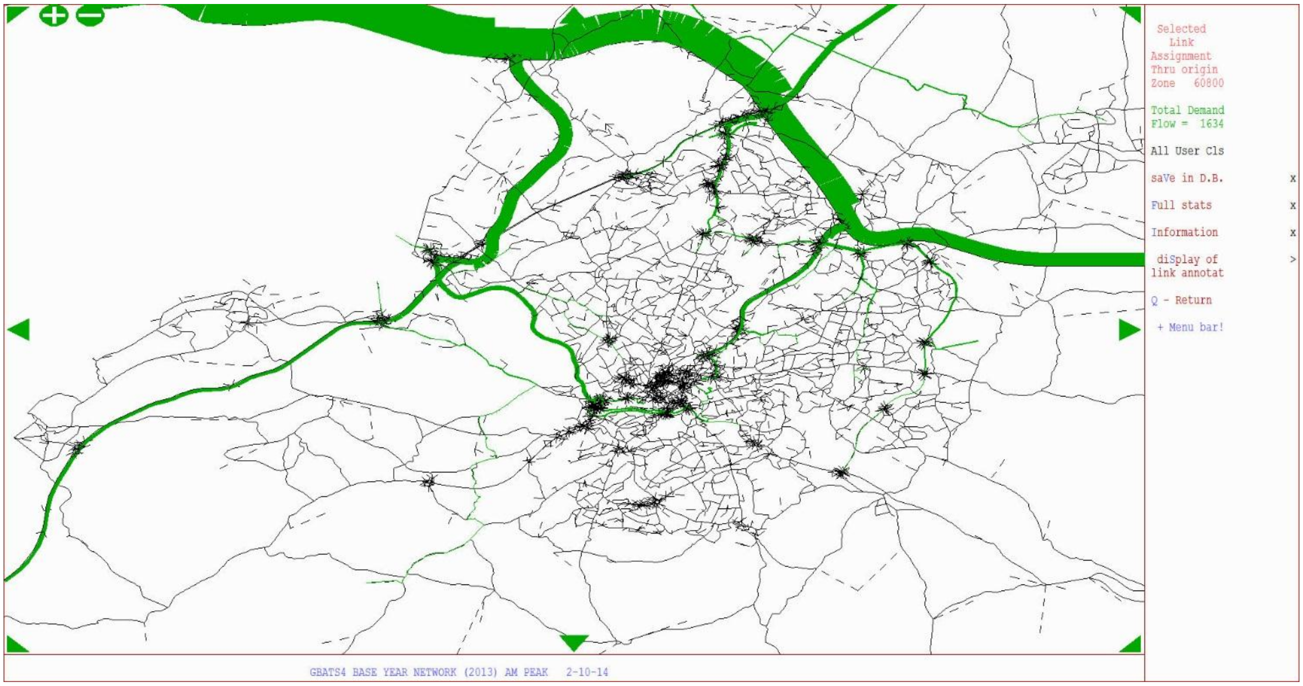
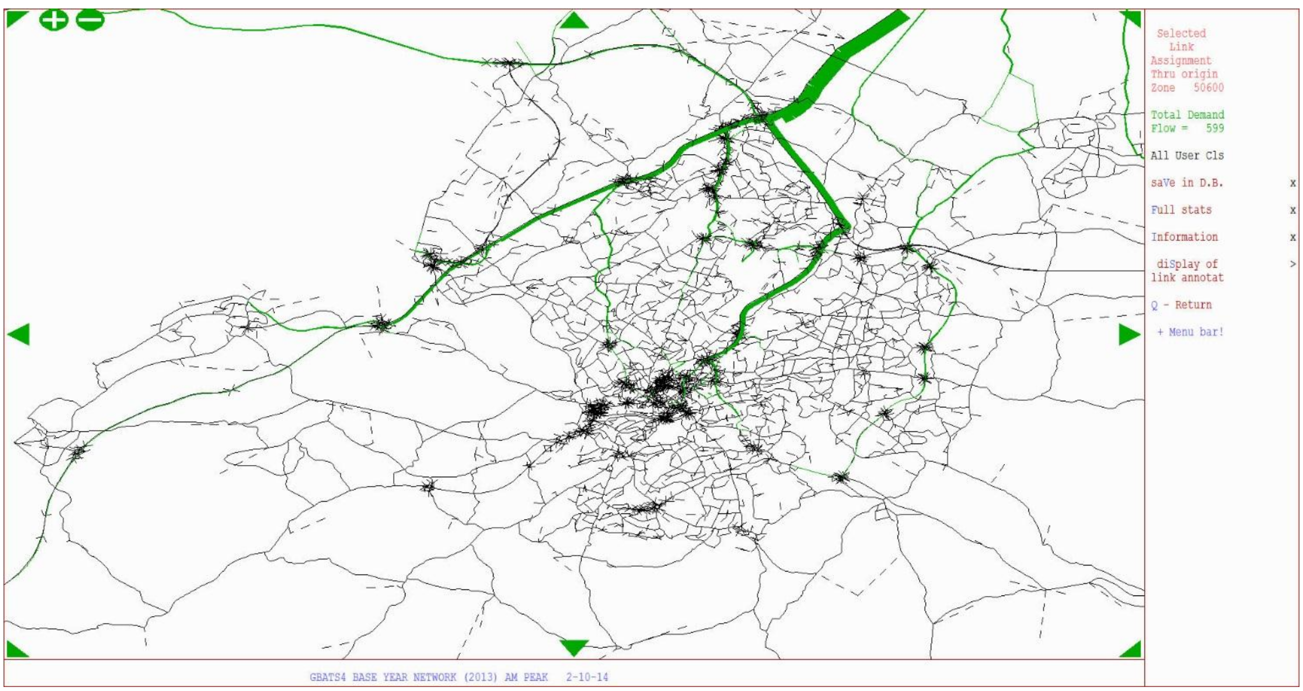
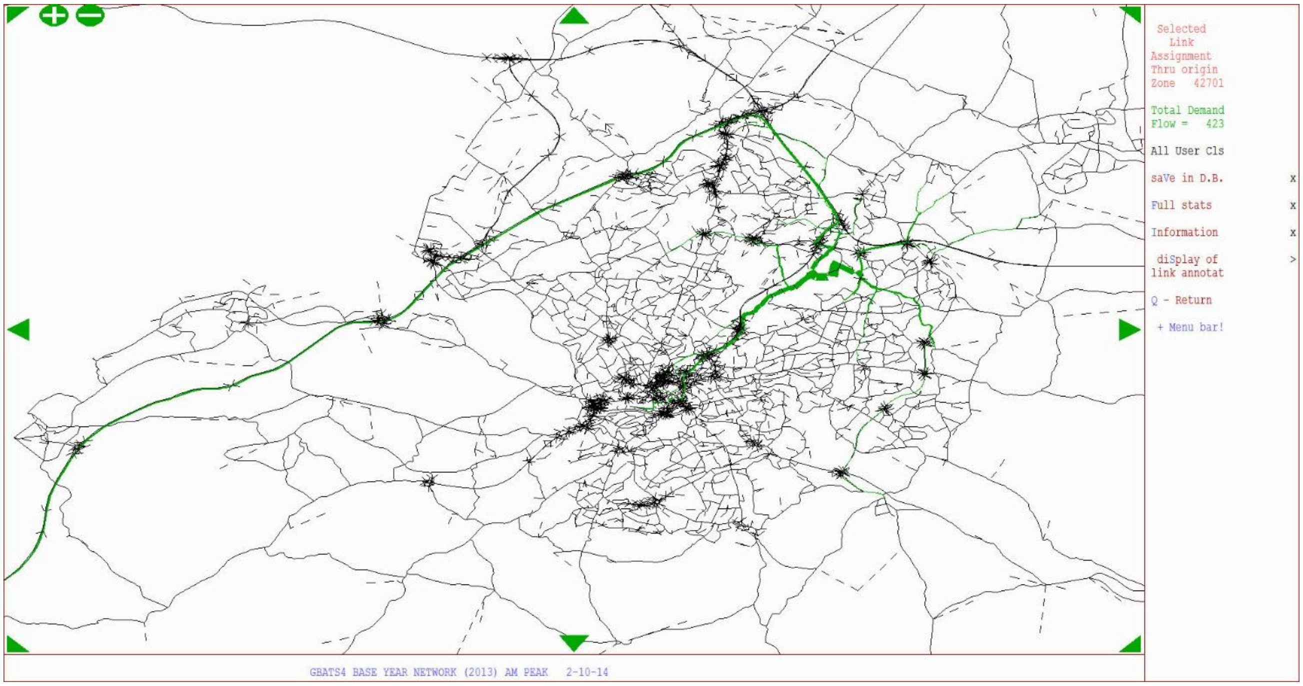
GBATS4 BASE YEAR NETWORK (2013) AM PEAK 2-10-14

Part 2: Route Choice Tree Plots



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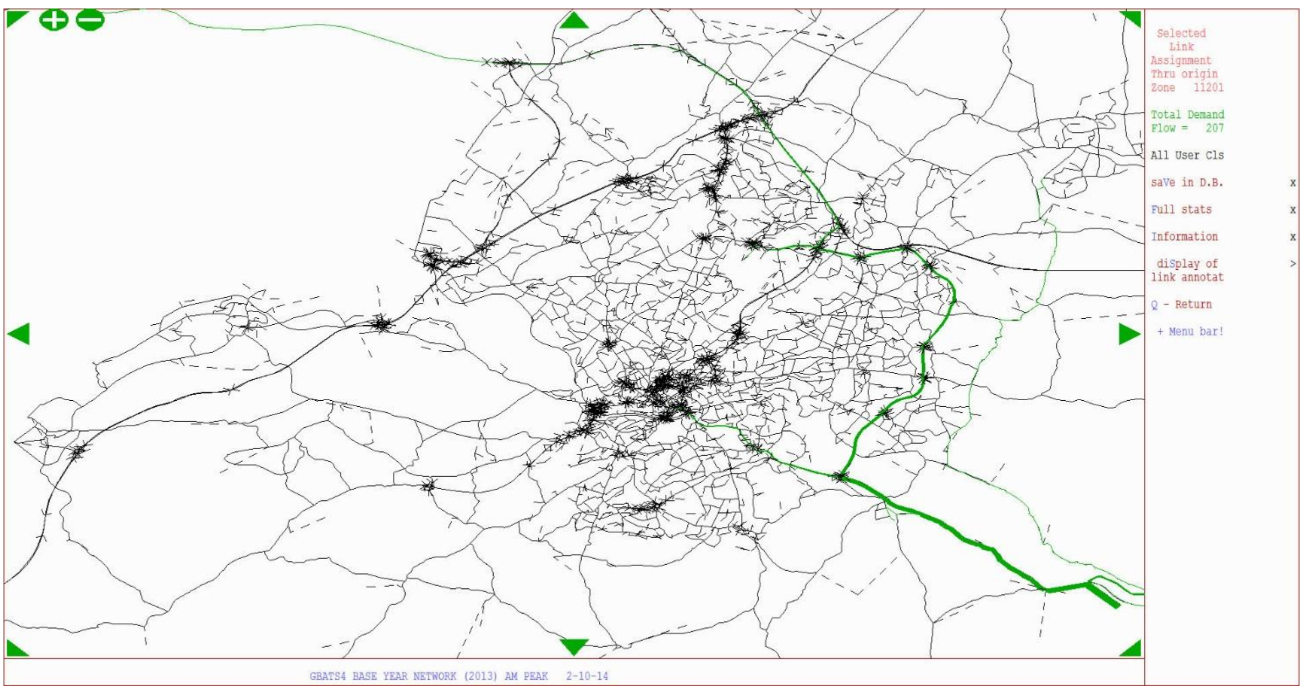
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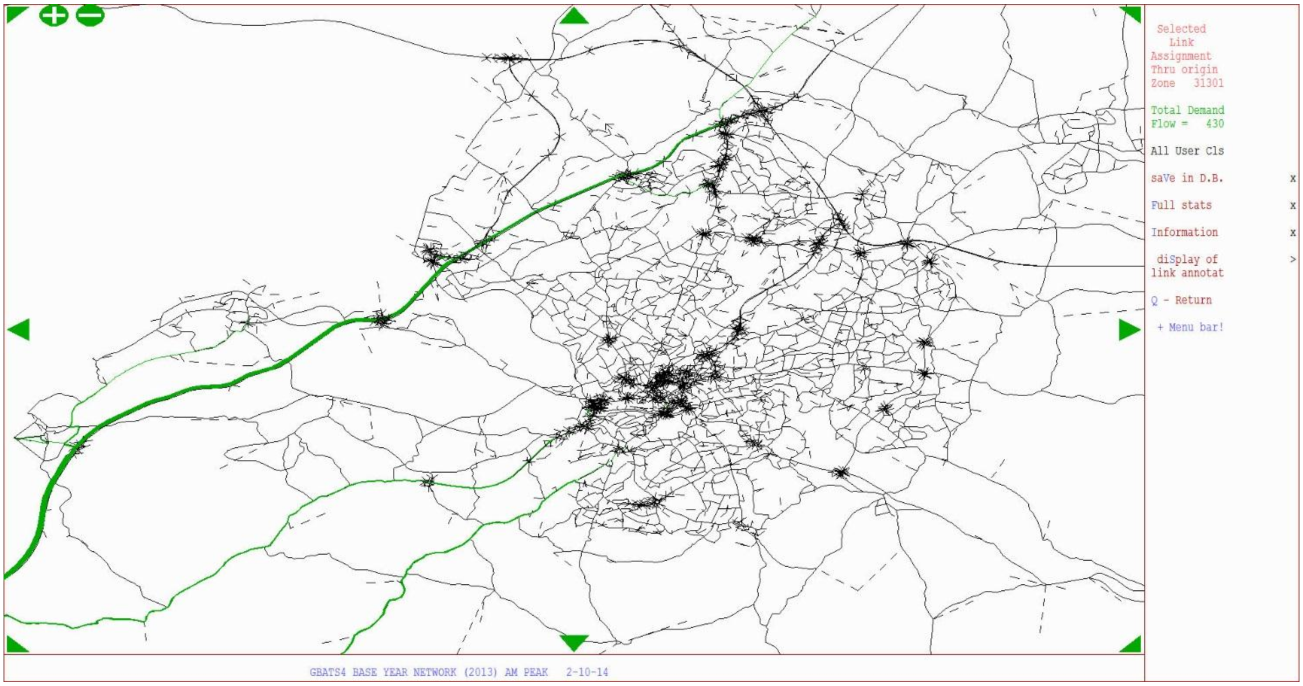
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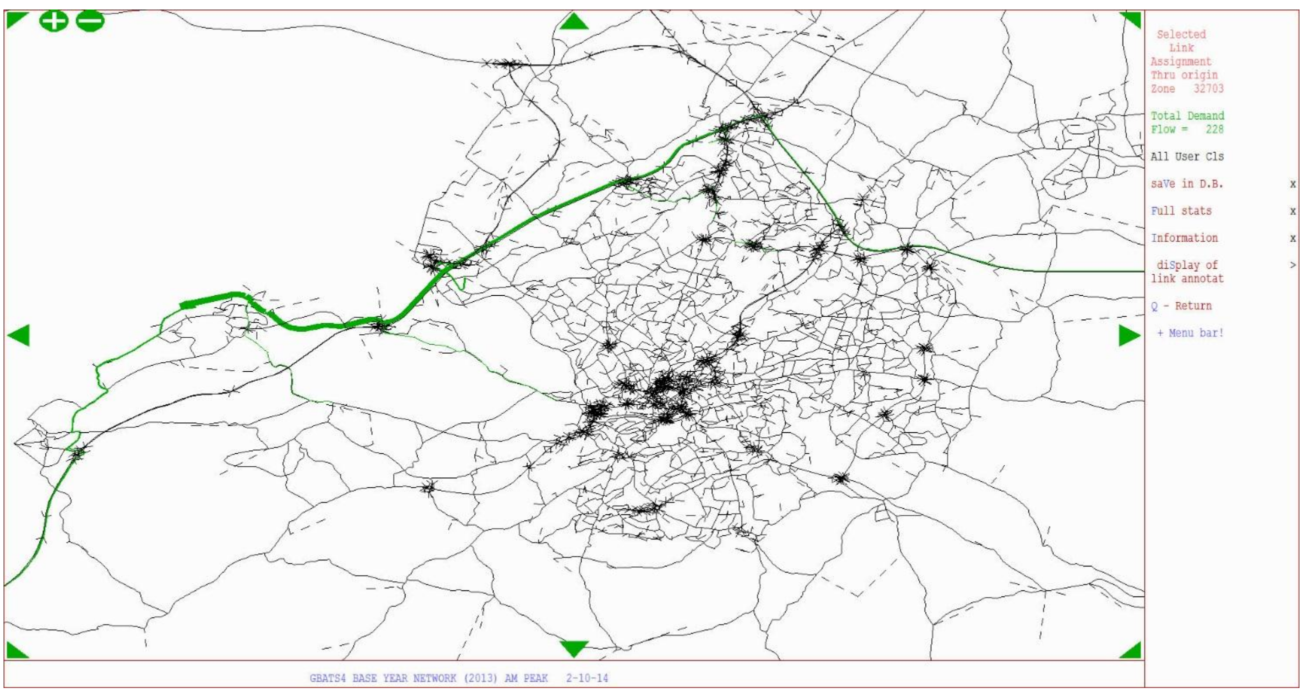
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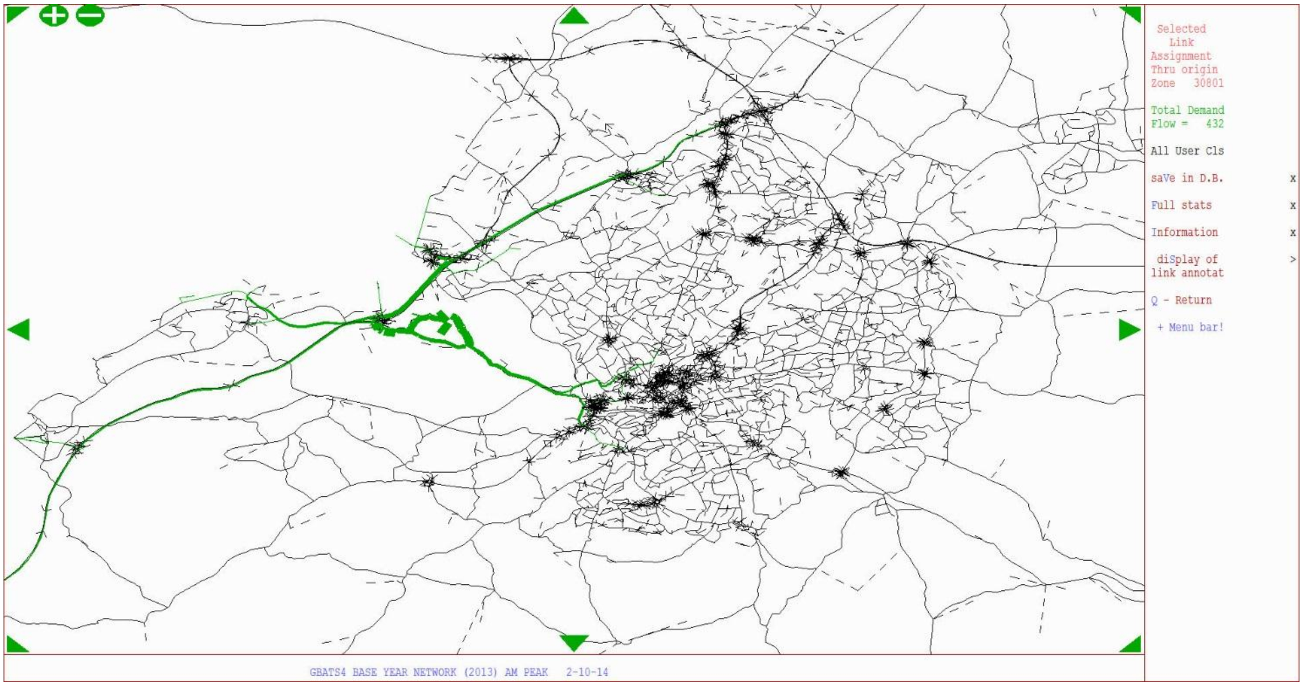
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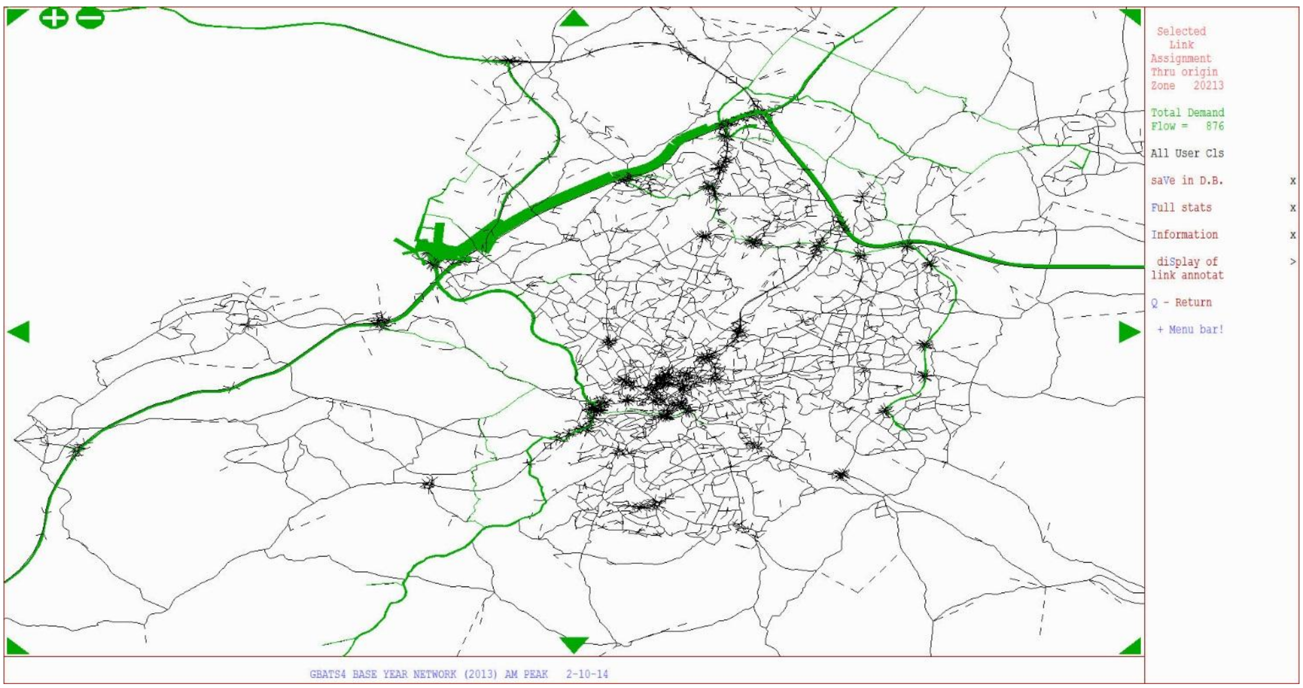
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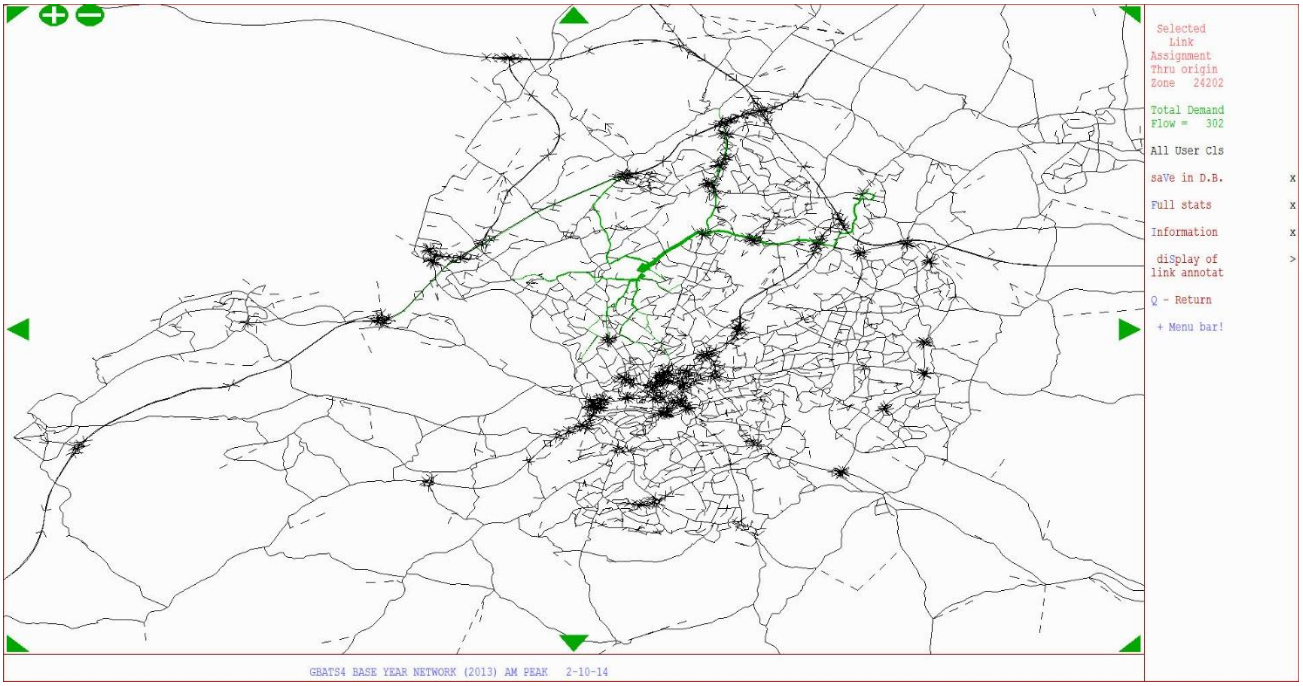
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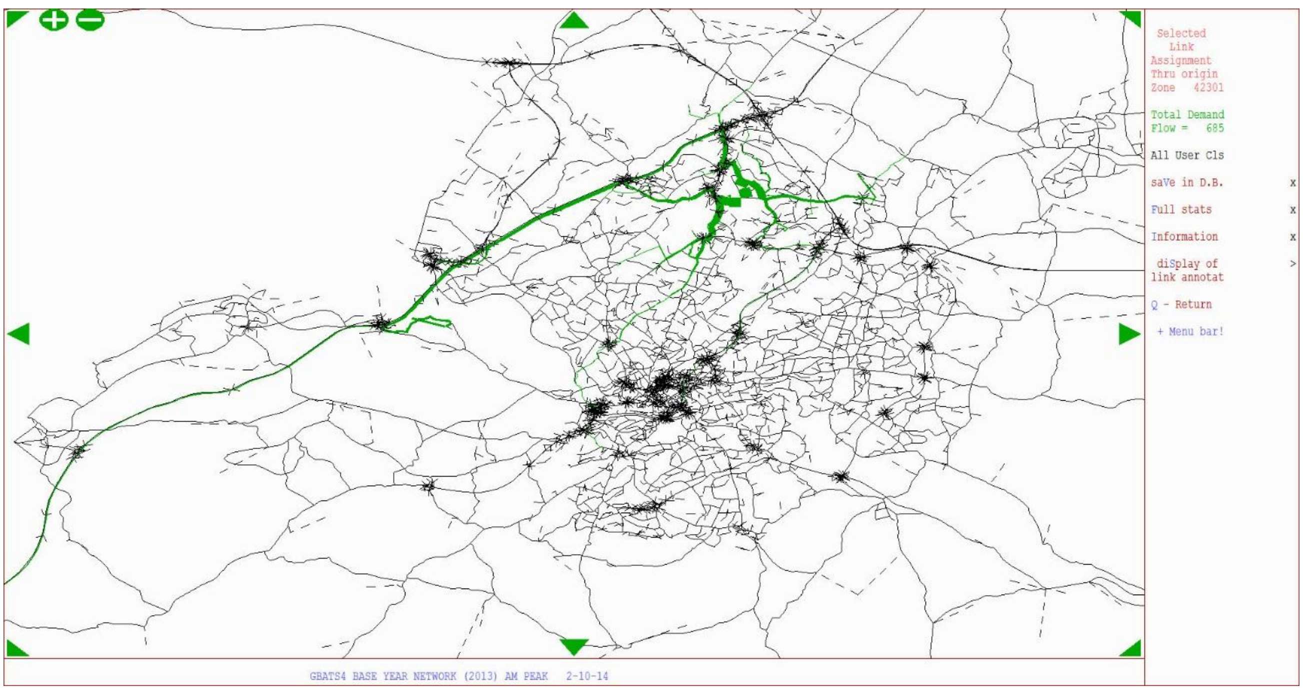
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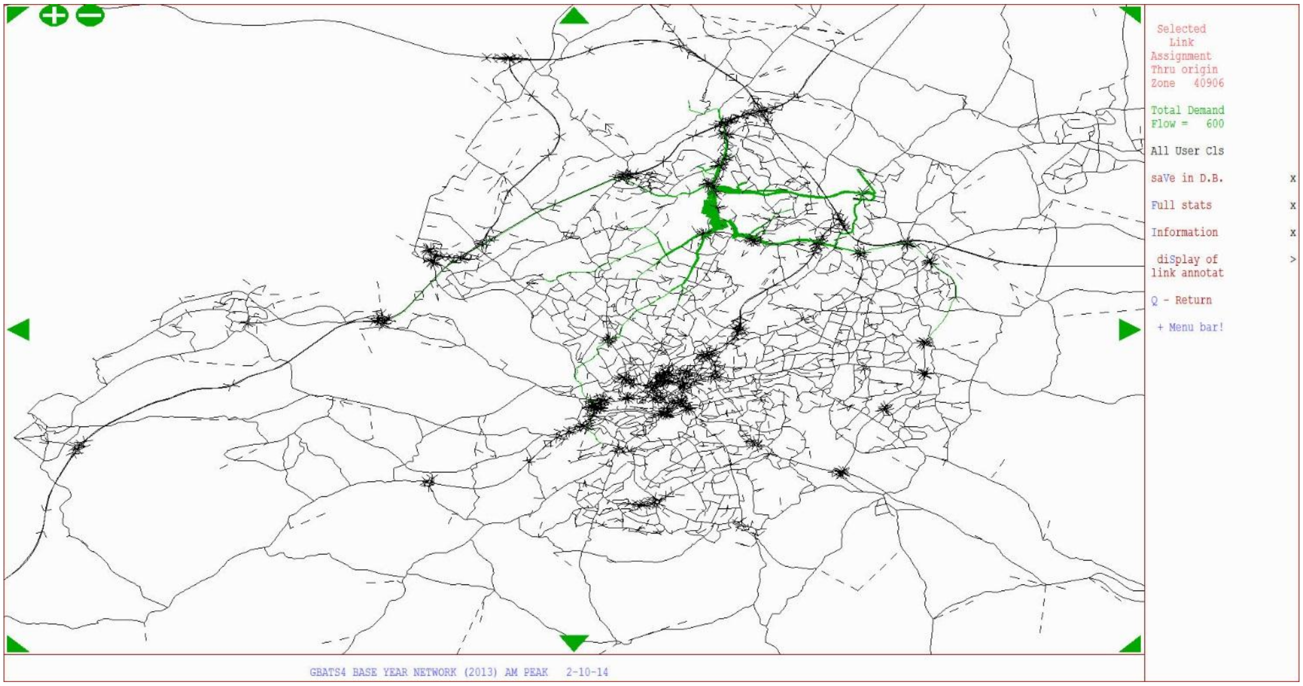
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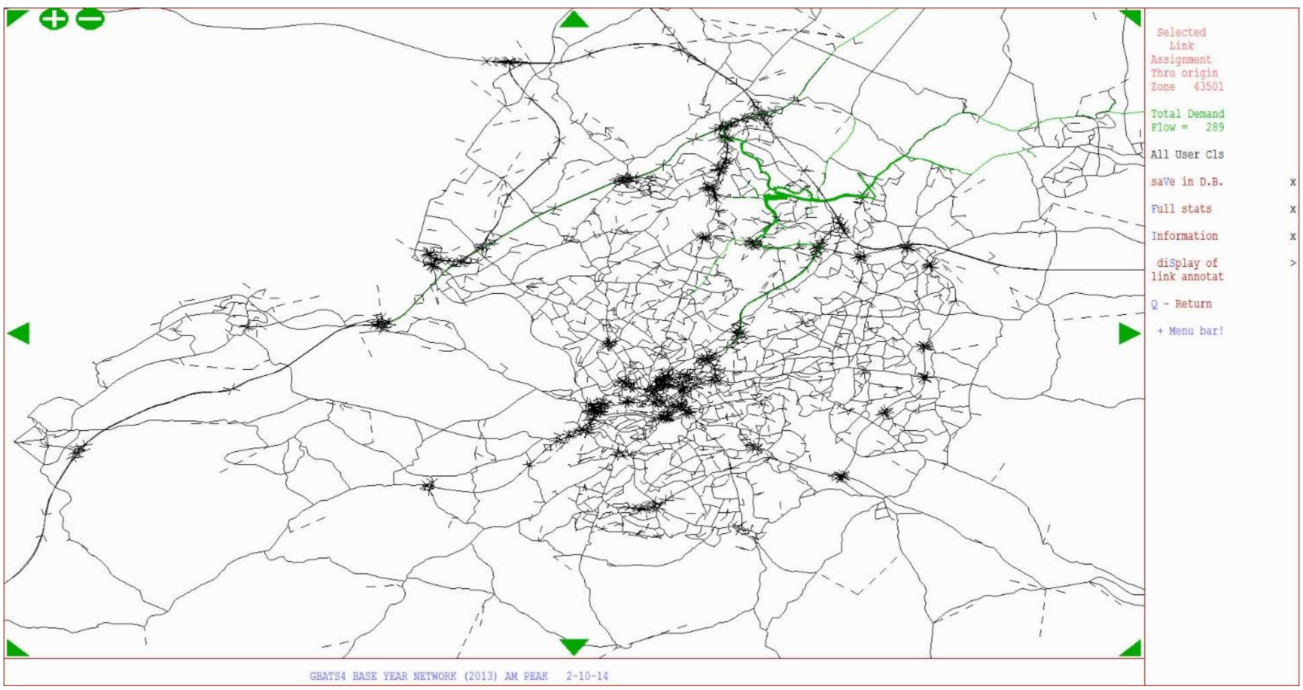
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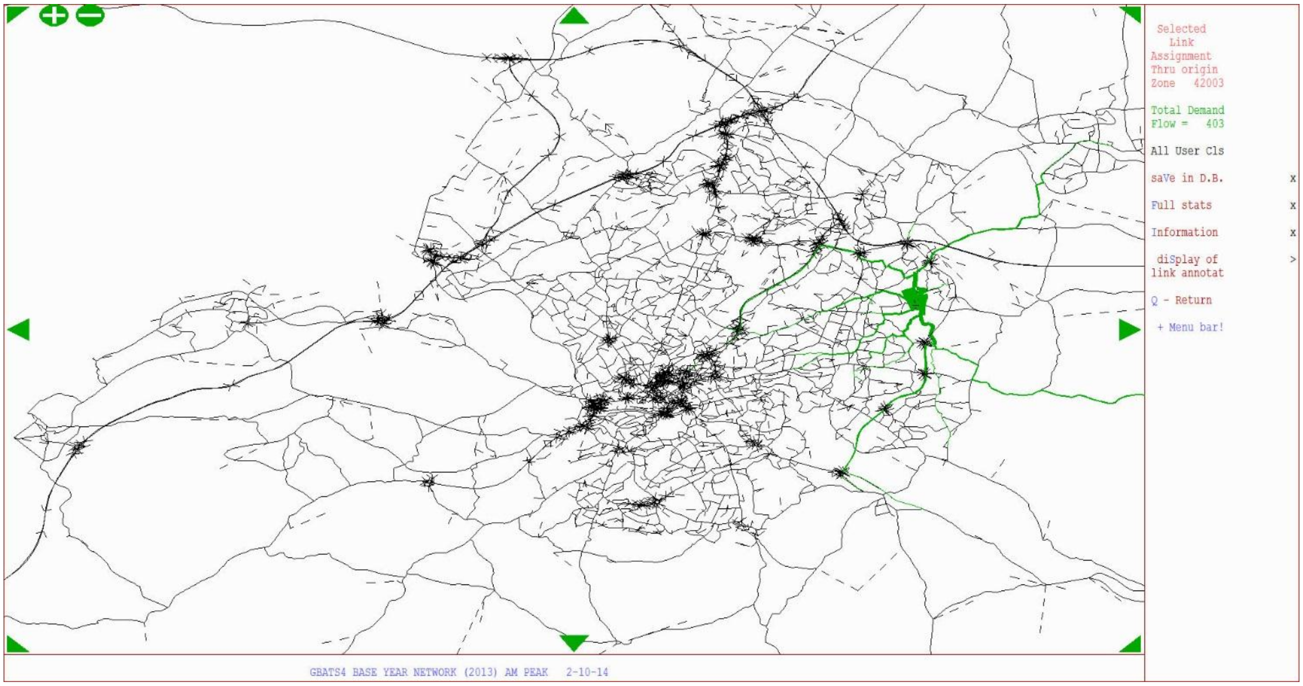
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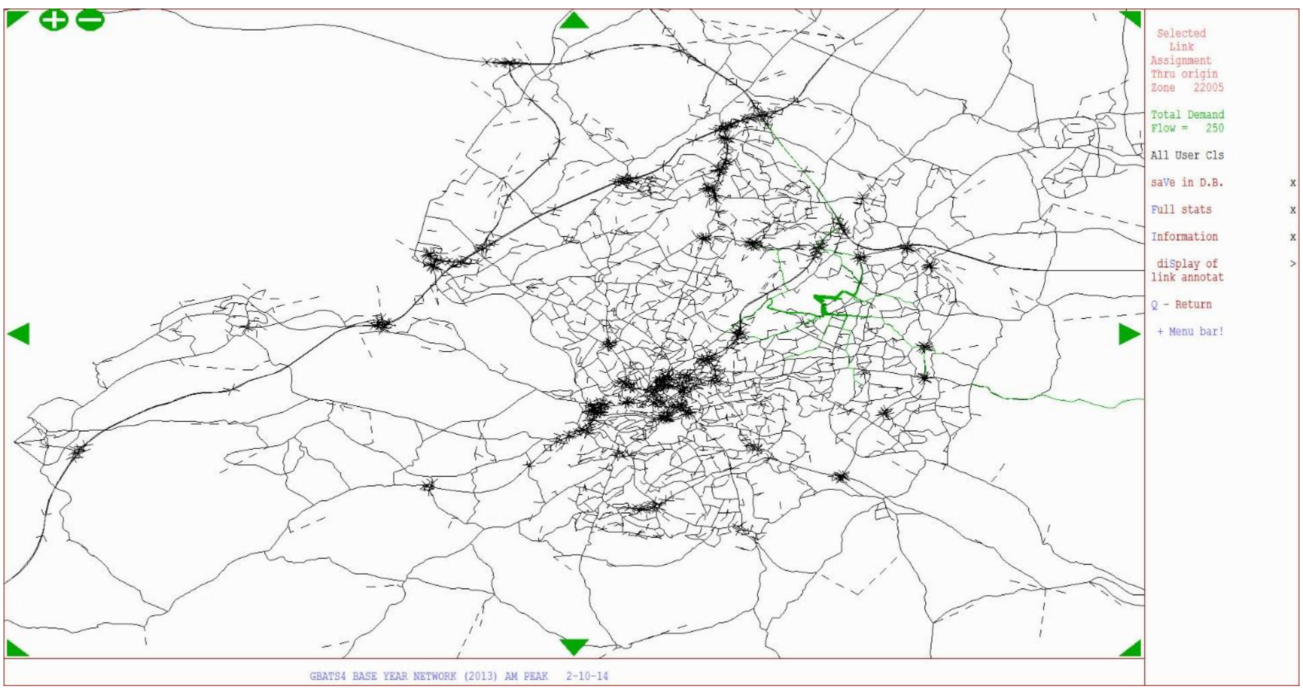
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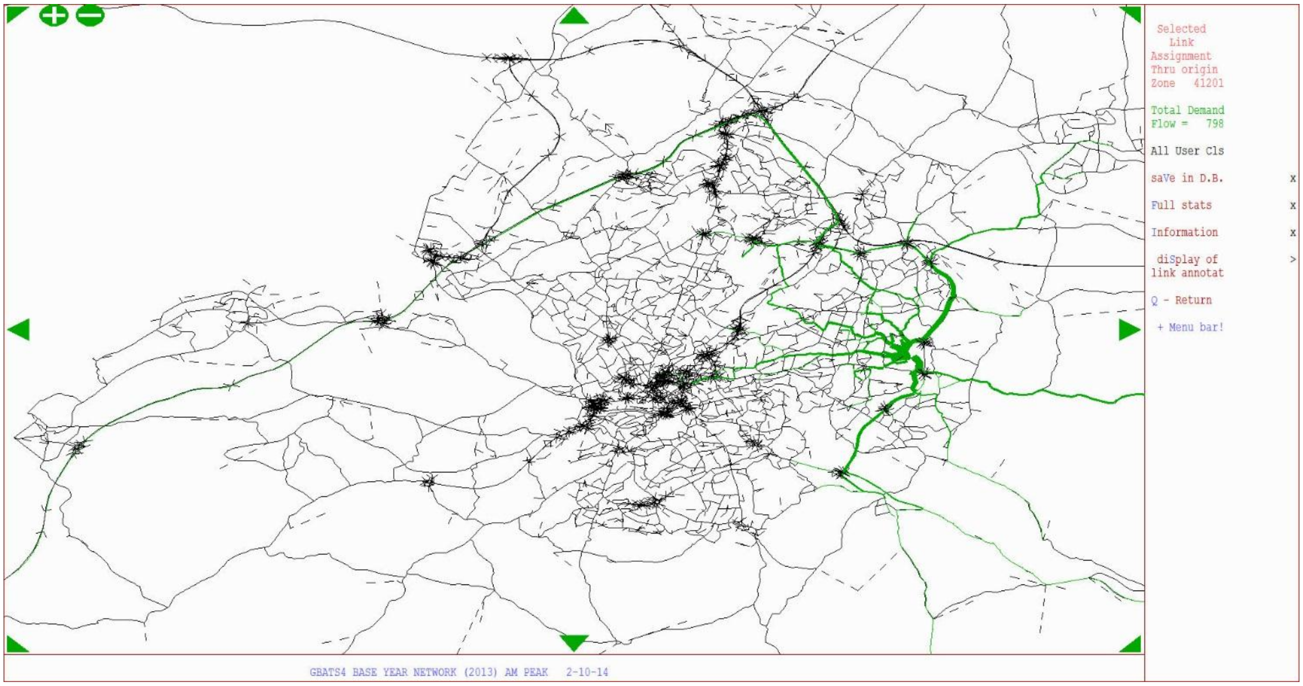
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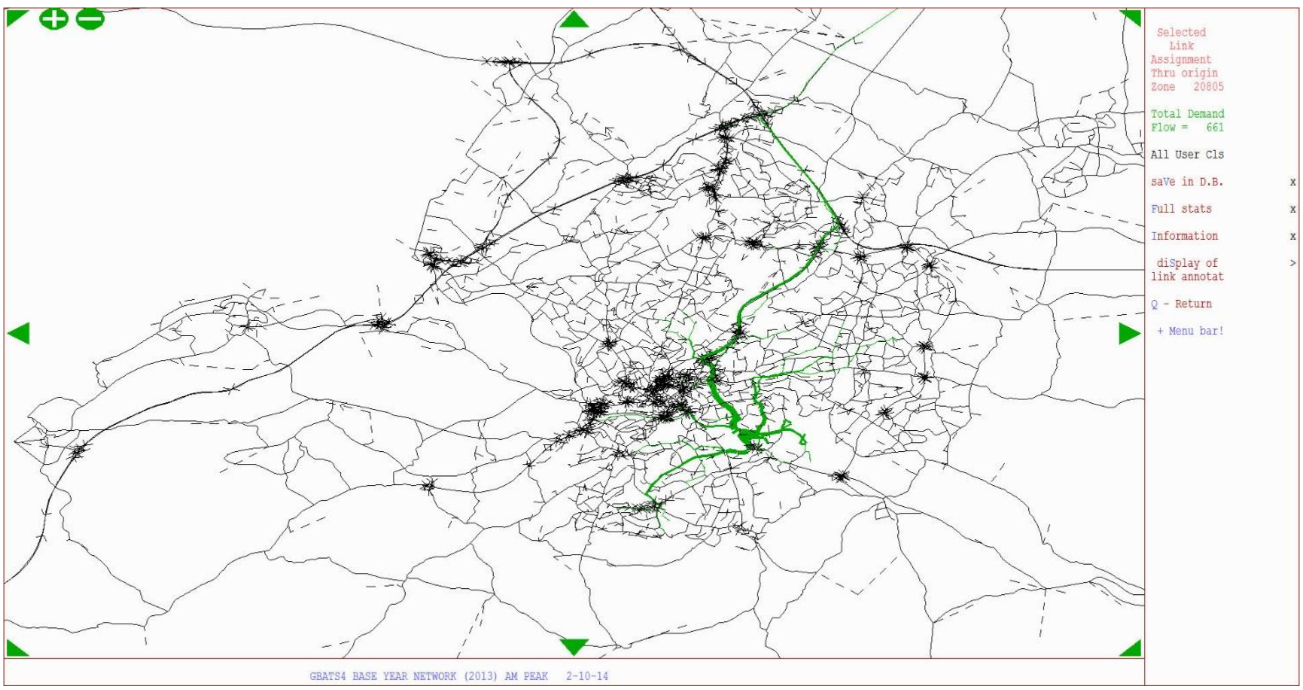
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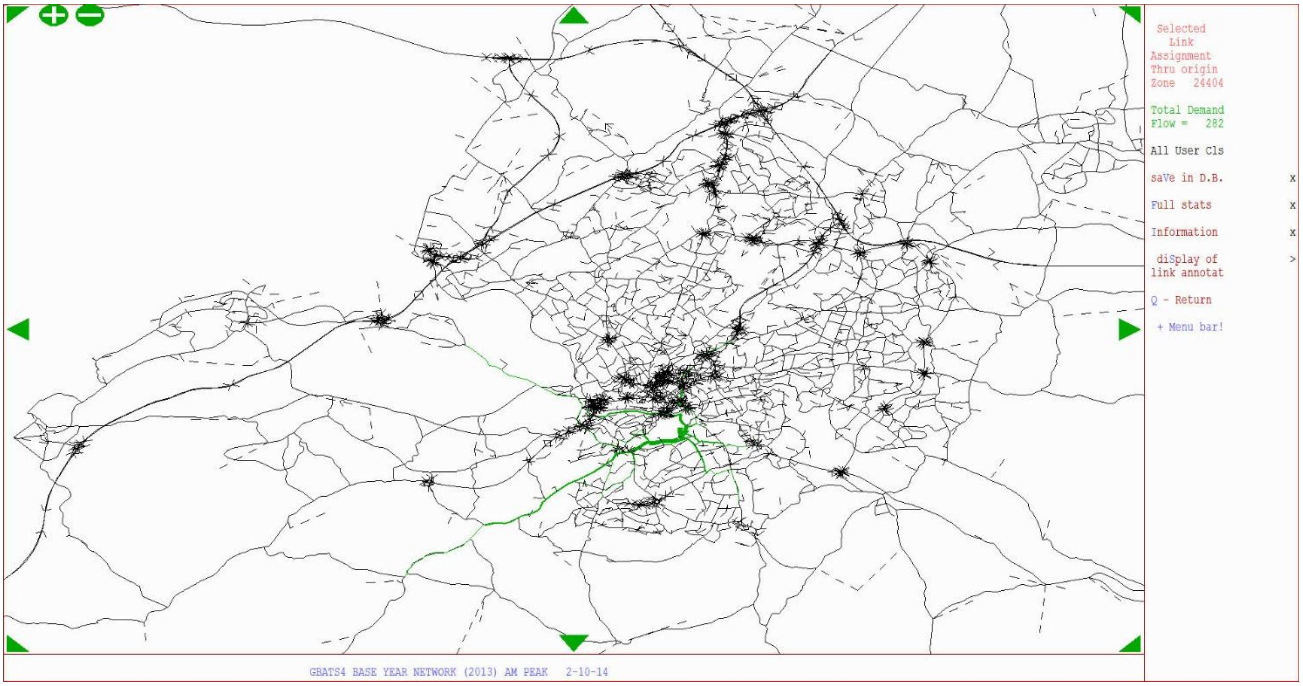
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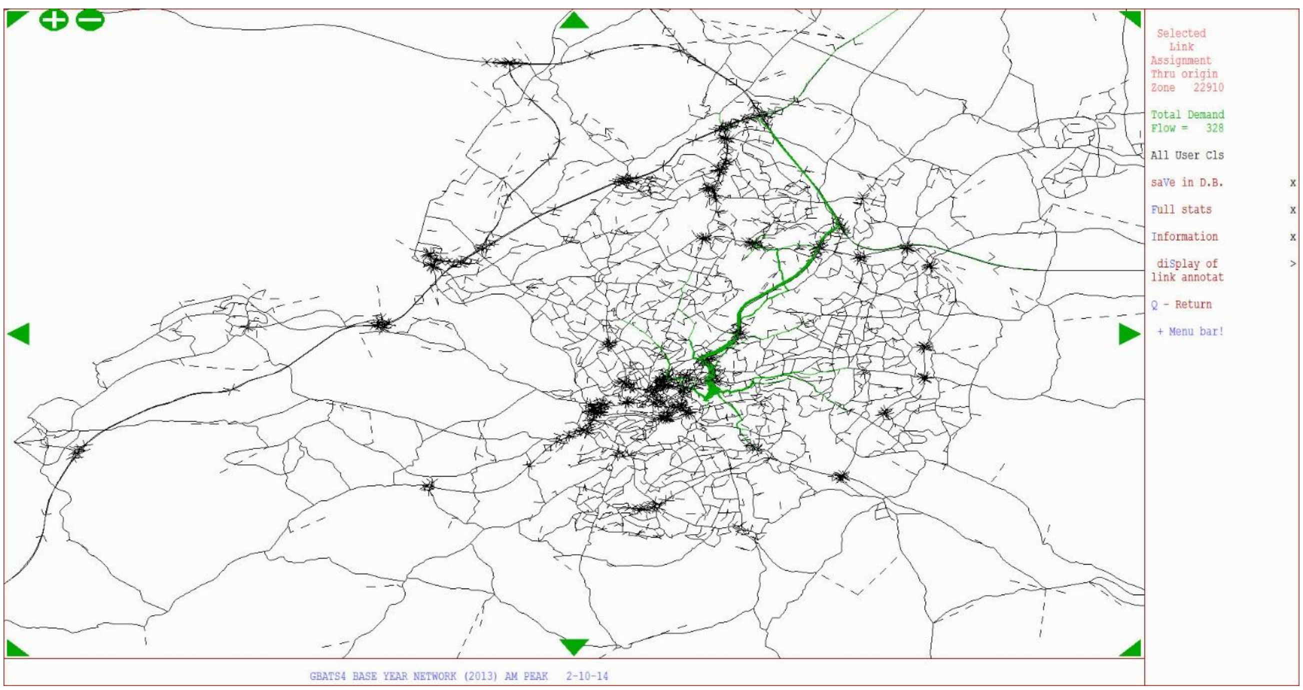
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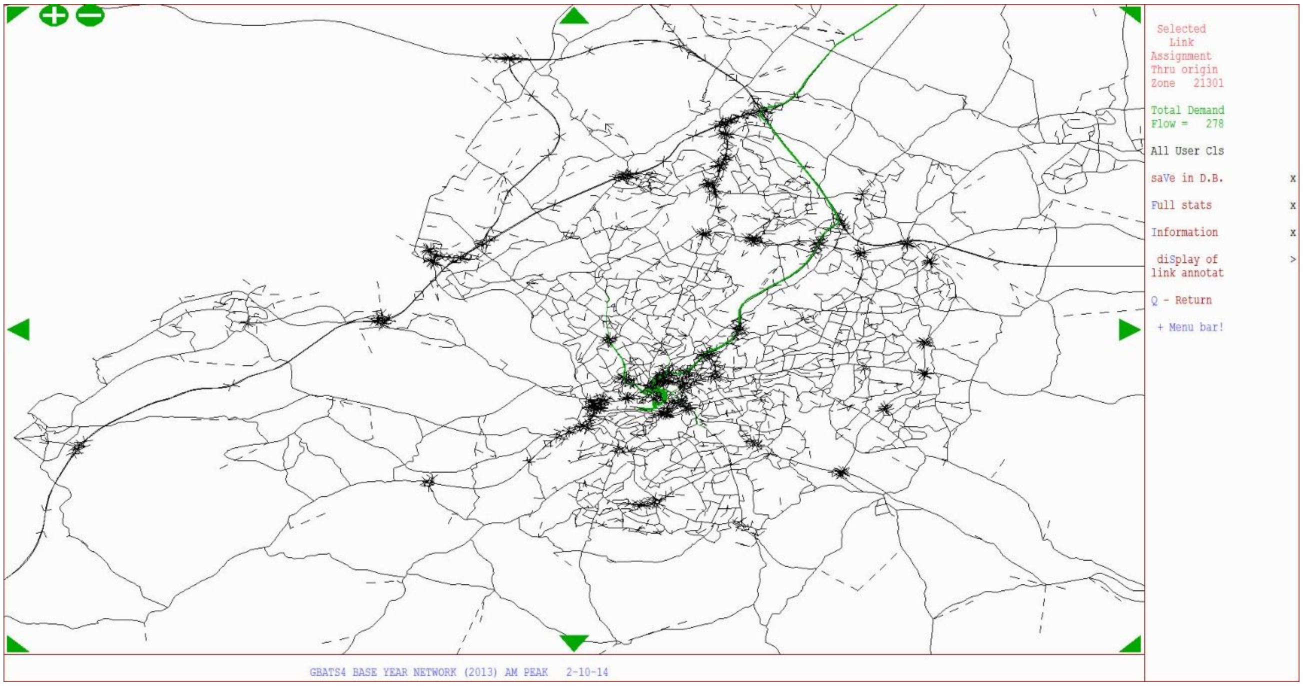
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GBATS4 BASE YEAR NETWORK (2013) AM PEAK 2-10-14

Appendix E: Traffic Link Flow Validation

TABLE E1

Morning Peak Traffic Flow Calibration Comparison

Ref No.	Road	Dir	A node	B node	Obs LV	Obs Total PCUs	Model LV	Model Total PCUs	GEH PCUs	GEH LVs
RSI1	A4018 Whiteladies Road	IN	1488	2709	1146	**1310**	1377	**1520**	5.6	6.5
I5	Woodland Rd	IN	2557	1226	243	**350**	264	**292**	3.2	1.3
RSI2	Horfield Road	IN	1863	1539	411	**436**	529	**545**	4.9	5.5
RSI3	A38 North Road	IN	1504	1566	690	**874**	647	**803**	2.4	1.6
I6	York Street	IN	2624	2625	37	**39**	35	**37**	0.4	0.4
RSI4	A4032 Newfoundland Street	IN	3976	3982	1773	**1922**	1861	**1947**	0.6	2.1
RSI5	A420 Old Market Street	IN	4034	1219	1506	**1667**	1608	**1754**	2.1	2.6
RSI6	Avon Street	IN	1769	1591	301	**323**	266	**291**	1.8	2.1
I8	Station Approach Rd	IN	1482	1480	236	**403**	147	**280**	6.6	6.4
RSI7	Feeder Road	IN	1286	1574	302	**351**	335	**372**	1.1	1.9
RSI8	A4 Bath Road	IN	1189	1572	1295	**1534**	1351	**1473**	1.6	1.5
RSI9	St Lukes Road	IN	2163	1191	361	**364**	425	**434**	3.5	3.3
I1_I2	Whitehouse/Spring Street	IN	2164	8250	207	**222**	146	**154**	5.0	4.6
RSI10	Bedminster Parade	IN	4022	2161	535	**643**	455	**558**	3.5	3.6
RSI11	A370 Coronation Road	IN	1489	1558	709	**800**	1129	**1185**	12.2	13.8
RSI12	Cumberland Road	IN	2668	1711	743	**767**	676	**721**	1.7	2.5
RSI13	Hotwell Road	IN	1164	1705	1815	**2000**	1844	**2010**	0.2	0.7
I4	Constitution Hill	IN	2558	2559	157	**162**	151	**154**	0.6	0.5
I3	Lower Clifton Hill (one way)	IN	2558	2560	59	**66**	85	**85**	2.2	3.0
RSI1	A4018 Whiteladies Road	OUT	1228	1229	1281	**1456**	1361	**1517**	1.6	2.2
I5	Woodland Rd	OUT	1226	2557	115	**165**	164	**164**	0.1	4.2
RSI2	Horfield Road	OUT	1539	1863	101	**122**	113	**130**	0.7	1.1
RSI3	A38 North Road	OUT	1607	1504	295	**443**	206	**332**	5.6	5.7
I6	York Street	OUT	2625	2624	88	**93**	18	**52**	4.7	9.7
RSI4	A4032 Newfoundland Street	OUT	1470	3977	2306	**2499**	2311	**2428**	1.4	0.1
RSI5	A420 Old Market Street	OUT	1837	1220	482	**655**	475	**630**	1.0	0.3
RSI6	Avon Street	OUT	1591	1769	115	**132**	151	**169**	3.0	3.1
I8	Station Approach Rd	OUT	1480	1482	287	**358**	304	**414**	2.9	1.0
RSI7	Feeder Road	OUT	1574	1286	169	**189**	94	**138**	4.0	6.5
RSI8	A4 Bath Road	OUT	1572	1189	978	**1210**	1082	**1362**	4.3	3.2
RSI9	St Lukes Road	OUT	1191	2163	165	**169**	212	**230**	4.3	3.4
I1_I2	Whitehouse/Spring Street	OUT	8250	2164	190	**199**	213	**217**	1.3	1.6
RSI10	Bedminster Parade	OUT	2161	4022	249	**316**	246	**327**	0.6	0.2
RSI11	A370 Coronation Road	OUT	1558	1489	550	**630**	666	**730**	3.8	4.7
RSI12	Cumberland Road	OUT	1711	2668	510	**535**	419	**433**	4.7	4.2
RSI13	Hotwell Road	OUT	2593	1521	1395	**1614**	1452	**1604**	0.3	1.5
I4	Constitution Hill	OUT	2559	2558	184	**191**	187	**193**	0.2	0.2
E1	A4174	IN	9961	9960	1597	**1888**	1866	**2018**	3.0	6.5
E2	Downend Rd	IN	2385	1066	484	**524**	493	**548**	1.1	0.4
E3	Staplehill Rd	IN	2383	1071	479	**525**	439	**505**	0.9	1.9
E4	Lodge Hill	IN	1079	1078	284	**376**	303	**332**	2.3	1.1
E5	Two Mile Hill Rd	IN	1255	2049	306	**341**	275	**326**	0.8	1.8

E6	Nags Head Hill	IN	2053	1276	633	**678**	705	**738**	2.3	2.8
E7	Crews Hole Road	IN	1999	1293	671	**687**	521	**541**	5.9	6.2
E9	Bath Rd	IN	8053	1406	1347	**1593**	1352	**1460**	3.4	0.1
E1	A4174	OUT	9960	9961	1484	**1754**	1539	**1695**	1.4	1.4
E2	Downend Rd	OUT	1066	2385	315	**348**	303	**364**	0.8	0.7
E3	Staplehill Rd	OUT	1071	2383	298	**330**	324	**360**	1.6	1.5
E4	Lodge Hill	OUT	1078	1079	136	**184**	116	**147**	2.9	1.8
E5	Two Mile Hill Rd	OUT	2049	1255	410	**462**	423	**472**	0.5	0.6
E6	Nags Head Hill	OUT	1276	2053	477	**517**	491	**540**	1.0	0.6
E7	Crews Hole Road	OUT	1293	1999	92	**100**	140	**141**	3.8	4.4
E9	Bath Rd	OUT	1406	8053	1072	**1268**	974	**1101**	4.8	3.0
NWI2	Shirehampton Rd	IN	3338	3339	289	**342**	300	**357**	0.8	0.6
NWI3	Henbury Rd	IN	8069	3329	142	**144**	146	**157**	1.0	0.3
NWI4	A4018 Passage Rd	IN	2261	3584	888	**1050**	970	**1035**	0.5	2.7
NWI5	Grey Stoke Av	IN	2259	4340	556	**657**	509	**516**	5.8	2.0
NWI7	Southmead Rd	IN	2265	3586	485	**522**	502	**574**	2.2	0.8
NWI8	Kellaway Av	IN	1026	1025	359	**424**	408	**428**	0.2	2.5
NWI9	Gloucester Rd	IN	1027	1028	516	**617**	566	**720**	4.0	2.1
NWI10	Muller Rd	IN	1058	1059	839	**955**	799	**867**	2.9	1.4
NWI11	Coldhabour Lane	IN	1663	1093	320	**346**	315	**353**	0.4	0.3
NWI12	Filton Rd	IN	3451	3490	1922	**2272**	1879	**2124**	3.2	1.0
NWI13	Hambrook Rd	IN	1941	3539	36	**43**	25	**31**	2.0	2.0
NWI14	Winterbourne Rd	IN	3529	3528	795	**940**	793	**920**	0.6	0.1
NWI15	M4	IN	3157	3901	4330	**5120**	3874	**4949**	2.4	7.1
NWI2	Shirehampton Rd	OUT	3339	3338	251	**297**	287	**437**	7.3	2.2
NWI3	Henbury Rd	OUT	3329	8069	134	**135**	131	**141**	0.5	0.2
NWI4	A4018 Passage Rd	OUT	3584	2261	800	**946**	799	**877**	2.3	0.1
NWI5	Grey Stoke Av	OUT	4340	2259	341	**403**	316	**345**	3.0	1.4
NWI7	Southmead Rd	OUT	3586	2265	370	**430**	395	**430**	0.0	1.3
NWI8	Kellaway Av	OUT	1025	1026	449	**531**	455	**494**	1.6	0.3
NWI9	Gloucester Rd	OUT	1028	1027	582	**682**	597	**721**	1.5	0.6
NWI10	Muller Rd	OUT	1059	1058	854	**938**	889	**1004**	2.1	1.2
NWI11	Coldhabour Lane	OUT	1093	1663	897	**949**	1001	**1066**	3.7	3.4
NWI12	Filton Rd	OUT	3490	3451	985	**1165**	1051	**1209**	1.3	2.1
NWI13	Hambrook Rd	OUT	1941	2365	463	**548**	499	**546**	0.1	1.6
NWI14	Winterbourne Rd	OUT	3528	3529	1452	**1716**	1392	**1500**	5.4	1.6
NWI15	M4	OUT	3910	3138	4039	**4776**	4072	**4984**	3.0	0.5
S1	Bridgewater Rd	IN	3635	2459	438	**519**	401	**436**	3.8	1.8
S2	Bishopsworth Rd	IN	2463	2195	388	**458**	345	**387**	3.5	2.3
S3	St Peters Rise	IN	1357	2523	219	**233**	237	**281**	2.9	1.2
S4	Hengrove Way	IN	1359	1360	777	**830**	768	**850**	0.7	0.3
S5	Hawkfield Rd	IN	1365	2519	414	**428**	401	**507**	3.7	0.6
S6	Whitchurch Lane	IN	7178	1376	620	**739**	570	**615**	4.8	2.1
S7	Bamfield	IN	2433	3644	153	**162**	179	**200**	2.8	2.0
S8	Wells Rd	IN	1380	1430	659	**821**	650	**714**	3.9	0.4
S9	Bath Rd	IN	1311	4044	1056	**1249**	1364	**1527**	7.5	8.9
S10	School Road	IN	1307	2121	338	**360**	352	**375**	0.8	0.8
S11	Allison Rd	IN	1307	2117	233	**264**	189	**210**	3.5	3.0
S1	Bridgewater Rd	OUT	2459	3635	533	**604**	510	**553**	2.1	1.0
S2	Bishopsworth Rd	OUT	2195	2463	467	**552**	393	**464**	3.9	3.5
S3	St Peters Rise	OUT	2523	1357	115	**136**	208	**223**	6.5	7.4

S4	Hengrove Way	OUT	1360	1359	846	**904**	775	**808**	3.3	2.5
S5	Hawkfield Rd	OUT	2519	1365	505	**520**	451	**546**	1.1	2.5
S6	Whitchurch Lane	OUT	7013	1376	572	**665**	733	**812**	5.4	6.3
S7	Bamfield	OUT	3644	2433	318	**321**	311	**321**	0.0	0.4
S8	Wells Rd	OUT	1430	1380	392	**511**	357	**533**	1.0	1.8
S9	Bath Rd	OUT	1490	4046	762	**902**	809	**882**	0.6	1.7
S10	School Road	OUT	2121	1307	494	**560**	546	**630**	2.9	2.3
S11	Allison Rd	OUT	2117	1307	346	**369**	300	**325**	2.4	2.5
R1	M5	IN	3213	3928	3173	**3752**	3117	**3821**	1.1	1.0
R3	A3029 Brunel Way (N)	IN	1165	1513	1649	**1908**	1937	**2151**	5.4	6.8
R4	A3029 Brunel Way (S)	IN	1513	1166	1959	**2242**	2056	**2277**	0.7	2.2
R5	Princes Street Bridge	IN	1436	1777	523	**528**	289	**424**	4.8	11.6
R6	Bedminster Bridge	IN	1477	1319	760	**957**	781	**906**	1.7	0.8
R7	Redcliffe Way	IN	2651	1203	177	**333**	318	**367**	1.8	9.0
R8	Bristol Bridge, Victoria Street	IN	1233	2547	497	**620**	511	**756**	5.2	0.6
R9	Passager Street	IN	1247	1594	392	**463**	495	**495**	1.5	4.9
R10	Temple Way	IN	1591	1593	1500	**1716**	1387	**1571**	3.6	3.0
R11	Bath Bridge	IN	1485	1210	1697	**2107**	1748	**2085**	0.5	1.2
R12	Avon Street	IN	1592	1286	273	**298**	292	**352**	3.0	1.1
R13	Albert Road	IN	1288	1301	274	**384**	273	**344**	2.1	0.1
R15	St PhillAMs Causeway	IN	1290	1302	856	**1005**	923	**990**	0.5	2.3
R16	Marsh Lane	IN	2011	3631	220	**253**	257	**278**	1.6	2.4
R17	Nethan Road	IN	2013	1425	920	**992**	734	**788**	6.8	6.4
R18	Feeder Road	IN	1426	2599	569	**617**	555	**602**	0.6	0.6
R1	M5	OUT	3927	3204	4639	**5485**	4621	**5315**	2.3	0.3
R3	A3029 Brunel Way (N)	OUT	1525	1524	2493	**2884**	2551	**2795**	1.7	1.1
R4	A3029 Brunel Way (S)	OUT	1527	1526	2861	**3134**	2691	**2950**	3.3	3.2
R5	Princes Street Bridge	OUT	1777	1436	232	**237**	170	**200**	2.5	4.4
R6	Bedminster Bridge	OUT	1474	1318	1859	**2189**	1827	**1988**	4.4	0.8
R7	Redcliffe Way	OUT	1204	2651	399	**512**	403	**453**	2.7	0.2
R8	Bristol Bridge, Victoria Street	OUT	2547	1233	586	**690**	664	**762**	2.7	3.1
R9	Passage Street	OUT	1594	1247	429	**507**	290	**397**	5.2	7.3
R10	Temple Way	OUT	1593	1207	1425	**1605**	1576	**1691**	2.1	3.9
R11	Bath Bridge	OUT	1483	1484	1698	**2049**	1871	**2032**	0.4	4.1
R12	Avon Street	OUT	1286	1592	539	**586**	401	**503**	3.5	6.4
R13	Albert Road	OUT	1301	1288	339	**373**	345	**414**	2.1	0.3
R15	St PhillAMs Causeway	OUT	1302	1290	1420	**1715**	1300	**1481**	5.9	3.3
R16	Marsh Lane	OUT	3631	2011	220	**241**	239	**265**	1.5	1.2
R17	Nethan Road	OUT	1425	2013	564	**611**	613	**646**	1.4	2.0
R18	Feeder Road	OUT	2599	1426	768	**824**	812	**878**	1.8	1.6
RW1	A4176 Portway	IN	1052	1162	989	**1262**	941	**1121**	4.1	1.5
RW5	Clifton Down	IN	1041	1161	675	**716**	534	**555**	6.4	5.7
RW22	Kingsland Road	IN	1733	1285	212	**238**	210	**255**	1.1	0.1
RW2	Avon Street	IN	1769	1592	115	**132**	177	**210**	5.9	5.1
RW26	B3021 St Johns Lane	IN	1181	1180	939	**1018**	871	**923**	3.0	2.2
RW27	A38 Parsons Street	IN	1173	1579	1248	**1449**	1222	**1387**	1.6	0.8
RW28	A38 Bedminster Down Road	IN	1433	2746	1747	**2067**	1663	**1825**	5.5	2.0
RW30	Whitby Road	IN	2599	1302	521	**528**	487	**546**	0.8	1.5
RW34	A4174	IN	2937	3612	1426	**1686**	1389	**1510**	4.4	1.0
RW35	A4175 Keynsham Road	IN	1394	1393	509	**538**	543	**563**	1.1	1.5
RW36	Muller Road	IN	1058	2335	703	**744**	747	**839**	3.4	1.6

RW37	Lockleaze Road	IN	2327	1486	177	**189**	145	**162**	2.1	2.5
RW38	Bonnington Walk	IN	2315	2305	173	**188**	170	**197**	0.7	0.2
RW39	A4174 Station Road	IN	3693	3471	1337	**1581**	1393	**1616**	0.9	1.5
RW40	GAMsy Patch Lane	IN	3234	1945	877	**1037**	911	**957**	2.5	1.2
RW41	A38 Gloucester Road	IN	3427	3307	1473	**1880**	1517	**1748**	3.1	1.1
RW42	M5	IN	3174	3181	3663	**4331**	3709	**4331**	0.0	0.8
RW1	A4176 Portway	OUT	1162	1052	934	**1159**	904	**1048**	3.3	1.0
RW5	Clifton Down	OUT	1161	1041	785	**820**	717	**775**	1.6	2.5
RW22	Kingsland Road	OUT	1285	1733	140	**187**	197	**223**	2.5	4.4
RW2	Avon Street	OUT	1592	1769	301	**323**	282	**314**	0.5	1.1
RW26	B3021 St Johns Lane	OUT	1180	1181	420	**444**	410	**451**	0.3	0.5
RW30	Whitby Road	OUT	1302	2599	373	**396**	181	**205**	11.0	11.5
RW35	A4175 Keynsham Road	OUT	1393	1394	482	**510**	466	**508**	0.1	0.8
RW36	Muller Road	OUT	2335	1058	567	**607**	611	**650**	1.7	1.8
RW37	Lockleaze Road	OUT	1486	2327	162	**185**	163	**178**	0.5	0.1
RW38	Bonnington Walk	OUT	2305	2315	178	**184**	160	**205**	1.4	1.4
RW39	A4174 Station Road	OUT	3471	3693	1827	**2161**	2026	**2257**	2.0	4.5
RW40	GAMsy Patch Lane	OUT	1945	3234	651	**770**	658	**757**	0.5	0.3
RW41	A38 Gloucester Road	OUT	3310	3313	711	**859**	756	**824**	1.2	1.6
M5 J19	*Docks*	*IN*	1619	3926	192	**440**	240	**354**	4.3	3.2
	Docks	*OUT*	7025	1619	383	**631**	431	**566**	2.6	2.4
	Gordano Services	*IN*	4336	7027	149	**224**	150	**190**	2.4	0.1
	Gordano Services	*OUT*	7027	4336	150	**215**	148	**185**	2.1	0.2
	A369 Martcombe Rd East	*IN*	3706	3705	721	**764**	765	**789**	0.9	1.6
	A369 Martcombe Rd East	*OUT*	3705	3706	1024	**1102**	714	**799**	9.8	10.5
	St George's Hill - Pill	*IN*	3705	7019	159	**174**	163	**202**	2.0	0.4
	St George's Hill - Pill	*OUT*	7019	3705	273	**290**	235	**288**	0.1	2.4
	Portbury High st	*IN*	7035	7036	243	**256**	221	**260**	0.3	1.5
	Portbury High st	*OUT*	7036	7035	505	**510**	418	**474**	1.6	4.1
	The Portbury Hundred	*IN*	3789	3703	1459	**1522**	1335	**1420**	2.7	3.3
	The Portbury Hundred	*OUT*	3703	3789	886	**974**	1183	**1272**	8.9	9.2
Temple Circus roundabout	*A4044 Temple Way (N)*	IN	1610	1206	1313	**1523**	945	**1115**	11.2	11.0
	Friary (E)	IN	1565	1508	41	**60**	4	**10**	8.4	7.8
	Redcliffe Way (S)	IN	1510	1506	1763	**2170**	2023	**2281**	2.3	6.0
	Victoria Street (NW)	IN	1562	1205	279	**420**	425	**566**	6.6	7.8
	A4044 Temple Way (N)	OUT	1205	1563	1339	**1597**	1624	**1735**	3.4	7.4
	Friary (E)	OUT	1206	1564	185	**199**	213	**227**	1.9	2.0
	A4 Temple Gate (SE)	OUT	1508	1507	1464	**1844**	1038	**1385**	11.4	12.0
	Victoria Street (NW)	OUT	1506	1561	408	**534**	527	**624**	3.8	5.5
	A4 Temple Gate (E)	IN	2647	2556	1513	**1867**	1461	**1680**	4.4	1.4
	Redcliff Mead Lane (S)	IN	2740	2556	155	**158**	31	**35**	12.5	12.9
	Redcliffe Way (W)	IN	1717	1605	511	**649**	787	**799**	5.6	10.8
	Redcliffe Way (W)	OUT	1604	1606	312	**379**	198	**229**	8.5	7.2
Bath Bridge	*A4 Temple Gate (N)*	IN	1480	1485	1146	**1442**	793	**1050**	11.1	11.3
	Cattle market Road (NE)	IN	1574	1485	297	**357**	335	**372**	0.8	2.1
	A4 Bath Road (SE)	IN	1572	1190	1287	**1635**	1353	**1474**	4.1	1.8
	A370 York Road (SW)	IN	1570	1483	348	**358**	363	**375**	0.9	0.8
	Clarence Road (W)	IN	1573	1484	567	**675**	591	**656**	0.7	1.0
	A4 Temple Gate (N)	OUT	1484	1480	1492	**1830**	1371	**1484**	8.5	3.2
	Cattle market Road (NE)	OUT	1485	1574	194	**219**	94	**138**	6.1	8.3
	A4 Bath Road (SE)	OUT	1210	1571	979	**1286**	1082	**1362**	2.1	3.2

	A370 York Road (SW)	OUT	1190	1570	496	**587**	510	**539**	2.0	0.6
	Clarence Road (W)	OUT	1484	1573	484	**546**	376	**404**	6.5	5.2
Bedminster Bridge roundabout	*Redcliff Hill (N)*	IN	1479	1476	340	**473**	359	**447**	1.2	1.0
	Clarence Road (NE)	IN	1554	1477	369	**425**	312	**333**	4.7	3.1
	A370 York Road (SE)	IN	1555	1478	634	**718**	471	**486**	9.4	7.0
	Bedminster Parade (S)	IN	1557	1192	657	**815**	498	**597**	8.2	6.6
	A370 Coronation Road (SW)	IN	1558	1474	697	**823**	1129	**1185**	11.4	14.3
	Commerical Road (NW)	IN	1559	1475	413	**459**	649	**686**	9.5	10.3
	Redcliff Hill (N)	OUT	1475	1552	795	**1008**	1470	**1545**	15.0	20.1
	Clarence Road (NE)	OUT	1476	1554	741	**856**	643	**717**	5.0	3.7
	A370 York Road (SE)	OUT	1319	1555	149	**152**	179	**180**	2.2	2.3
	Bedminster Parade (S)	OUT	1478	1556	292	**402**	244	**322**	4.2	2.9
	A370 Coronation Road (SW)	OUT	1553	1558	548	**656**	630	**683**	1.0	3.4
	Commerical Road (NW)	OUT	1560	1559	585	**639**	248	**282**	16.6	16.5
Redcliffe Way roundabout	*Redcliff Street (N)*	IN	2546	1204	245	**280**	271	**275**	0.3	1.6
	Redcliffe Way (E)	IN	2550	1204	334	**398**	198	**230**	9.5	8.4
	Redcliff Hill (S)	IN	1552	1204	905	**1067**	1470	**1545**	13.2	16.4
	Redcliff Street (N)	OUT	1204	2546	334	**354**	411	**415**	3.1	4.0
	Redcliffe Way (E)	OUT	1204	2550	605	**741**	992	**1061**	10.7	13.7
	Redcliff Hill (S)	OUT	1204	4021	326	**474**	382	**469**	0.2	3.0
Jacob Wells Road roundabout	*Jacobs Wells Road (N)*	IN	1198	9994	467	**510**	602	**631**	5.1	5.8
	St Georges Street (NE)	IN	9997	9995	150	**160**	124	**136**	2.0	2.2
	A4 Anchor Road €	IN	9998	9996	438	**572**	503	**541**	1.3	3.0
	A4 Hotwells Road (W)	IN	1618	9993	1392	**1630**	1363	**1490**	3.5	0.8
	Jacobs Wells Road (N)	OUT	1198	2559	531	**606**	492	**498**	4.6	1.7
	St Georges Street (NE)	OUT	9997	2671	390	**398**	177	**179**	12.9	12.7
	A4 Anchor Road €	OUT	9998	9999	785	**960**	1080	**1156**	6.0	9.7
	A4 Hotwells Road (W)	OUT	1618	1707	741	**908**	843	**967**	1.9	3.6
The Triangle	*A4018 Queens Road (N)*	IN	1817	1488	1184	**1395**	968	**1104**	8.2	6.6
	Triangle (W) circulatory		1229	4053	1328	**1612**	1151	**1280**	8.7	5.0
	A4018 Queens Road (N)	OUT	4053	4054	992	**1232**	742	**864**	11.4	8.5
	Triangle (W) circulatory		4053	1488	336	**380**	409	**416**	1.8	3.8
	University Road	OUT	2708	4060	90	**101**	124	**124**	2.2	3.3
	Park Row (E)	IN	2710	1228	979	**1167**	799	**900**	8.3	6.0
	Park Row (E)	OUT	2709	2708	1117	**1324**	1058	**1168**	4.4	1.8
	Triangle (E) circulatory		2709	1228	382	**426**	319	**353**	3.7	3.4
	Park Row (E)	OUT	2708	2710	1027	**1224**	935	**1043**	5.4	3.0
	Berkeley Place (S)	IN	2673	1229	561	**636**	608	**620**	0.6	1.9
	Berkeley Place (S)	OUT	1229	2673	459	**495**	818	**856**	13.9	14.2
Lawrence Hill Rbt	*A4320 Easton Way (N)*	IN	1611	1244	2011	**2301**	1726	**1784**	11.4	6.6
	Lawrence Hill (E)	IN	4036	1245	981	**1135**	1388	**1517**	10.5	11.8
	A4320 St Phillips Causeway (S)	IN	1284	1246	1141	**1449**	1267	**1514**	1.7	3.6
	Lawrence Hill (W)	IN	1249	1248	495	**615**	689	**761**	5.6	8.0
	A4320 Easton Way (N)	OUT	1248	1620	1362	**1670**	1398	**1602**	1.7	1.0
	Lawrence Hill (E)	OUT	1244	4092	585	**749**	665	**785**	1.3	3.2
	A4320 St Phillips Causeway (S)	OUT	1245	1284	1376	**1622**	1382	**1438**	4.7	0.2
	Lawrence Hill (W)	OUT	1246	1249	1305	**1458**	1912	**2037**	13.9	15.1
M32 Junction 3	*M32 (North)*	IN	3597	3973	2314	**2664**	1996	**2124**	11.0	6.9
	A4320 (E)	IN	2571	3974	1505	**1848**	1402	**1629**	5.3	2.7
	M32 (South)	IN	3977	3978	335	**374**	77	**81**	19.4	18.0
	B4051 (W)	IN	3578	3979	795	**823**	820	**839**	0.6	0.9

	M32 (North)	OUT	3979	3986	1375	1690	1284	1474	5.4	2.5
	A4320 (E)	OUT	3973	3577	1931	2196	1586	1694	11.4	8.2
	M32 (South)	OUT	3974	3975	631	699	180	185	24.4	22.4
	B4051 (W)	OUT	3978	3578	1012	1124	1313	1386	7.4	8.8
M32 / Cabot circus	*A4032 Newfoundland Way*	IN	3982	1471	1979	2191	1862	1947	5.4	2.7
	Houlton Street	IN	9972	1471	137	173	111	132	3.3	2.4
	Car Park	IN	2628	9974	12	12	41	41	5.7	5.7
	A4044 Temple Way	IN	9985	9967	1688	2169	1825	2116	1.1	3.3
	A4044 Newfoundland Street	IN	9970	1209	1912	2164	2166	2282	2.5	5.6
	A4032 Newfoundland Way	OUT	1221	9981	2151	2456	2311	2428	0.6	3.4
	Houlton Street	OUT	1471	9972	334	352	313	316	1.9	1.2
	Car Park	OUT	9974	2628	134	134	146	146	1.0	1.0
	A4044 Temple Way	OUT	9967	9985	1088	1239	1477	1604	9.7	10.9
	A4044 Newfoundland Street	OUT	1209	9970	1875	2376	1658	1901	10.3	5.2
	St Paul Street	OUT	1209	9975	146	154	113	121	2.8	2.9
Hambrook	*Bristol Rd (N) to A4174 (W)*	N to W	3487	3560	296	350	609	615	12.1	14.7
	Bristol Rd (N) to (S)	N to S	3487	3560	147	174	186	204	2.2	3.0
	Bristol Rd (N) to A4174 (E)	N to E	3487	3560	112	133	50	54	8.2	6.9
	A4174 (W) to Bristol Rd (N)	W to N	3499	3560	519	614	491	559	2.3	1.3
	A4174 (W) to Bristol Rd (S)	W to S	3499	3560	307	363	258	285	4.3	2.9
	A4174 (W) to (E)	W to E	3499	3560	1296	1533	1459	1596	1.6	4.4
	Bristol Rd (S) to (N)	S to N	3473	3560	283	334	179	202	8.1	6.8
	Bristol Rd (S) to A4174 (W)	S to W	3473	3560	306	362	643	738	16.1	15.5
	Bristol Rd (S) to A4174 (E)	S to E	3473	3560	62	73	29	45	3.7	4.8
	A4174 (E) to Bristol Rd (N)	E to N	9960	3560	287	340	238	239	5.9	3.1
	A4174 (E) to (W)	E to W	9960	3560	1307	1545	1539	1651	2.6	6.1
	A4174 (E) to Bristol Rd (S)	E to S	9960	3473	123	145	82	121	2.1	4.0
M32 J1	*M32 (N) to A4174 (E)*	N to E	3900	3952	757	998	760	778	7.3	0.1
	M32 (N) to A4174 (W)	N to W	3952	3953	854	895	811	995	3.3	1.5
	A4174 (E) to M32 (S)	E to S	3561	3953	596	658	1141	1162	16.7	18.5
	A4174 (E) to M32 (N)	E to N	3953	3957	650	845	682	812	1.2	1.2
	A4174 (E) to (W)	E to W	3561	3953	499	576	837	1029	16.0	13.1
	M32 (S) to A4174 (W)	S to W	9916	3957	708	779	236	244	23.7	21.7
	M32 (S) to A4174 (E)	S to E	3957	3958	758	806	775	930	4.2	0.6
	A4174 (W) to M32 (N)	W to N	3562	3958	238	268	101	187	5.3	10.6
	A4174 (W) to (E)	W to E	3562	3958	543	598	659	730	5.1	4.7
	A4174 (W) to M32 (S)	W to S	3958	3952	302	354	280	291	3.5	1.3

TABLE E2

Morning Peak Traffic Flow Validation Comparison

Ref No.	Road	Dir	A node	B node	Obs LV	Obs Total PCUs	Model LV	Model Total PCUs	GEH PCUs	GEH LVs
O1	A38 Bridgewater Road	IN	7147	3635	862	**1019**	880	**918**	3.3	0.6
O2	A370 Long Ashton Bypass	IN	2703	1355	1133	**1281**	1268	**1348**	1.8	3.9
O3	B3128 Ashton Road	IN	1148	1149	808	**930**	963	**1002**	2.3	5.2
O4	A369 Clanage Road	IN	1158	2471	417	**491**	405	**453**	1.8	0.6
O5	B3129 Clifton Suspension Bridge	IN	1159	1160	681	**752**	587	**587**	6.4	3.8
O6	A4 Portway	IN	3348	3591	736	**1251**	859	**1055**	5.8	4.4
O7	B4054 Shirehampton Road	IN	2223	3340	390	**450**	357	**426**	1.1	1.7
O8	Kings Weston Lane	IN	3389	3342	105	**117**	79	**84**	3.2	2.7
O9	Hallen Road	IN	3362	3363	143	**162**	140	**157**	0.4	0.3
O10	A4018 Cribbs Causeway	IN	3197	3324	1010	**1194**	1166	**1212**	0.5	4.7
O11	Merlin Road	IN	3193	3198	954	**1129**	1022	**1167**	1.1	2.1
O12	Highwood Lane	IN	3191	3195	427	**505**	363	**401**	4.9	3.2
O13	A38 Gloucester Rd	IN	3162	3410	3126	**3495**	3439	**3785**	4.8	5.5
O14	B4427 Old Gloucester Road	IN	3030	3526	384	**454**	365	**392**	3.0	1.0
O15	B4057 Beacon Lane	IN	3037	3528	1040	**1229**	1066	**1110**	3.5	0.8
O16	M32	IN	3907	3951	3646	**4481**	3837	**4304**	2.7	3.1
O17	B4058 Bristol Road	IN	2371	3550	564	**667**	721	**777**	4.1	6.2
O18	A432 Badminton Road	IN	4236	3047	671	**794**	791	**935**	4.8	4.4
O19	Westerleigh Road	IN	4237	3685	658	**778**	658	**720**	2.1	0.0
O20	Shortwood Road	IN	1125	3055	361	**427**	336	**397**	1.5	1.3
O21	A420 London Rd	IN	3761	3760	449	**531**	544	**630**	4.1	4.2
O22	A431 Bath Road	IN	3798	3772	358	**424**	506	**549**	5.7	7.1
O23	A4 Bath Road	IN	1408	1407	1031	**1161**	954	**1030**	3.9	2.5
O24	B3116 Wellsway	IN	3767	1404	658	**710**	528	**618**	3.6	5.3
O25	A37 Bristol Road	IN	3645	8052	615	**727**	629	**682**	1.7	0.6
O26	Queens Rd	IN	3636	7115	348	**367**	319	**320**	2.5	1.6
O1	A38 Bridgewater Road	OUT	3635	7147	705	**834**	840	**891**	2.0	4.9
O2	A370 Long Ashton Bypass	OUT	1355	2703	526	**622**	574	**631**	0.3	2.0
O3	B3128 Ashton Road	OUT	1149	1148	329	**389**	268	**366**	1.2	3.5
O4	A369 Clanage Road	OUT	2471	1158	436	**451**	472	**492**	1.9	1.7
O5	B3129 Clifton Suspension Bridge	OUT	1160	1159	419	**495**	280	**280**	10.9	7.4
O6	A4 Portway	OUT	3591	3348	868	**1135**	1020	**1095**	1.2	4.9
O7	B4054 Shirehampton Road	OUT	3340	2223	359	**386**	389	**478**	4.4	1.5
O8	Kings Weston Lane	OUT	3342	3389	339	**345**	337	**393**	2.5	0.1
O9	Hallen Road	OUT	3363	3362	135	**144**	152	**158**	1.1	1.4
O10	A4018 Cribbs Causeway	OUT	3324	3197	978	**1156**	1014	**1091**	1.9	1.2
O11	Merlin Road	OUT	3198	3193	319	**377**	378	**416**	2.0	3.2
O12	Highwood Lane	OUT	3195	3193	202	**239**	230	**259**	1.3	1.9
O13	A38 Gloucester Rd	OUT	3410	3162	1315	**1466**	1206	**1320**	3.9	3.1
O14	B4427 Old Gloucester Road	OUT	3526	3030	204	**241**	259	**315**	4.4	3.6
O15	B4057 Beacon Lane	OUT	3528	3037	657	**776**	557	**675**	3.8	4.1
O16	M32	OUT	3960	3908	2765	**3398**	2883	**3354**	0.7	2.2
O17	B4058 Bristol Road	OUT	3550	2371	297	**351**	304	**331**	1.1	0.4
O18	A432 Badminton Road	OUT	3047	4236	1075	**1271**	999	**1212**	1.7	2.4
O19	Westerleigh Road	OUT	3685	4237	715	**846**	696	**829**	0.6	0.7

O20	Shortwood Road	OUT	3055	1125	457	**540**	555	**590**	2.1	4.4
O21	A420 London Rd	OUT	3760	3761	880	**1040**	906	**1089**	1.5	0.9
O22	A431 Bath Road	OUT	3772	3798	789	**894**	896	**987**	3.0	3.7
O23	A4 Bath Road	OUT	1407	1408	859	**1000**	791	**908**	3.0	2.4
O24	B3116 Wellsway	OUT	1404	3767	529	**570**	450	**581**	0.5	3.6
O25	A37 Bristol Road	OUT	8052	3645	418	**484**	452	**562**	3.4	1.6
O26	Queens Rd	OUT	7115	3636	201	**210**	178	**187**	1.6	1.7
M2	A4176 Portway	IN	1162	1582	1462	**1769**	1470	**1653**	2.8	0.2
M4	College Road	IN	1801	1160	211	**264**	195	**224**	2.6	1.2
M5	Pembroke Road	IN	1041	1803	240	**261**	228	**248**	0.8	0.8
M7	Whiteladies Road	IN	1809	1238	844	**953**	846	**940**	0.4	0.1
M8	Hampton Road	IN	1015	1881	494	**499**	592	**599**	4.3	4.2
M9	Redland Grove	IN	1659	1853	627	**651**	568	**605**	1.8	2.4
M10	Redland Road	IN	1034	1855	262	**262**	251	**251**	0.7	0.7
M11	A38 Cheltenham Road	IN	1030	1031	512	**751**	720	**847**	3.4	8.4
M12	North Road	IN	1146	1031	353	**374**	319	**330**	2.3	1.8
RW14	Ashley Hill	IN	1036	1917	817	**833**	788	**845**	0.4	1.0
MM12	Glenfrome Road	IN	1107	1919	430	**508**	487	**516**	0.4	2.6
M13	M32	IN	3971	3972	3397	**3731**	3257	**3460**	4.5	2.4
M14	Stapleton Road	IN	1437	1440	572	**675**	823	**881**	7.4	9.5
M15	Easton Road	IN	2005	1995	481	**487**	392	**403**	4.0	4.3
M16	A420 Lawrence Hill	IN	1251	1466	1162	**1312**	1211	**1303**	0.2	1.4
M17	Ducie Road	IN	1763	1250	201	**238**	150	**179**	4.1	3.8
M18	Barrow Road	IN	1283	1747	248	**258**	250	**261**	0.2	0.1
M19	A4320 St Phillips Causeway	IN	1290	1549	877	**1287**	1104	**1347**	1.6	7.2
M20	Feeder Road	IN	1751	1741	805	**883**	784	**957**	2.4	0.7
M21	Albert Road	IN	1290	1755	465	**630**	502	**573**	2.3	1.7
M22	Bath Road	IN	2087	4038	475	**571**	607	**660**	3.6	5.7
M23	Wells Road	IN	2131	2085	579	**716**	494	**532**	7.4	3.7
MM23	Redcatch Road	IN	1185	2125	562	**595**	630	**661**	2.6	2.8
M24	Wedmore Vale	IN	2213	2159	416	**426**	431	**470**	2.1	0.7
M25	Novers Hill	IN	2469	2211	472	**484**	429	**465**	0.9	2.0
M26	A4174 Hartcliffe Way	IN	2728	1361	782	**920**	826	**951**	1.0	1.5
M27	A38 Bedminster Down Road	IN	1183	1433	856	**979**	751	**829**	5.0	3.7
M28	South Liberty Lane	IN	7166	3607	118	**157**	159	**173**	1.3	3.5
M29	Ashton Drive	IN	10005	4082	273	**319**	282	**299**	1.1	0.5
M30	A370 Ashton Road	IN	1153	1154	1683	**1993**	1791	**1937**	1.3	2.6
M2	A4176 Portway	OUT	1582	1162	1347	**1628**	1408	**1584**	1.1	1.6
M4	College Road	OUT	1160	1801	213	**266**	217	**236**	1.9	0.2
M5	Pembroke Road	OUT	1803	1041	177	**193**	168	**182**	0.8	0.7
M7	Whiteladies Road	OUT	1238	1809	638	**771**	545	**684**	3.2	3.8
M8	Hampton Road	OUT	1881	1015	281	**292**	354	**368**	4.2	4.0
M9	Redland Grove	OUT	1853	1659	321	**342**	343	**410**	3.5	1.2
M10	Redland Road	OUT	1855	1034	83	**83**	113	**113**	3.0	3.0
M11	A38 Cheltenham Road	OUT	1031	1030	450	**830**	560	**676**	5.6	4.9
M12	North Road	OUT	1031	1146	30	**40**	33	**44**	0.7	0.6
RW14	Ashley Hill	OUT	1917	1036	771	**784**	928	**961**	6.0	5.4
MM12	Glenfrome Road	OUT	1919	1107	467	**552**	526	**556**	0.2	2.6
M13	M32	OUT	3981	3965	3192	**3660**	3486	**3795**	2.2	5.1
M14	Stapleton Road	OUT	1440	1437	267	**325**	296	**377**	2.8	1.7
M15	Easton Road	OUT	1995	2005	100	**106**	110	**115**	0.9	1.1

M16	A420 Lawrence Hill	OUT	1466	1251	564	**625**	523	**588**	1.5	1.8
M17	Ducie Road	OUT	1250	1763	12	**14**	19	**27**	2.7	1.8
M18	Barrow Road	OUT	1747	1283	350	**395**	301	**350**	2.3	2.7
M19	A4320 St Phillips Causeway	OUT	1549	1290	829	**1120**	1083	**1188**	2.0	8.2
M20	Feeder Road	OUT	1741	1751	374	**451**	390	**444**	0.3	0.8
M21	Albert Road	OUT	1755	1290	183	**351**	276	**444**	4.7	6.1
M22	Bath Road	OUT	4038	2087	401	**507**	440	**492**	0.7	1.9
M23	Wells Road	OUT	2085	2131	527	**687**	450	**642**	1.7	3.5
MM23	Redcatch Road	OUT	2125	1185	339	**366**	392	**423**	2.9	2.7
M24	Wedmore Vale	OUT	2159	2213	155	**180**	126	**155**	1.9	2.5
M25	Novers Hill	OUT	2211	2469	179	**187**	241	**241**	3.7	4.3
M26	A4174 Hartcliffe Way	OUT	1361	2728	633	**769**	722	**809**	1.4	3.4
M27	A38 Bedminster Down Road	OUT	1433	1183	882	**1075**	808	**909**	5.3	2.5
M28	South Liberty Lane	OUT	3607	7166	139	**166**	119	**125**	3.4	1.8
M29	Ashton Drive	OUT	4082	10005	192	**198**	129	**150**	3.7	4.9
M30	A370 Ashton Road	OUT	1530	1531	907	**1091**	901	**1072**	0.6	0.2
NWO1	M5	IN	3192	3201	3119	**3833**	3305	**3935**	1.6	3.3
NWO2	A4018 Cribbs Causeway	IN	4351	3347	1056	**1248**	1214	**1315**	1.9	4.7
NWO4	Gloucester Rd North	IN	3496	1651	1507	**1793**	1697	**1963**	3.9	4.8
NWO5	Great Stoke Way	IN	3488	4386	867	**1025**	963	**1068**	1.3	3.2
NWO6	M32	IN	3951	3954	1927	**2335**	2256	**2522**	3.8	7.2
NWO7	Bristol Rd	IN	3487	3560	610	**702**	838	**864**	5.8	8.5
NWO1	M5	OUT	3216	3183	3981	**4823**	3926	**4756**	1.0	0.9
NWO2	A4018 Cribbs Causeway	OUT	3347	4351	1218	**1440**	1303	**1434**	0.1	2.4
NWO4	Gloucester Rd North	OUT	1651	3496	1044	**1234**	963	**1117**	3.4	2.5
NWO5	Great Stoke Way	OUT	4386	3488	780	**892**	704	**754**	4.8	2.8
NWO6	M32	OUT	3956	3959	1845	**2235**	2101	**2357**	2.5	5.8
NWO7	Bristol Rd	OUT	3560	3487	952	**1010**	907	**1000**	0.3	1.5
NE1	Frenchay park Rd	IN	2355	1094	797	**863**	716	**778**	2.9	2.9
NE2	Blackberry Hill	IN	1094	2393	456	**498**	485	**507**	0.4	1.3
NE3	Fishponds Road	IN	1985	1062	384	**498**	315	**422**	3.5	3.7
NE4	Berkley Rd	IN	1077	2025	507	**600**	486	**503**	4.1	0.9
NE5	Charlton Road	IN	2027	1098	361	**380**	353	**477**	4.7	0.4
NE6	Lodge Rd	IN	1097	1080	302	**313**	220	**232**	4.9	5.0
NE7	Downend Rd	IN	1612	2724	285	**301**	316	**336**	2.0	1.8
NE8	Syston Way	IN	1541	2031	401	**419**	531	**564**	6.5	6.0
NE9	Lees Hill	IN	2490	2409	202	**210**	232	**236**	1.8	2.0
NE10	Pound Rd	IN	2405	1685	138	**143**	127	**156**	1.1	1.0
NE12	Station Rd	IN	1089	1087	516	**610**	546	**574**	1.5	1.3
NE1	Frenchay park Rd	OUT	1094	2355	845	**962**	1048	**1097**	4.2	6.6
NE2	Blackberry Hill	OUT	2393	1094	674	**745**	677	**711**	1.3	0.1
NE3	Fishponds Road	OUT	1062	1985	664	**737**	636	**762**	0.9	1.1
NE4	Berkley Rd	OUT	2025	1077	497	**572**	442	**482**	3.9	2.6
NE5	Charlton Road	OUT	1098	2027	598	**620**	484	**562**	2.3	4.9
NE6	Lodge Rd	OUT	1080	1097	318	**329**	331	**371**	2.2	0.7
NE7	Downend Rd	OUT	2724	1612	210	**224**	251	**281**	3.5	2.7
NE8	Syston Way	OUT	2031	1541	301	**339**	321	**343**	0.2	1.2
NE9	Lees Hill	OUT	2409	2490	220	**229**	281	**284**	3.4	3.9
NE10	Pound Rd	OUT	1685	2405	264	**268**	227	**241**	1.7	2.4
NE12	Station Rd	OUT	1087	1089	348	**412**	365	**382**	1.5	0.9

TABLE E3

Inter Peak Traffic Flow Calibration Comparison

Ref No.	Road	Dir	A node	B node	Obs LV	Obs Total PCUs	Model LV	Model Total PCUs	GEH PCUs	GEH LVs
RSI1	A4018 Whiteladies Road	IN	1488	2709	901	**1068**	904	**1008**	1.9	0.1
I5	Woodland Rd	IN	2557	1226	101	**150**	90	**95**	4.9	1.1
RSI2	Horfield Road	IN	1863	1539	210	**222**	220	**225**	0.2	0.7
RSI3	A38 North Road	IN	1504	1566	440	**543**	396	**509**	1.5	2.1
I6	York Street	IN	2624	2625	47	**50**	40	**42**	1.2	1.1
RSI4	A4032 Newfoundland Street	IN	3976	3982	1560	**1793**	1644	**1898**	2.4	2.1
RSI5	A420 Old Market Street	IN	4034	1219	752	**912**	744	**903**	0.3	0.3
RSI6	Avon Street	IN	1769	1591	92	**98**	91	**102**	0.4	0.1
I8	Station Approach Rd	IN	1482	1480	278	**418**	213	**312**	5.5	4.1
RSI7	Feeder Road	IN	1286	1574	264	**283**	271	**311**	1.6	0.4
RSI8	A4 Bath Road	IN	1189	1572	970	**1239**	671	**943**	9.0	10.4
RSI9	St Lukes Road	IN	2163	1191	252	**257**	252	**257**	0.0	0.0
I1_I2	Whitehouse/Spring Street	IN	2164	8250	184	**191**	121	**128**	5.0	5.1
RSI10	Bedminster Parade	IN	4022	2161	497	**615**	339	**461**	6.6	7.7
RSI11	A370 Coronation Road	IN	1489	1558	587	**709**	853	**971**	9.0	9.9
RSI12	Cumberland Road	IN	2668	1711	362	**407**	346	**352**	2.8	0.9
RSI13	Hotwell Road	IN	1164	1705	981	**1147**	951	**1102**	1.4	1.0
I4	Constitution Hill	IN	2558	2559	84	**89**	86	**88**	0.1	0.2
I3	Lower Clifton Hill (one way)	IN	2558	2560	21	**23**	6	**13**	2.4	4.2
RSI1	A4018 Whiteladies Road	OUT	1228	1229	1067	**1279**	912	**1046**	6.8	4.9
I5	Woodland Rd	OUT	1226	2557	96	**108**	84	**84**	2.5	1.3
RSI2	Horfield Road	OUT	1539	1863	117	**136**	114	**127**	0.8	0.3
RSI3	A38 North Road	OUT	1607	1504	328	**465**	216	**324**	7.1	6.8
I6	York Street	OUT	2625	2624	59	**62**	24	**54**	1.2	5.3
RSI4	A4032 Newfoundland Street	OUT	1470	3977	1786	**2042**	1828	**2084**	0.9	1.0
RSI5	A420 Old Market Street	OUT	1837	1220	570	**730**	516	**633**	3.7	2.3
RSI6	Avon Street	OUT	1591	1769	99	**113**	153	**156**	3.6	4.8
I8	Station Approach Rd	OUT	1480	1482	287	**356**	287	**385**	1.5	0.0
RSI7	Feeder Road	OUT	1574	1286	180	**204**	117	**178**	1.8	5.1
RSI8	A4 Bath Road	OUT	1572	1189	1133	**1448**	1169	**1554**	2.7	1.1
RSI9	St Lukes Road	OUT	1191	2163	329	**335**	412	**439**	5.3	4.3
I1_I2	Whitehouse/Spring Street	OUT	8250	2164	181	**188**	182	**217**	2.1	0.1
RSI10	Bedminster Parade	OUT	2161	4022	346	**445**	341	**434**	0.5	0.2
RSI11	A370 Coronation Road	OUT	1558	1489	786	**893**	786	**850**	1.4	0.0
RSI12	Cumberland Road	OUT	1711	2668	309	**331**	259	**266**	3.7	3.0
RSI13	Hotwell Road	OUT	2593	1521	1081	**1215**	1084	**1199**	0.5	0.1
I4	Constitution Hill	OUT	2559	2558	108	**112**	159	**178**	5.5	4.4
E1	A4174	IN	9961	9960	1369	**1764**	1438	**1643**	2.9	1.8
E2	Downend Rd	IN	2385	1066	333	**361**	347	**383**	1.1	0.8
E3	Staplehill Rd	IN	2383	1071	336	**376**	246	**386**	0.5	5.3
E4	Lodge Hill	IN	1079	1078	199	**268**	97	**202**	4.3	8.4
E5	Two Mile Hill Rd	IN	1255	2049	278	**308**	245	**341**	1.8	2.1
E6	Nags Head Hill	IN	2053	1276	396	**428**	406	**437**	0.4	0.5
E7	Crews Hole Road	IN	1999	1293	122	**136**	126	**128**	0.7	0.4
E9	Bath Rd	IN	8053	1406	1096	**1412**	1016	**1150**	7.3	2.4
E1	A4174	OUT	9960	9961	1556	**2005**	1613	**1858**	3.3	1.4

E2	Downend Rd	OUT	1066	2385	331	**361**	329	**353**	0.4	0.1
E3	Staplehill Rd	OUT	1071	2383	330	**364**	331	**417**	2.7	0.1
E4	Lodge Hill	OUT	1078	1079	163	**220**	122	**188**	2.3	3.5
E5	Two Mile Hill Rd	OUT	2049	1255	347	**386**	340	**394**	0.4	0.4
E6	Nags Head Hill	OUT	1276	2053	448	**489**	446	**480**	0.4	0.1
E7	Crews Hole Road	OUT	1293	1999	211	**229**	249	**283**	3.4	2.5
E9	Bath Rd	OUT	1406	8053	1087	**1401**	1054	**1207**	5.4	1.0
NWI2	Shirehampton Rd	IN	3338	3339	283	**365**	365	**443**	3.9	4.5
NWI3	Henbury Rd	IN	8069	3329	68	**70**	82	**105**	3.8	1.6
NWI4	A4018 Passage Rd	IN	2261	3584	692	**892**	700	**746**	5.1	0.3
NWI5	Grey Stoke Av	IN	2259	4340	371	**478**	371	**428**	2.4	0.0
NWI7	Southmead Rd	IN	2265	3586	532	**569**	531	**595**	1.1	0.0
NWI8	Kellaway Av	IN	1026	1025	444	**572**	452	**503**	2.9	0.4
NWI9	Gloucester Rd	IN	1027	1028	424	**522**	425	**525**	0.1	0.0
NWI10	Muller Rd	IN	1058	1059	778	**867**	789	**930**	2.1	0.4
NWI11	Coldhabour Lane	IN	1663	1093	353	**384**	345	**443**	2.9	0.4
NWI12	Filton Rd	IN	3451	3490	876	**1129**	883	**989**	4.3	0.2
NWI13	Hambrook Rd	IN	1941	3539	73	**94**	71	**86**	0.8	0.2
NWI14	Winterbourne Rd	IN	3529	3528	880	**1134**	866	**989**	4.5	0.5
NWI15	M4	IN	3157	3901	3195	**4116**	3150	**4223**	1.6	0.8
NWI2	Shirehampton Rd	OUT	3339	3338	259	**334**	289	**389**	2.9	1.8
NWI3	Henbury Rd	OUT	3329	8069	72	**73**	89	**110**	3.8	1.8
NWI4	A4018 Passage Rd	OUT	3584	2261	648	**834**	646	**754**	2.8	0.1
NWI5	Grey Stoke Av	OUT	4340	2259	342	**441**	338	**385**	2.7	0.2
NWI7	Southmead Rd	OUT	3586	2265	520	**576**	522	**571**	0.2	0.1
NWI8	Kellaway Av	OUT	1025	1026	442	**570**	441	**482**	3.8	0.1
NWI9	Gloucester Rd	OUT	1028	1027	484	**577**	473	**566**	0.5	0.5
NWI10	Muller Rd	OUT	1059	1058	772	**829**	774	**883**	1.8	0.0
NWI11	Coldhabour Lane	OUT	1093	1663	307	**339**	303	**413**	3.8	0.2
NWI12	Filton Rd	OUT	3490	3451	1196	**1542**	1184	**1372**	4.4	0.3
NWI13	Hambrook Rd	OUT	1941	2365	75	**97**	61	**64**	3.6	1.6
NWI14	Winterbourne Rd	OUT	3528	3529	929	**1197**	928	**1075**	3.6	0.0
NWI15	M4	OUT	3910	3138	3093	**3985**	3141	**4203**	3.4	0.9
S1	Bridgewater Rd	IN	3635	2459	453	**539**	449	**496**	1.9	0.2
S2	Bishopsworth Rd	IN	2463	2195	432	**557**	423	**505**	2.3	0.4
S3	St Peters Rise	IN	1357	2523	129	**146**	146	**178**	2.5	1.5
S4	Hengrove Way	IN	1359	1360	696	**735**	681	**736**	0.0	0.6
S5	Hawkfield Rd	IN	1365	2519	427	**444**	352	**436**	0.4	3.8
S6	Whitchurch Lane	IN	7178	1376	507	**614**	483	**600**	0.6	1.1
S7	Bamfield	IN	2433	3644	166	**169**	152	**155**	1.1	1.1
S8	Wells Rd	IN	1380	1430	547	**690**	572	**741**	1.9	1.1
S9	Bath Rd	IN	1311	4044	987	**1272**	1163	**1388**	3.2	5.4
S10	School Road	IN	1307	2121	257	**279**	208	**266**	0.8	3.2
S11	Allison Rd	IN	1307	2117	170	**209**	171	**184**	1.8	0.1
S1	Bridgewater Rd	OUT	2459	3635	478	**559**	475	**577**	0.8	0.2
S2	Bishopsworth Rd	OUT	2195	2463	454	**584**	460	**548**	1.5	0.3
S3	St Peters Rise	OUT	2523	1357	145	**166**	156	**180**	1.0	0.9
S4	Hengrove Way	OUT	1360	1359	734	**773**	687	**730**	1.6	1.8
S5	Hawkfield Rd	OUT	2519	1365	414	**426**	369	**454**	1.3	2.2
S6	Whitchurch Lane	OUT	7013	1376	497	**583**	551	**653**	2.8	2.4
S7	Bamfield	OUT	3644	2433	161	**170**	188	**203**	2.4	2.1

S8	Wells Rd	OUT	1430	1380	522	661	585	730	2.6	2.7
S9	Bath Rd	OUT	1490	4046	926	1193	962	1126	2.0	1.2
S10	School Road	OUT	2121	1307	357	389	326	386	0.2	1.7
S11	Allison Rd	OUT	2117	1307	174	199	155	165	2.5	1.5
R1	M5	IN	3213	3928	2925	3769	2938	3591	2.9	0.2
R3	A3029 Brunel Way (N)	IN	1165	1513	1459	1772	1291	1619	3.7	4.5
R4	A3029 Brunel Way (S)	IN	1513	1166	1614	1901	1746	2086	4.1	3.2
R5	Princes Street Bridge	IN	1436	1777	138	145	96	96	4.5	3.9
R6	Bedminster Bridge	IN	1477	1319	777	988	1135	1307	9.4	11.6
R7	Redcliffe Way	IN	2651	1203	189	335	239	296	2.2	3.4
R8	Bristol Bridge, Victoria Street	IN	1233	2547	542	694	508	766	2.7	1.5
R9	Passager Street	IN	1247	1594	210	271	277	281	0.6	4.3
R10	Temple Way	IN	1591	1593	1198	1517	1097	1360	4.1	3.0
R11	Bath Bridge	IN	1485	1210	1990	2453	1867	2342	2.3	2.8
R12	Avon Street	IN	1592	1286	324	350	331	386	1.9	0.4
R13	Albert Road	IN	1288	1301	384	484	393	451	1.6	0.4
R15	St Phillips Causeway	IN	1290	1302	939	1091	840	937	4.8	3.3
R16	Marsh Lane	IN	2011	3631	199	243	132	134	8.0	5.2
R17	Nethan Road	IN	2013	1425	569	643	613	630	0.5	1.8
R18	Feeder Road	IN	1426	2599	552	623	521	558	2.7	1.3
R1	M5	OUT	3927	3204	3193	4114	3179	4085	0.5	0.3
R3	A3029 Brunel Way (N)	OUT	1525	1524	1503	1914	1530	1888	0.6	0.7
R4	A3029 Brunel Way (S)	OUT	1527	1526	1642	1941	1591	1949	0.2	1.3
R5	Princes Street Bridge	OUT	1777	1436	192	200	130	153	3.5	4.9
R6	Bedminster Bridge	OUT	1474	1318	1328	1657	1343	1575	2.0	0.4
R7	Redcliffe Way	OUT	1204	2651	287	405	252	304	5.3	2.2
R8	Bristol Bridge, Victoria Street	OUT	2547	1233	538	684	552	679	0.2	0.6
R9	Passage Street	OUT	1594	1247	268	346	131	245	5.8	9.7
R10	Temple Way	OUT	1593	1207	1161	1385	1192	1427	1.1	0.9
R11	Bath Bridge	OUT	1483	1484	1195	1549	1225	1551	0.0	0.9
R12	Avon Street	OUT	1286	1592	259	286	265	303	1.0	0.4
R13	Albert Road	OUT	1301	1288	294	374	154	263	6.2	9.4
R15	St Phillips Causeway	OUT	1302	1290	1006	1211	971	1070	4.2	1.1
R16	Marsh Lane	OUT	3631	2011	188	212	289	318	6.5	6.5
R17	Nethan Road	OUT	1425	2013	625	695	637	698	0.1	0.5
R18	Feeder Road	OUT	2599	1426	593	666	622	673	0.3	1.2
RW1	A4176 Portway	IN	1052	1162	689	965	616	853	3.7	2.9
RW5	Clifton Down	IN	1041	1161	555	597	568	612	0.6	0.5
RW22	Kingsland Road	IN	1733	1285	191	201	199	222	1.4	0.5
RW2	Avon Street	IN	1769	1592	99	113	178	181	5.5	6.7
RW26	B3021 St Johns Lane	IN	1181	1180	612	694	629	721	1.0	0.7
RW27	A38 Parsons Street	IN	1173	1579	1397	1632	1395	1605	0.7	0.1
RW28	A38 Bedminster Down Road	IN	1433	2746	1386	1661	1350	1612	1.2	1.0
RW30	Whitby Road	IN	2599	1302	332	339	324	341	0.1	0.4
RW34	A4174	IN	2937	3612	1142	1320	1124	1200	3.4	0.5
RW35	A4175 Keynsham Road	IN	1394	1393	377	399	357	421	1.0	1.1
RW36	Muller Road	IN	1058	2335	632	658	634	692	1.3	0.1
RW37	Lockleaze Road	IN	2327	1486	113	131	114	153	1.8	0.1
RW38	Bonnington Walk	IN	2315	2305	139	148	107	120	2.4	2.9
RW39	A4174 Station Road	IN	3693	3471	1116	1438	1118	1324	3.1	0.1
RW40	Gipsy Patch Lane	IN	3234	1945	668	861	667	722	4.9	0.0

RW41	A38 Gloucester Road	IN	3427	3307	964	1158	910	1011	4.5	1.7
RW42	M5	IN	3174	3181	2946	3796	2962	3660	2.2	0.3
RW1	A4176 Portway	OUT	1162	1052	669	932	527	731	7.0	5.8
RW5	Clifton Down	OUT	1161	1041	697	725	681	725	0.0	0.6
RW22	Kingsland Road	OUT	1285	1733	125	145	182	224	5.8	4.6
RW2	Avon Street	OUT	1592	1769	92	98	96	109	1.0	0.4
RW26	B3021 St Johns Lane	OUT	1180	1181	672	711	633	706	0.2	1.5
RW30	Whitby Road	OUT	1302	2599	409	458	271	319	7.1	7.5
RW35	A4175 Keynsham Road	OUT	1393	1394	382	404	401	489	4.0	0.9
RW36	Muller Road	OUT	2335	1058	617	666	642	747	3.0	1.0
RW37	Lockleaze Road	OUT	1486	2327	133	148	132	176	2.2	0.1
RW38	Bonnington Walk	OUT	2305	2315	129	139	104	119	1.8	2.3
RW39	A4174 Station Road	OUT	3471	3693	1213	1563	1172	1396	4.3	1.2
RW40	Gipsy Patch Lane	OUT	1945	3234	649	836	631	656	6.6	0.7
RW41	A38 Gloucester Road	OUT	3310	3313	694	820	684	803	0.6	0.4
M5 J19	Docks	IN	1619	3926	0	0	127	299		
	Docks	OUT	7025	1619	0	0	88	138		
	Gordano Services	IN	4336	7027	0	0	68	161		
	Gordano Services	OUT	7027	4336	0	0	56	66		
	A369 Martcombe Rd East	IN	3706	3705	0	0	378	405		
	A369 Martcombe Rd East	OUT	3705	3706	0	0	484	512		
	St George's Hill - Pill	IN	3705	7019	0	0	180	203		
	St George's Hill - Pill	OUT	7019	3705	0	0	123	165		
	Portbury High st	IN	7035	7036	0	0	58	70		
	Portbury High st	OUT	7036	7035	0	0	42	54		
	The Portbury Hundred	IN	3789	3703	0	0	1128	1216		
	The Portbury Hundred	OUT	3703	3789	0	0	964	1027		
Temple Circus roundabout	A4044 Temple Way (N)	IN	1610	1206	1149	1455	1011	1272	5.0	4.2
	Friary (E)	IN	1565	1508	61	103	52	58	5.1	1.3
	Redcliffe Way (S)	IN	1510	1506	1395	1873	1416	1840	0.8	0.6
	Victoria Street (NW)	IN	1562	1205	340	484	413	615	5.6	3.7
	A4044 Temple Way (N)	OUT	1205	1563	1054	1368	1087	1318	1.4	1.0
	Friary (E)	OUT	1206	1564	56	93	45	72	2.3	1.5
	A4 Temple Gate (SE)	OUT	1508	1507	1566	2069	1345	1824	5.5	5.8
	Victoria Street (NW)	OUT	1506	1561	271	387	415	571	8.4	7.8
	A4 Temple Gate (E)	IN	2647	2556	1126	1546	816	1154	10.7	9.9
	Redcliff Mead Lane (S)	IN	2740	2556	57	60	59	81	2.5	0.3
	Redcliffe Way (W)	IN	1717	1605	420	564	707	776	8.2	12.1
	Redcliffe Way (W)	OUT	1604	1606	184	253	76	102	11.3	9.5
Bath Bridge	A4 Temple Gate (N)	IN	1480	1485	1361	1719	1131	1513	5.1	6.5
	Cattle market Road (NE)	IN	1574	1485	264	315	271	311	0.2	0.4
	A4 Bath Road (SE)	IN	1572	1190	1000	1345	672	943	11.9	11.4
	A370 York Road (SW)	IN	1570	1483	296	328	318	328	0.0	1.3
	Clarence Road (W)	IN	1573	1484	459	616	459	549	2.8	0.0
	A4 Temple Gate (N)	OUT	1484	1480	960	1267	675	931	10.1	9.9
	Cattle market Road (NE)	OUT	1485	1574	188	228	117	178	3.4	5.8
	A4 Bath Road (SE)	OUT	1210	1571	1172	1568	1169	1554	0.4	0.1
	A370 York Road (SW)	OUT	1190	1570	768	896	463	509	14.6	12.3
	Clarence Road (W)	OUT	1484	1573	293	364	426	472	5.3	7.0
Bedminster Bridge roundabout	Redcliff Hill (N)	IN	1479	1476	424	567	698	807	9.2	11.5
	Clarence Road (NE)	IN	1554	1477	262	334	405	452	6.0	7.9

	A370 York Road (SE)	IN	1555	1478	575	**705**	23	**23**	35.7	31.9
	Bedminster Parade (S)	IN	1557	1192	559	**731**	489	**598**	5.1	3.0
	A370 Coronation Road (SW)	IN	1558	1474	525	**684**	853	**971**	10.0	12.5
	Commerical Road (NW)	IN	1559	1475	336	**394**	301	**313**	4.3	2.0
	Redcliff Hill (N)	OUT	1475	1552	615	**803**	1015	**1117**	10.1	14.0
	Clarence Road (NE)	OUT	1476	1554	522	**688**	484	**569**	4.7	1.7
	A370 York Road (SE)	OUT	1319	1555	187	**203**	98	**114**	7.1	7.4
	Bedminster Parade (S)	OUT	1478	1556	349	**494**	321	**411**	3.9	1.5
	A370 Coronation Road (SW)	OUT	1553	1558	744	**909**	738	**800**	3.7	0.2
	Commerical Road (NW)	OUT	1560	1559	265	**317**	113	**153**	10.7	11.1
Redcliffe Way roundabout	*Redcliff Street (N)*	IN	2546	1204	317	**346**	313	**354**	0.4	0.2
	Redcliffe Way (E)	IN	2550	1204	184	**250**	92	**120**	9.6	7.8
	Redcliff Hill (S)	IN	1552	1204	686	**874**	1015	**1117**	7.7	11.3
	Redcliff Street (N)	OUT	1204	2546	279	**304**	243	**243**	3.7	2.2
	Redcliffe Way (E)	OUT	1204	2550	433	**581**	721	**825**	9.2	12.0
	Redcliff Hill (S)	OUT	1204	4021	379	**516**	659	**756**	9.5	12.3
Jacob Wells Road roundabout	*Jacobs Wells Road (N)*	IN	1198	9994	373	**434**	337	**343**	4.6	1.9
	St Georges Street (NE)	IN	9997	9995	156	**165**	137	**138**	2.2	1.6
	A4 Anchor Road €	IN	9998	9996	402	**595**	563	**584**	0.4	7.3
	A4 Hotwells Road (W)	IN	1618	9993	772	**964**	762	**875**	2.9	0.4
	Jacobs Wells Road (N)	OUT	1198	2559	342	**399**	231	**240**	8.9	6.5
	St Georges Street (NE)	OUT	9997	2671	176	**192**	90	**90**	8.6	7.4
	A4 Anchor Road €	OUT	9998	9999	446	**601**	729	**746**	5.6	11.7
	A4 Hotwells Road (W)	OUT	1618	1707	739	**965**	748	**851**	3.8	0.3
The Triangle	*A4018 Queens Road (N)*	IN	1817	1488	791	**1060**	670	**765**	9.8	4.5
	Triangle (W) circulatory		1229	4053	1134	**1407**	717	**849**	16.6	13.7
	A4018 Queens Road (N)	OUT	4053	4054	815	**1046**	483	**606**	15.3	13.0
	Triangle (W) circulatory		4053	1488	352	**416**	234	**243**	9.5	6.9
	University Road	OUT	2708	4060	58	**63**	91	**92**	3.2	3.9
	Park Row (E)	IN	2710	1228	886	**1102**	532	**654**	15.1	13.3
	Park Row (E)	OUT	2709	2708	823	**5658**	666	**757**	86.5	5.8
	Triangle (E) circulatory		2709	1228	195	**237**	239	**250**	0.9	3.0
	Park Row (E)	OUT	2708	2710	788	**1046**	574	**665**	13.0	8.2
	Berkeley Place (S)	IN	2673	1229	388	**462**	285	**304**	8.1	5.6
	Berkeley Place (S)	OUT	1229	2673	407	**473**	480	**501**	1.3	3.5
Lawrence Hill Rbt	*A4320 Easton Way (N)*	IN	1611	1244	1374	**1680**	1362	**1479**	5.1	0.3
	Lawrence Hill (E)	IN	4036	1245	654	**792**	891	**1026**	7.7	8.5
	A4320 St Phillips Causeway (S)	IN	1284	1246	979	**1215**	1086	**1227**	0.3	3.3
	Lawrence Hill (W)	IN	1249	1248	693	**816**	668	**743**	2.6	0.9
	A4320 Easton Way (N)	OUT	1248	1620	1206	**1438**	1323	**1482**	1.1	3.3
	Lawrence Hill (E)	OUT	1244	4092	699	**845**	852	**925**	2.7	5.5
	A4320 St Phillips Causeway (S)	OUT	1245	1284	1181	**1471**	880	**978**	14.1	9.4
	Lawrence Hill (W)	OUT	1246	1249	616	**749**	645	**748**	0.0	1.2
M32 Junction 3	*M32 (North)*	IN	3597	3973	1067	**1334**	1240	**1413**	2.1	5.1
	A4320 (E)	IN	2571	3974	1231	**1500**	1184	**1365**	3.6	1.3
	M32 (South)	IN	3977	3978	382	**430**	259	**274**	8.3	6.8
	B4051 (W)	IN	3578	3979	689	**768**	862	**885**	4.0	6.2
	M32 (North)	OUT	3979	3986	1108	**1372**	858	**1031**	9.8	8.0
	A4320 (E)	OUT	3973	3577	1396	**1695**	1587	**1734**	0.9	4.9
	M32 (South)	OUT	3974	3975	206	**236**	142	**159**	5.4	4.8
	B4051 (W)	OUT	3978	3578	659	**730**	959	**1012**	9.6	10.5

M32 / Cabot circus	*A4032 Newfoundland Way*	IN	3982	1471	1724	**2037**	1644	**1898**	3.1	2.0
	Houlton Street	IN	9972	1471	88	**103**	37	**38**	7.7	6.5
	Car Park	IN	2628	9974	70	**70**	107	**107**	4.0	4.0
	A4044 Temple Way	IN	9985	9967	1404	**1974**	1470	**1848**	2.9	1.7
	A4044 Newfoundland Street	IN	9970	1209	1590	**1870**	1718	**1927**	1.3	3.1
	A4032 Newfoundland Way	OUT	1221	9981	1940	**2279**	1828	**2084**	4.2	2.6
	Houlton Street	OUT	1471	9972	323	**346**	194	**216**	7.8	8.1
	Car Park	OUT	9974	2628	270	**273**	346	**346**	4.2	4.4
	A4044 Temple Way	OUT	9967	9985	777	**1057**	1175	**1386**	9.4	12.8
	A4044 Newfoundland Street	OUT	1209	9970	1463	**1993**	1339	**1672**	7.5	3.3
	St Paul Street	OUT	1209	9975	105	**107**	94	**114**	0.7	1.1
Hambrook	*Bristol Rd (N) to A4174 (W)*	N to W	3487	3560	218	**281**	227	**280**	0.1	0.6
	Bristol Rd (N) to (S)	N to S	3487	3560	143	**184**	326	**361**	10.7	12.0
	Bristol Rd (N) to A4174 (E)	N to E	3487	3560	297	**383**	69	**80**	19.9	16.8
	A4174 (W) to Bristol Rd (N)	W to N	3499	3560	269	**347**	370	**464**	5.9	5.6
	A4174 (W) to Bristol Rd (S)	W to S	3499	3560	211	**272**	70	**137**	9.5	11.9
	A4174 (W) to (E)	W to E	3499	3560	1086	**1399**	1484	**1699**	7.6	11.1
	Bristol Rd (S) to (N)	S to N	3473	3560	146	**188**	190	**211**	1.6	3.4
	Bristol Rd (S) to A4174 (W)	S to W	3473	3560	203	**262**	96	**174**	5.9	8.8
	Bristol Rd (S) to A4174 (E)	S to E	3473	3560	116	**150**	60	**79**	6.7	6.1
	A4174 (E) to Bristol Rd (N)	E to N	9960	3560	227	**293**	223	**225**	4.2	0.3
	A4174 (E) to (W)	E to W	9960	3560	966	**1244**	1126	**1321**	2.1	5.0
	A4174 (E) to Bristol Rd (S)	E to S	9960	3473	128	**165**	83	**92**	6.5	4.4
M32 J1	*M32 (N) to A4174 (E)*	N to E	3900	3952	523	**760**	705	**871**	3.9	7.4
	M32 (N) to A4174 (W)	N to W	3952	3953	220	**253**	179	**206**	3.1	2.9
	A4174 (E) to M32 (S)	E to S	3561	3953	460	**532**	423	**516**	0.7	1.7
	A4174 (E) to M32 (N)	E to N	3953	3957	524	**771**	544	**709**	2.3	0.9
	A4174 (E) to (W)	E to W	3561	3953	375	**437**	322	**554**	5.3	2.8
	M32 (S) to A4174 (W)	S to W	9916	3957	280	**331**	252	**288**	2.5	1.7
	M32 (S) to A4174 (E)	S to E	3957	3958	521	**602**	467	**586**	0.7	2.4
	A4174 (W) to M32 (N)	W to N	3562	3958	288	**322**	133	**179**	9.0	10.7
	A4174 (W) to (E)	W to E	3562	3958	549	**624**	702	**844**	8.1	6.1
	A4174 (W) to M32 (S)	W to S	3958	3952	300	**364**	300	**349**	0.8	0.0

TABLE E4

Inter Peak Traffic Flow Validation Comparison

Ref No.	Road	Dir	A node	B node	Obs LV	Obs Total PCUs	Model LV	Model Total PCUs	GEH PCUs	GEH LVs
O1	A38 Bridgewater Road	IN	7147	3635	564	**727**	610	**662**	2.5	1.9
O2	A370 Long Ashton Bypass	IN	2703	1355	499	**644**	533	**555**	3.6	1.5
O3	B3128 Ashton Road	IN	1148	1149	353	**455**	295	**474**	0.9	3.2
O4	A369 Clanage Road	IN	1158	2471	417	**453**	334	**366**	4.3	4.3
O5	B3129 Clifton Suspension Bridge	IN	1159	1160	292	**376**	321	**321**	3.0	1.6
O6	A4 Portway	IN	3348	3591	514	**868**	629	**759**	3.8	4.8
O7	B4054 Shirehampton Road	IN	2223	3340	270	**308**	243	**278**	1.8	1.7
O8	Kings Weston Lane	IN	3389	3342	195	**208**	144	**196**	0.8	4.0
O9	Hallen Road	IN	3362	3363	132	**139**	120	**130**	0.8	1.1
O10	A4018 Cribbs Causeway	IN	3197	3324	553	**713**	541	**608**	4.1	0.5
O11	Merlin Road	IN	3193	3198	740	**954**	822	**901**	1.7	2.9
O12	Highwood Lane	IN	3191	3195	565	**728**	599	**716**	0.4	1.4
O13	A38 Gloucester Rd	IN	3162	3410	1010	**1302**	1100	**1292**	0.3	2.8
O14	B4427 Old Gloucester Road	IN	3030	3526	172	**221**	209	**224**	0.2	2.7
O15	B4057 Beacon Lane	IN	3037	3528	478	**616**	441	**554**	2.6	1.7
O16	M32	IN	3907	3951	2229	**2739**	2197	**2677**	1.2	0.7
O17	B4058 Bristol Road	IN	2371	3550	268	**346**	254	**325**	1.1	0.9
O18	A432 Badminton Road	IN	4236	3047	594	**766**	583	**681**	3.2	0.5
O19	Westerleigh Road	IN	4237	3685	377	**486**	334	**459**	1.3	2.3
O20	Shortwood Road	IN	1125	3055	230	**296**	258	**319**	1.4	1.8
O21	A420 London Rd	IN	3761	3760	386	**497**	365	**508**	0.5	1.1
O22	A431 Bath Road	IN	3798	3772	268	**345**	286	**321**	1.3	1.1
O23	A4 Bath Road	IN	1408	1407	823	**929**	728	**848**	2.7	3.4
O24	B3116 Wellsway	IN	3767	1404	425	**455**	394	**441**	0.7	1.5
O25	A37 Bristol Road	IN	3645	8052	435	**560**	443	**615**	2.3	0.4
O26	Queens Rd	IN	3636	7115	145	**151**	156	**194**	3.3	0.9
O1	A38 Bridgewater Road	OUT	3635	7147	583	**751**	695	**828**	2.7	4.4
O2	A370 Long Ashton Bypass	OUT	1355	2703	576	**742**	563	**612**	5.0	0.5
O3	B3128 Ashton Road	OUT	1149	1148	398	**513**	415	**577**	2.8	0.8
O4	A369 Clanage Road	OUT	2471	1158	365	**385**	308	**346**	2.0	3.1
O5	B3129 Clifton Suspension Bridge	OUT	1160	1159	327	**421**	356	**356**	3.3	1.6
O6	A4 Portway	OUT	3591	3348	614	**859**	557	**773**	3.0	2.4
O7	B4054 Shirehampton Road	OUT	3340	2223	257	**292**	171	**223**	4.3	5.9
O8	Kings Weston Lane	OUT	3342	3389	182	**193**	137	**182**	0.8	3.5
O9	Hallen Road	OUT	3363	3362	104	**112**	85	**106**	0.6	1.9
O10	A4018 Cribbs Causeway	OUT	3324	3197	620	**798**	547	**684**	4.2	3.0
O11	Merlin Road	OUT	3198	3193	565	**727**	727	**761**	1.2	6.4
O12	Highwood Lane	OUT	3195	3193	406	**523**	494	**612**	3.7	4.1
O13	A38 Gloucester Rd	OUT	3410	3162	1185	**1527**	1261	**1453**	1.9	2.2
O14	B4427 Old Gloucester Road	OUT	3526	3030	129	**166**	182	**188**	1.7	4.2
O15	B4057 Beacon Lane	OUT	3528	3037	479	**617**	483	**590**	1.1	0.2
O16	M32	OUT	3960	3908	2034	**2500**	1855	**2385**	2.3	4.1
O17	B4058 Bristol Road	OUT	3550	2371	284	**366**	289	**371**	0.3	0.3
O18	A432 Badminton Road	OUT	3047	4236	609	**785**	520	**629**	5.9	3.8

O19	Westerleigh Road	OUT	3685	4237	349	**449**	394	**489**	1.8	2.3
O20	Shortwood Road	OUT	3055	1125	249	**321**	265	**312**	0.5	1.0
O21	A420 London Rd	OUT	3760	3761	357	**460**	362	**527**	3.0	0.3
O22	A431 Bath Road	OUT	3772	3798	239	**308**	268	**322**	0.8	1.8
O23	A4 Bath Road	OUT	1407	1408	853	**916**	861	**1000**	2.7	0.3
O24	B3116 Wellsway	OUT	1404	3767	445	**478**	367	**408**	3.3	3.9
O25	A37 Bristol Road	OUT	8052	3645	361	**466**	352	**530**	2.9	0.5
O26	Queens Rd	OUT	7115	3636	140	**149**	172	**206**	4.3	2.6
M2	A4176 Portway	IN	1162	1582	1105	**1421**	1070	**1317**	2.8	1.1
M4	College Road	IN	1801	1160	313	**351**	327	**353**	0.1	0.8
M5	Pembroke Road	IN	1041	1803	139	**159**	179	**196**	2.8	3.2
M7	Whiteladies Road	IN	1809	1238	711	**851**	715	**801**	1.8	0.2
M8	Hampton Road	IN	1015	1881	204	**210**	208	**211**	0.0	0.2
M9	Redland Grove	IN	1659	1853	191	**210**	115	**136**	5.7	6.1
M10	Redland Road	IN	1034	1855	130	**133**	172	**173**	3.2	3.4
M11	A38 Cheltenham Road	IN	1030	1031	427	**645**	454	**538**	4.4	1.3
M12	North Road	IN	1146	1031	239	**249**	186	**197**	3.5	3.7
RW14	Ashley Hill	IN	1036	1917	498	**514**	530	**543**	1.2	1.4
MM12	Glenfrome Road	IN	1107	1919	350	**451**	301	**319**	6.8	2.7
M13	M32	IN	3971	3972	2290	**2666**	2395	**2783**	2.3	2.2
M14	Stapleton Road	IN	1437	1440	413	**476**	354	**432**	2.0	3.1
M15	Easton Road	IN	2005	1995	261	**270**	75	**81**	14.3	14.4
M16	A420 Lawrence Hill	IN	1251	1466	738	**829**	815	**950**	4.1	2.8
M17	Ducie Road	IN	1763	1250	68	**88**	87	**115**	2.8	2.2
M18	Barrow Road	IN	1283	1747	307	**327**	284	**344**	0.9	1.4
M19	A4320 St Phillips Causeway	IN	1290	1549	961	**1164**	1033	**1169**	0.2	2.3
M20	Feeder Road	IN	1751	1741	482	**581**	421	**461**	5.2	2.8
M21	Albert Road	IN	1290	1755	358	**574**	349	**446**	5.7	0.5
M22	Bath Road	IN	2087	4038	519	**625**	420	**505**	5.0	4.6
M23	Wells Road	IN	2131	2085	469	**583**	345	**497**	3.7	6.1
MM23	Redcatch Road	IN	1185	2125	244	**275**	301	**331**	3.2	3.5
M24	Wedmore Vale	IN	2213	2159	184	**188**	163	**206**	1.3	1.5
M25	Novers Hill	IN	2469	2211	220	**239**	222	**223**	1.1	0.2
M26	A4174 Hartcliffe Way	IN	2728	1361	802	**906**	749	**945**	1.3	1.9
M27	A38 Bedminster Down Road	IN	1183	1433	905	**1022**	809	**939**	2.7	3.3
M28	South Liberty Lane	IN	7166	3607	120	**156**	113	**126**	2.5	0.6
M29	Ashton Drive	IN	10005	4082	181	**208**	144	**161**	3.5	2.9
M30	A370 Ashton Road	IN	1153	1154	894	**1054**	796	**1007**	1.5	3.4
M2	A4176 Portway	OUT	1582	1162	1071	**1382**	970	**1200**	5.1	3.2
M4	College Road	OUT	1160	1801	238	**249**	253	**267**	1.1	1.0
M5	Pembroke Road	OUT	1803	1041	147	**167**	164	**181**	1.1	1.4
M7	Whiteladies Road	OUT	1238	1809	663	**817**	578	**659**	5.8	3.4
M8	Hampton Road	OUT	1881	1015	272	**280**	295	**295**	0.9	1.3
M9	Redland Grove	OUT	1853	1659	189	**211**	129	**149**	4.6	4.8
M10	Redland Road	OUT	1855	1034	90	**92**	115	**116**	2.4	2.4
M11	A38 Cheltenham Road	OUT	1031	1030	430	**640**	497	**588**	2.1	3.1
M12	North Road	OUT	1031	1146	25	**35**	24	**32**	0.5	0.3
RW14	Ashley Hill	OUT	1917	1036	536	**551**	585	**591**	1.7	2.1
MM12	Glenfrome Road	OUT	1919	1107	325	**419**	319	**337**	4.2	0.3
M13	M32	OUT	3981	3965	2454	**2906**	2406	**2829**	1.4	1.0
M14	Stapleton Road	OUT	1440	1437	424	**498**	369	**418**	3.8	2.7

M15	Easton Road	OUT	1995	2005	189	198	218	230	2.2	2.0
M16	A420 Lawrence Hill	OUT	1466	1251	659	754	704	757	0.1	1.7
M17	Ducie Road	OUT	1250	1763	27	34	55	84	6.5	4.5
M18	Barrow Road	OUT	1747	1283	229	264	210	246	1.1	1.3
M19	A4320 St Phillips Causeway	OUT	1549	1290	785	1074	784	875	6.4	0.0
M20	Feeder Road	OUT	1741	1751	487	577	450	562	0.6	1.7
M21	Albert Road	OUT	1755	1290	293	443	356	502	2.7	3.5
M22	Bath Road	OUT	4038	2087	526	647	594	722	2.9	2.8
M23	Wells Road	OUT	2085	2131	567	712	482	621	3.5	3.7
MM23	Redcatch Road	OUT	2125	1185	356	393	350	377	0.8	0.3
M24	Wedmore Vale	OUT	2159	2213	165	185	231	257	4.8	4.6
M25	Novers Hill	OUT	2211	2469	309	327	293	305	1.3	1.0
M26	A4174 Hartcliffe Way	OUT	1361	2728	780	953	710	841	3.7	2.6
M27	A38 Bedminster Down Road	OUT	1433	1183	854	988	914	1104	3.6	2.0
M28	South Liberty Lane	OUT	3607	7166	109	149	92	119	2.6	1.6
M29	Ashton Drive	OUT	4082	10005	191	202	178	201	0.1	1.0
M30	A370 Ashton Road	OUT	1530	1531	1004	1210	916	1132	2.3	2.9
NWO1	M5	IN	3192	3201	2543	3125	2836	3496	6.5	5.7
NWO2	A4018 Cribbs Causeway	IN	4351	3347	913	1176	969	1052	3.7	1.8
NWO4	Gloucester Rd North	IN	3496	1651	886	1142	994	1144	0.1	3.5
NWO5	Great Stoke Way	IN	3488	4386	723	931	725	992	2.0	0.1
NWO6	M32	IN	3951	3954	1348	1657	1320	1621	0.9	0.8
NWO7	Bristol Rd	IN	3487	3560	650	713	622	721	0.3	1.1
NWO1	M5	OUT	3216	3183	2787	3425	2910	3763	5.6	2.3
NWO2	A4018 Cribbs Causeway	OUT	3347	4351	947	1220	954	1096	3.6	0.2
NWO4	Gloucester Rd North	OUT	1651	3496	984	1268	1110	1239	0.8	3.9
NWO5	Great Stoke Way	OUT	4386	3488	626	807	700	784	0.8	2.9
NWO6	M32	OUT	3956	3959	1245	1531	1179	1497	0.9	1.9
NWO7	Bristol Rd	OUT	3560	3487	711	755	783	901	5.1	2.7
NE1	Frenchay park Rd	IN	2355	1094	580	617	626	694	3.0	1.9
NE2	Blackberry Hill	IN	1094	2393	494	533	594	650	4.8	4.3
NE3	Fishponds Road	IN	1985	1062	649	750	509	734	0.6	5.8
NE4	Berkley Rd	IN	1077	2025	308	396	341	362	1.8	1.9
NE5	Charlton Road	IN	2027	1098	298	310	303	327	0.9	0.3
NE6	Lodge Rd	IN	1097	1080	242	254	115	212	2.7	9.5
NE7	Downend Rd	IN	1612	2724	330	346	292	306	2.2	2.1
NE8	Syston Way	IN	1541	2031	259	275	298	361	4.8	2.4
NE9	Lees Hill	IN	2490	2409	131	140	107	110	2.7	2.2
NE10	Pound Rd	IN	2405	1685	119	122	108	130	0.7	1.0
NE12	Station Rd	IN	1089	1087	338	435	459	467	1.5	6.1
NE1	Frenchay park Rd	OUT	1094	2355	498	527	499	599	3.0	0.0
NE2	Blackberry Hill	OUT	2393	1094	504	548	516	590	1.8	0.5
NE3	Fishponds Road	OUT	1062	1985	652	764	521	652	4.2	5.4
NE4	Berkley Rd	OUT	2025	1077	352	453	294	355	4.9	3.2
NE5	Charlton Road	OUT	1098	2027	329	342	350	367	1.3	1.1
NE6	Lodge Rd	OUT	1080	1097	212	223	129	269	2.9	6.3
NE7	Downend Rd	OUT	2724	1612	228	241	202	236	0.4	1.8
NE8	Syston Way	OUT	2031	1541	277	310	279	364	2.9	0.1
NE9	Lees Hill	OUT	2409	2490	174	184	205	224	2.8	2.3
NE10	Pound Rd	OUT	1685	2405	158	161	154	185	1.8	0.3
NE12	Station Rd	OUT	1087	1089	282	363	323	348	0.8	2.4

TABLE E5

Evening Peak Traffic Flow Calibration Comparison

Ref No.	Road	Dir	A node	B node	Obs LV	Obs Total PCUs	Model LV	Model Total PCUs	GEH PCUs	GEH LVs
RSI1	A4018 Whiteladies Road	IN	1488	2709	1024	**1111**	1120	**1210**	2.9	3.0
I5	Woodland Rd	IN	2557	1226	127	**186**	109	**110**	6.2	1.7
RSI2	Horfield Road	IN	1863	1539	198	**215**	280	**286**	4.5	5.3
RSI3	A38 North Road	IN	1504	1566	504	**661**	520	**617**	1.7	0.7
I6	York Street	IN	2624	2625	76	**77**	39	**43**	4.4	4.8
RSI4	A4032 Newfoundland Street	IN	3976	3982	1547	**1646**	1671	**1758**	2.7	3.1
RSI5	A420 Old Market Street	IN	4034	1219	878	**980**	964	**1050**	2.2	2.8
RSI6	Avon Street	IN	1769	1591	124	**132**	115	**122**	0.9	0.8
I8	Station Approach Rd	IN	1482	1480	298	**426**	234	**386**	2.0	3.9
RSI7	Feeder Road	IN	1286	1574	295	**325**	339	**373**	2.6	2.5
RSI8	A4 Bath Road	IN	1189	1572	1033	**1189**	917	**1049**	4.2	3.7
RSI9	St Lukes Road	IN	2163	1191	259	**259**	273	**274**	0.9	0.8
I1_I2	Whitehouse/Spring Street	IN	2164	8250	205	**224**	192	**259**	2.2	0.9
RSI10	Bedminster Parade	IN	4022	2161	597	**695**	403	**469**	9.4	8.7
RSI11	A370 Coronation Road	IN	1489	1558	664	**729**	902	**936**	7.2	8.5
RSI12	Cumberland Road	IN	2668	1711	656	**669**	608	**629**	1.6	1.9
RSI13	Hotwell Road	IN	1164	1705	1238	**1375**	1315	**1401**	0.7	2.1
I4	Constitution Hill	IN	2558	2559	99	**101**	114	**115**	1.4	1.4
I3	Lower Clifton Hill (one way)	IN	2558	2560	27	**31**	10	**10**	4.5	3.9
RSI1	A4018 Whiteladies Road	OUT	1228	1229	1271	**1392**	1426	**1554**	4.2	4.2
I5	Woodland Rd	OUT	1226	2557	140	**188**	156	**156**	2.4	1.3
RSI2	Horfield Road	OUT	1539	1863	127	**144**	100	**119**	2.2	2.6
RSI3	A38 North Road	OUT	1607	1504	453	**561**	330	**419**	6.4	6.3
I6	York Street	OUT	2625	2624	65	**68**	15	**15**	8.1	7.9
RSI4	A4032 Newfoundland Street	OUT	1470	3977	2642	**2787**	2751	**2783**	0.1	2.1
RSI5	A420 Old Market Street	OUT	1837	1220	992	**1117**	841	**951**	5.2	5.0
RSI6	Avon Street	OUT	1591	1769	253	**258**	271	**278**	1.3	1.1
I8	Station Approach Rd	OUT	1480	1482	285	**353**	292	**417**	3.3	0.4
RSI7	Feeder Road	OUT	1574	1286	265	**276**	77	**151**	8.6	14.3
RSI8	A4 Bath Road	OUT	1572	1189	1499	**1653**	1606	**1749**	2.3	2.7
RSI9	St Lukes Road	OUT	1191	2163	516	**525**	737	**744**	8.7	8.8
I1_I2	Whitehouse/Spring Street	OUT	8250	2164	207	**213**	216	**220**	0.5	0.6
RSI10	Bedminster Parade	OUT	2161	4022	429	**585**	453	**514**	3.0	1.1
RSI11	A370 Coronation Road	OUT	1558	1489	1125	**1177**	1061	**1143**	1.0	1.9
RSI12	Cumberland Road	OUT	1711	2668	747	**817**	534	**612**	7.7	8.4
RSI13	Hotwell Road	OUT	2593	1521	1902	**2216**	2030	**2196**	0.4	2.9
I4	Constitution Hill	OUT	2559	2558	196	**198**	238	**239**	2.8	2.8
E1	A4174	IN	9961	9960	1648	**1841**	1678	**1754**	2.1	0.7
E2	Downend Rd	IN	2385	1066	358	**375**	360	**406**	1.6	0.1
E3	Staplehill Rd	IN	2383	1071	403	**435**	378	**404**	1.5	1.3
E4	Lodge Hill	IN	1079	1078	234	**309**	270	**285**	1.3	2.2

E5	Two Mile Hill Rd	IN	1255	2049	361	384	279	317	3.6	4.6
E6	Nags Head Hill	IN	2053	1276	471	493	480	508	0.7	0.4
E7	Crews Hole Road	IN	1999	1293	96	101	113	114	1.2	1.6
E9	Bath Rd	IN	8053	1406	1257	1404	1231	1277	3.5	0.7
E1	A4174	OUT	9960	9961	2563	2863	2808	2899	0.7	4.7
E2	Downend Rd	OUT	1066	2385	405	431	412	452	1.0	0.4
E3	Staplehill Rd	OUT	1071	2383	500	548	450	470	3.4	2.3
E4	Lodge Hill	OUT	1078	1079	245	325	223	229	5.7	1.4
E5	Two Mile Hill Rd	OUT	2049	1255	519	573	515	553	0.8	0.2
E6	Nags Head Hill	OUT	1276	2053	677	744	771	796	1.9	3.5
E7	Crews Hole Road	OUT	1293	1999	648	648	653	660	0.5	0.2
E9	Bath Rd	OUT	1406	8053	1598	1785	1584	1630	3.8	0.4
NWI2	Shirehampton Rd	IN	3338	3339	391	437	386	476	1.9	0.3
NWI3	Henbury Rd	IN	8069	3329	109	109	125	129	1.8	1.5
NWI4	A4018 Passage Rd	IN	2261	3584	984	1100	939	966	4.2	1.5
NWI5	Grey Stoke Av	IN	2259	4340	416	464	484	495	1.4	3.2
NWI7	Southmead Rd	IN	2265	3586	677	730	693	726	0.2	0.6
NWI8	Kellaway Av	IN	1026	1025	560	626	591	597	1.2	1.3
NWI9	Gloucester Rd	IN	1027	1028	622	687	313	387	13.0	14.3
NWI10	Muller Rd	IN	1058	1059	820	918	764	817	3.4	2.0
NWI11	Coldhabour Lane	IN	1663	1093	584	620	571	610	0.4	0.5
NWI12	Filton Rd	IN	3451	3490	959	1072	803	871	6.4	5.3
NWI13	Hambrook Rd	IN	1941	3539	137	153	187	192	3.0	3.9
NWI14	Winterbourne Rd	IN	3529	3528	1237	1382	1303	1342	1.1	1.9
NWI15	M4	IN	3157	3901	4645	5190	4702	5345	2.1	0.8
NWI2	Shirehampton Rd	OUT	3339	3338	336	375	385	423	2.4	2.6
NWI3	Henbury Rd	OUT	3329	8069	134	136	131	138	0.2	0.3
NWI4	A4018 Passage Rd	OUT	3584	2261	851	950	909	941	0.3	2.0
NWI5	Grey Stoke Av	OUT	4340	2259	595	665	510	562	4.2	3.6
NWI7	Southmead Rd	OUT	3586	2265	564	613	623	724	4.3	2.5
NWI8	Kellaway Av	OUT	1025	1026	591	660	474	487	7.2	5.1
NWI9	Gloucester Rd	OUT	1028	1027	555	626	486	573	2.2	3.0
NWI10	Muller Rd	OUT	1059	1058	989	1050	904	931	3.8	2.8
NWI11	Coldhabour Lane	OUT	1093	1663	352	382	329	384	0.1	1.2
NWI12	Filton Rd	OUT	3490	3451	2080	2324	2188	2402	1.6	2.3
NWI13	Hambrook Rd	OUT	1941	2365	94	105	94	96	0.9	0.0
NWI14	Winterbourne Rd	OUT	3528	3529	1373	1534	1372	1420	3.0	0.0
NWI15	M4	OUT	3910	3138	4801	5364	4812	5450	1.2	0.2
S1	Bridgewater Rd	IN	3635	2459	548	605	624	647	1.7	3.1
S2	Bishopsworth Rd	IN	2463	2195	438	489	460	479	0.5	1.0
S3	St Peters Rise	IN	1357	2523	132	144	157	172	2.2	2.1
S4	Hengrove Way	IN	1359	1360	814	846	721	742	3.7	3.4
S5	Hawkfield Rd	IN	1365	2519	554	570	551	596	1.1	0.1
S6	Whitchurch Lane	IN	7178	1376	632	735	687	742	0.3	2.2
S7	Bamfield	IN	2433	3644	299	299	238	248	3.1	3.7
S8	Wells Rd	IN	1380	1430	560	675	581	662	0.5	0.9
S9	Bath Rd	IN	1311	4044	1102	1231	1222	1302	2.0	3.5
S10	School Road	IN	1307	2121	389	410	424	427	0.8	1.7
S11	Allison Rd	IN	1307	2117	284	318	313	338	1.1	1.7
S1	Bridgewater Rd	OUT	2459	3635	578	630	694	716	3.3	4.6
S2	Bishopsworth Rd	OUT	2195	2463	705	787	692	710	2.8	0.5

S3	St Peters Rise	OUT	2523	1357	203	220	209	222	0.1	0.5
S4	Hengrove Way	OUT	1360	1359	884	900	892	906	0.2	0.3
S5	Hawkfield Rd	OUT	2519	1365	432	442	446	527	3.8	0.6
S6	Whitchurch Lane	OUT	7013	1376	692	760	689	729	1.1	0.1
S7	Bamfield	OUT	3644	2433	245	248	280	300	3.1	2.2
S8	Wells Rd	OUT	1430	1380	638	775	703	772	0.1	2.5
S9	Bath Rd	OUT	1490	4046	1058	1182	1585	1639	12.2	14.5
S10	School Road	OUT	2121	1307	543	596	389	390	9.3	7.1
S11	Allison Rd	OUT	2117	1307	278	295	313	328	1.9	2.0
R1	M5	IN	3213	3928	4471	4995	4424	4897	1.4	0.7
R3	A3029 Brunel Way (N)	IN	1165	1513	2575	2689	2757	2915	4.3	3.5
R4	A3029 Brunel Way (S)	IN	1513	1166	2912	3047	3126	3295	4.4	3.9
R5	Princes Street Bridge	IN	1436	1777	157	162	196	202	2.9	3.0
R6	Bedminster Bridge	IN	1477	1319	1258	1443	1303	1427	0.4	1.3
R7	Redcliffe Way	IN	2651	1203	324	475	325	395	3.8	0.1
R8	Bristol Bridge, Victoria Street	IN	1233	2547	620	736	701	810	2.6	3.2
R9	Passager Street	IN	1247	1594	323	361	364	372	0.6	2.2
R10	Temple Way	IN	1591	1593	1128	1292	1136	1227	1.8	0.3
R11	Bath Bridge	IN	1485	1210	2432	2825	2648	2857	0.6	4.3
R12	Avon Street	IN	1592	1286	575	605	564	589	0.7	0.5
R13	Albert Road	IN	1288	1301	361	382	433	447	3.2	3.6
R15	St Phillips Causeway	IN	1290	1302	1329	1405	1551	1618	5.5	5.8
R16	Marsh Lane	IN	2011	3631	260	278	221	224	3.4	2.5
R17	Nethan Road	IN	2013	1425	644	675	702	726	1.9	2.2
R18	Feeder Road	IN	1426	2599	791	847	839	868	0.7	1.7
R1	M5	OUT	3927	3204	3866	4319	3831	4665	5.2	0.6
R3	A3029 Brunel Way (N)	OUT	1525	1524	1944	2087	2277	2411	6.8	7.2
R4	A3029 Brunel Way (S)	OUT	1527	1526	2122	2266	2362	2497	4.8	5.1
R5	Princes Street Bridge	OUT	1777	1436	683	683	412	433	10.6	11.6
R6	Bedminster Bridge	OUT	1474	1318	1500	1744	1644	1821	1.8	3.6
R7	Redcliffe Way	OUT	1204	2651	329	435	269	342	4.7	3.5
R8	Bristol Bridge, Victoria Street	OUT	2547	1233	727	842	736	826	0.6	0.4
R9	Passage Street	OUT	1594	1247	372	416	353	354	3.2	1.0
R10	Temple Way	OUT	1593	1207	1187	1344	1670	1764	10.7	12.8
R11	Bath Bridge	OUT	1483	1484	1330	1617	1345	1537	2.0	0.4
R12	Avon Street	OUT	1286	1592	252	276	267	308	1.9	0.9
R13	Albert Road	OUT	1301	1288	287	305	216	230	4.6	4.5
R15	St Phillips Causeway	OUT	1302	1290	1117	1160	1136	1189	0.8	0.6
R16	Marsh Lane	OUT	3631	2011	268	270	291	302	1.9	1.4
R17	Nethan Road	OUT	1425	2013	1187	1216	731	778	13.9	14.7
R18	Feeder Road	OUT	2599	1426	761	800	774	793	0.2	0.5
RW1	A4176 Portway	IN	1052	1162	969	1073	1098	1139	2.0	4.0
RW5	Clifton Down	IN	1041	1161	708	733	659	679	2.0	1.9
RW22	Kingsland Road	IN	1733	1285	252	264	315	344	4.6	3.8
RW2	Avon Street	IN	1769	1592	253	258	305	314	3.3	3.1
RW26	B3021 St Johns Lane	IN	1181	1180	611	651	610	634	0.7	0.0
RW27	A38 Parsons Street	IN	1173	1579	1889	1987	2050	2219	5.1	3.6
RW28	A38 Bedminster Down Road	IN	1433	2746	1923	2049	2004	2106	1.2	1.8
RW30	Whitby Road	IN	2599	1302	271	276	301	305	1.7	1.8

RW34	A4174	IN	2937	3612	1861	**2079**	1834	**1857**	5.0	0.6
RW35	A4175 Keynsham Road	IN	1394	1393	569	**590**	600	**624**	1.4	1.3
RW36	Muller Road	IN	1058	2335	746	**766**	752	**774**	0.3	0.2
RW37	Lockleaze Road	IN	2327	1486	148	**158**	166	**175**	1.3	1.4
RW38	Bonnington Walk	IN	2315	2305	245	**255**	248	**268**	0.8	0.2
RW39	A4174 Station Road	IN	3693	3471	1573	**1758**	1593	**1718**	0.9	0.5
RW40	Gipsy Patch Lane	IN	3234	1945	710	**793**	717	**738**	2.0	0.3
RW41	A38 Gloucester Road	IN	3427	3307	1164	**1417**	1217	**1281**	3.7	1.5
RW42	M5	IN	3174	3181	4206	**4699**	4153	**4547**	2.2	0.8
RW1	A4176 Portway	OUT	1162	1052	1081	**1216**	1104	**1164**	1.5	0.7
RW5	Clifton Down	OUT	1161	1041	826	**858**	713	**732**	4.5	4.1
RW22	Kingsland Road	OUT	1285	1733	167	**205**	206	**222**	1.1	2.9
RW2	Avon Street	OUT	1592	1769	124	**132**	127	**135**	0.2	0.3
RW26	B3021 St Johns Lane	OUT	1180	1181	915	**993**	778	**808**	6.2	4.7
RW30	Whitby Road	OUT	1302	2599	307	**325**	131	**139**	12.2	11.9
RW35	A4175 Keynsham Road	OUT	1393	1394	606	**622**	608	**639**	0.7	0.1
RW36	Muller Road	OUT	2335	1058	579	**639**	601	**640**	0.1	0.9
RW37	Lockleaze Road	OUT	1486	2327	209	**228**	208	**221**	0.4	0.0
RW38	Bonnington Walk	OUT	2305	2315	183	**203**	148	**175**	2.0	2.7
RW39	A4174 Station Road	OUT	3471	3693	1371	**1532**	1483	**1740**	5.1	2.9
RW40	Gipsy Patch Lane	OUT	1945	3234	852	**952**	894	**907**	1.5	1.4
RW41	A38 Gloucester Road	OUT	3310	3313	513	**581**	533	**574**	0.3	0.9
M5 J19	*Docks*	*IN*	1619	3926	528	**770**	529	**723**	1.7	0.0
	Docks	*OUT*	7025	1619	87	**330**	161	**205**	7.6	6.6
	Gordano Services	*IN*	4336	7027	203	**262**	49	**96**	12.4	13.8
	Gordano Services	*OUT*	7027	4336	164	**228**	166	**215**	0.9	0.2
	A369 Martcombe Rd East	*IN*	3706	3705	770	**780**	956	**984**	6.9	6.3
	A369 Martcombe Rd East	*OUT*	3705	3706	857	**869**	846	**870**	0.1	0.4
	St George's Hill - Pill	*IN*	3705	7019	248	**259**	244	**260**	0.1	0.2
	St George's Hill - Pill	*OUT*	7019	3705	277	**280**	93	**192**	5.7	13.5
	Portbury High st	*IN*	7035	7036	487	**491**	533	**538**	2.1	2.0
	Portbury High st	*OUT*	7036	7035	300	**300**	300	**336**	2.1	0.0
	The Portbury Hundred	*IN*	3789	3703	1013	**1028**	1016	**1121**	2.8	0.1
	The Portbury Hundred	*OUT*	3703	3789	1480	**1503**	1590	**1646**	3.6	2.8
Temple Circus roundabout	*A4044 Temple Way (N)*	IN	1610	1206	1134	**1297**	1061	**1151**	4.2	2.2
	Friary (E)	IN	1565	1508	165	**180**	89	**110**	5.8	6.8
	Redcliffe Way (S)	IN	1510	1506	1567	**1924**	1565	**1834**	2.1	0.1
	Victoria Street (NW)	IN	1562	1205	477	**586**	797	**900**	11.5	12.7
	A4044 Temple Way (N)	OUT	1205	1563	1230	**1449**	1455	**1548**	2.6	6.1
	Friary (E)	OUT	1206	1564	49	**64**	25	**32**	4.6	4.0
	A4 Temple Gate (SE)	OUT	1508	1507	1839	**2174**	1899	**2192**	0.4	1.4
	Victoria Street (NW)	OUT	1506	1561	225	**300**	133	**222**	4.8	6.9
	A4 Temple Gate (E)	IN	2647	2556	1208	**1525**	1060	**1305**	5.9	4.4
	Redcliff Mead Lane (S)	IN	2740	2556	129	**129**	74	**85**	4.3	5.4
	Redcliffe Way (W)	IN	1717	1605	582	**682**	776	**789**	3.9	7.4
	Redcliffe Way (W)	OUT	1604	1606	277	**343**	211	**247**	5.5	4.3
Bath Bridge	*A4 Temple Gate (N)*	IN	1480	1485	1785	**2010**	1639	**1866**	3.3	3.5
	Cattle market Road (NE)	IN	1574	1485	325	**338**	339	**373**	1.9	0.8
	A4 Bath Road (SE)	IN	1572	1190	1046	**1235**	917	**1049**	5.5	4.1
	A370 York Road (SW)	IN	1570	1483	413	**436**	394	**431**	0.2	0.9
	Clarence Road (W)	IN	1573	1484	565	**633**	597	**620**	0.5	1.3

	A4 Temple Gate (N)	OUT	1484	1480	977	**1167**	858	**1009**	4.8	3.9
	Cattle market Road (NE)	OUT	1485	1574	304	**334**	77	**151**	11.8	16.4
	A4 Bath Road (SE)	OUT	1210	1571	1462	**1686**	1606	**1749**	1.5	3.7
	A370 York Road (SW)	OUT	1190	1570	1015	**1080**	1008	**1051**	0.9	0.2
	Clarence Road (W)	OUT	1484	1573	376	**385**	309	**349**	1.8	3.6
Bedminster Bridge roundabout	*Redcliff Hill (N)*	IN	1479	1476	585	**694**	691	**786**	3.4	4.2
	Clarence Road (NE)	IN	1554	1477	379	**403**	319	**347**	2.9	3.2
	A370 York Road (SE)	IN	1555	1478	780	**818**	512	**576**	9.2	10.6
	Bedminster Parade (S)	IN	1557	1192	532	**625**	524	**619**	0.2	0.4
	A370 Coronation Road (SW)	IN	1558	1474	641	**700**	902	**936**	8.2	9.4
	Commerical Road (NW)	IN	1559	1475	736	**770**	702	**722**	1.8	1.3
	Redcliff Hill (N)	OUT	1475	1552	668	**789**	1244	**1325**	16.5	18.6
	Clarence Road (NE)	OUT	1476	1554	682	**738**	538	**564**	6.8	5.8
	A370 York Road (SE)	OUT	1319	1555	432	**440**	386	**388**	2.5	2.3
	Bedminster Parade (S)	OUT	1478	1556	445	**560**	432	**493**	2.9	0.6
	A370 Coronation Road (SW)	OUT	1553	1558	1041	**1088**	779	**854**	7.5	8.7
	Commerical Road (NW)	OUT	1560	1559	385	**396**	269	**357**	2.0	6.4
Redcliffe Way roundabout	*Redcliff Street (N)*	IN	2546	1204	280	**290**	273	**294**	0.2	0.4
	Redcliffe Way (E)	IN	2550	1204	263	**326**	232	**269**	3.3	2.0
	Redcliff Hill (S)	IN	1552	1204	772	**903**	1244	**1324**	12.6	14.9
	Redcliff Street (N)	OUT	1204	2546	299	**320**	361	**366**	2.5	3.4
	Redcliffe Way (E)	OUT	1204	2550	551	**656**	962	**1026**	12.8	14.9
	Redcliff Hill (S)	OUT	1204	4021	460	**583**	585	**682**	3.9	5.5
Jacob Wells Road roundabout	*Jacobs Wells Road (N)*	IN	1198	9994	488	**510**	715	**754**	9.7	9.3
	St Georges Street (NE)	IN	9997	9995	192	**195**	110	**112**	6.6	6.7
	A4 Anchor Road €	IN	9998	9996	711	**850**	873	**892**	1.4	5.8
	A4 Hotwells Road (W)	IN	1618	9993	738	**854**	666	**736**	4.2	2.7
	Jacobs Wells Road (N)	OUT	1198	2559	395	**421**	375	**381**	2.0	1.0
	St Georges Street (NE)	OUT	9997	2671	226	**229**	175	**175**	3.7	3.6
	A4 Anchor Road €	OUT	9998	9999	320	**419**	383	**385**	1.7	3.4
	A4 Hotwells Road (W)	OUT	1618	1707	1188	**1339**	1429	**1549**	5.5	6.7
The Triangle	*A4018 Queens Road (N)*	IN	1817	1488	606	**759**	863	**953**	6.6	9.5
	Triangle (W) circulatory		1229	4053	1442	**1546**	1049	**1145**	10.9	11.1
	A4018 Queens Road (N)	OUT	4053	4054	1144	**1226**	792	**887**	10.4	11.3
	Triangle (W) circulatory		4053	1488	298	**353**	257	**257**	5.5	2.4
	University Road	OUT	2708	4060	54	**54**	19	**19**	5.8	5.8
	Park Row (E)	IN	2710	1228	1140	**1210**	815	**925**	8.7	10.4
	Park Row (E)	OUT	2709	2708	649	**854**	733	**808**	1.6	3.2
	Triangle (E) circulatory		2709	1228	209	**265**	387	**403**	7.6	10.3
	Park Row (E)	OUT	2708	2710	595	**778**	714	**789**	0.4	4.6
	Berkeley Place (S)	IN	2673	1229	505	**557**	460	**466**	4.0	2.1
	Berkeley Place (S)	OUT	1229	2673	559	**582**	837	**875**	10.9	10.5
Lawrence Hill Rbt	*A4320 Easton Way (N)*	IN	1611	1244	1490	**1581**	1962	**2011**	10.1	11.4
	Lawrence Hill (E)	IN	4036	1245	645	**711**	1002	**1084**	12.4	12.4
	A4320 St Phillips Causeway (S)	IN	1284	1246	920	**1003**	1318	**1359**	10.4	11.9
	Lawrence Hill (W)	IN	1249	1248	749	**832**	906	**970**	4.6	5.4
	A4320 Easton Way (N)	OUT	1248	1620	1174	**1230**	1365	**1392**	4.5	5.4
	Lawrence Hill (E)	OUT	1244	4092	805	**920**	1279	**1364**	13.1	14.7

	A4320 St Phillips Causeway (S)	OUT	1245	1284	1255	1346	1986	2060	17.3	18.2
	Lawrence Hill (W)	OUT	1246	1249	570	631	980	1029	13.8	14.7
M32 Junction 3	M32 (North)	IN	3597	3973	1735	1862	1531	1595	6.4	5.0
	A4320 (E)	IN	2571	3974	1994	2078	1233	1271	19.7	18.9
	M32 (South)	IN	3977	3978	467	472	270	276	10.2	10.2
	B4051 (W)	IN	3578	3979	751	769	808	819	1.8	2.0
	M32 (North)	OUT	3979	3986	1810	1891	1019	1082	21.0	21.0
	A4320 (E)	OUT	3973	3577	1940	2067	1767	1814	5.8	4.0
	M32 (South)	OUT	3974	3975	167	170	49	52	11.2	11.3
	B4051 (W)	OUT	3978	3578	1030	1053	1025	1032	0.6	0.2
M32 / Cabot circus	A4032 Newfoundland Way	IN	3982	1471	1548	1661	1671	1758	2.4	3.1
	Houlton Street	IN	9972	1471	116	122	97	107	1.4	1.8
	Car Park	IN	2628	9974	81	81	72	72	1.1	1.1
	A4044 Temple Way	IN	9985	9967	1838	2242	2030	2203	0.8	4.4
	A4044 Newfoundland Street	IN	9970	1209	2321	2517	2275	2332	3.7	1.0
	A4032 Newfoundland Way	OUT	1221	9981	2957	3181	2751	2783	7.3	3.9
	Houlton Street	OUT	1471	9972	441	461	221	225	12.7	12.1
	Car Park	OUT	9974	2628	223	223	201	201	1.5	1.5
	A4044 Temple Way	OUT	9967	9985	564	647	1370	1454	24.9	25.9
	A4044 Newfoundland Street	OUT	1209	9970	1625	2016	1527	1730	6.6	2.5
	St Paul Street	OUT	1209	9975	94	94	76	77	1.9	2.0
Hambrook	Bristol Rd (N) to A4174 (W)	N to W	3487	3560	284	317	311	323	0.3	1.6
	Bristol Rd (N) to (S)	N to S	3487	3560	113	144	201	206	4.6	7.0
	Bristol Rd (N) to A4174 (E)	N to E	3487	3560	308	344	268	273	4.1	2.4
	A4174 (W) to Bristol Rd (N)	W to N	3499	3560	712	795	605	629	6.2	4.1
	A4174 (W) to Bristol Rd (S)	W to S	3499	3560	240	268	159	169	6.7	5.7
	A4174 (W) to (E)	W to E	3499	3560	2254	2518	2477	2540	0.4	4.6
	Bristol Rd (S) to (N)	S to N	3473	3560	217	242	221	231	0.7	0.3
	Bristol Rd (S) to A4174 (W)	S to W	3473	3560	321	359	230	244	6.6	5.5
	Bristol Rd (S) to A4174 (E)	S to E	3473	3560	135	151	79	104	4.2	5.4
	A4174 (E) to Bristol Rd (N)	E to N	9960	3560	382	426	216	217	11.7	9.6
	A4174 (E) to (W)	E to W	9960	3560	1290	1441	1342	1403	1.0	1.4
	A4174 (E) to Bristol Rd (S)	E to S	9960	3473	118	132	117	132	0.0	0.1
M32 J1	M32 (N) to A4174 (E)	N to E	3900	3952	1256	1415	1291	1317	2.6	1.0
	M32 (N) to A4174 (W)	N to W	3952	3953	226	234	195	220	1.0	2.2
	A4174 (E) to M32 (S)	E to S	3561	3953	581	607	610	632	1.0	1.2
	A4174 (E) to M32 (N)	E to N	3953	3957	682	802	837	862	2.1	5.6
	A4174 (E) to (W)	E to W	3561	3953	365	375	415	478	5.0	2.5
	M32 (S) to A4174 (W)	S to W	9916	3957	304	335	197	202	8.1	6.7
	M32 (S) to A4174 (E)	S to E	3957	3958	889	936	971	999	2.0	2.7
	A4174 (W) to M32 (N)	W to N	3562	3958	947	966	812	977	0.4	4.6
	A4174 (W) to (E)	W to E	3562	3958	745	763	952	1001	8.0	7.1
	A4174 (W) to M32 (S)	W to S	3958	3952	469	496	419	425	3.3	2.4

TABLE E6

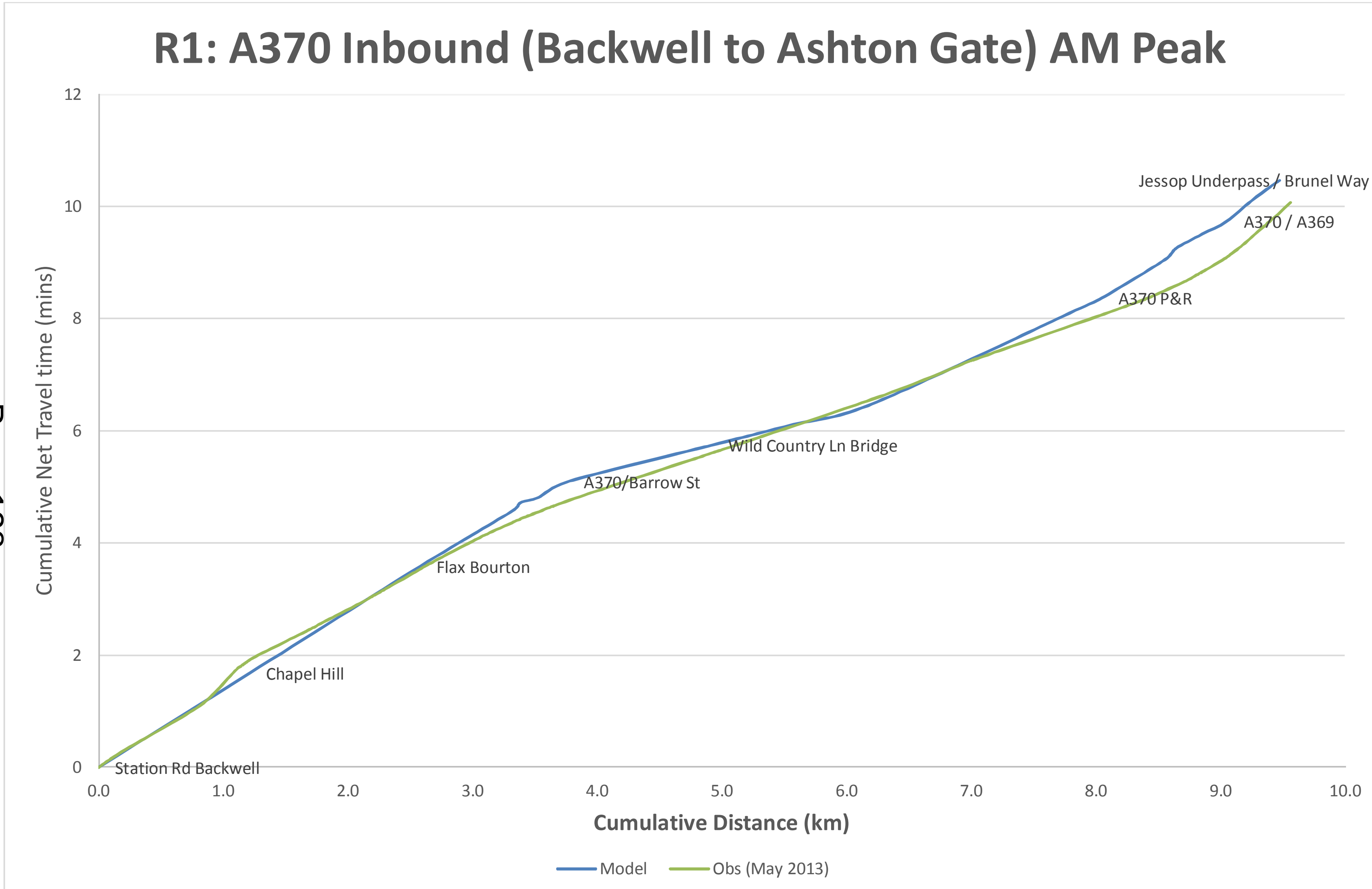
Evening Peak Traffic Flow Validation Comparison

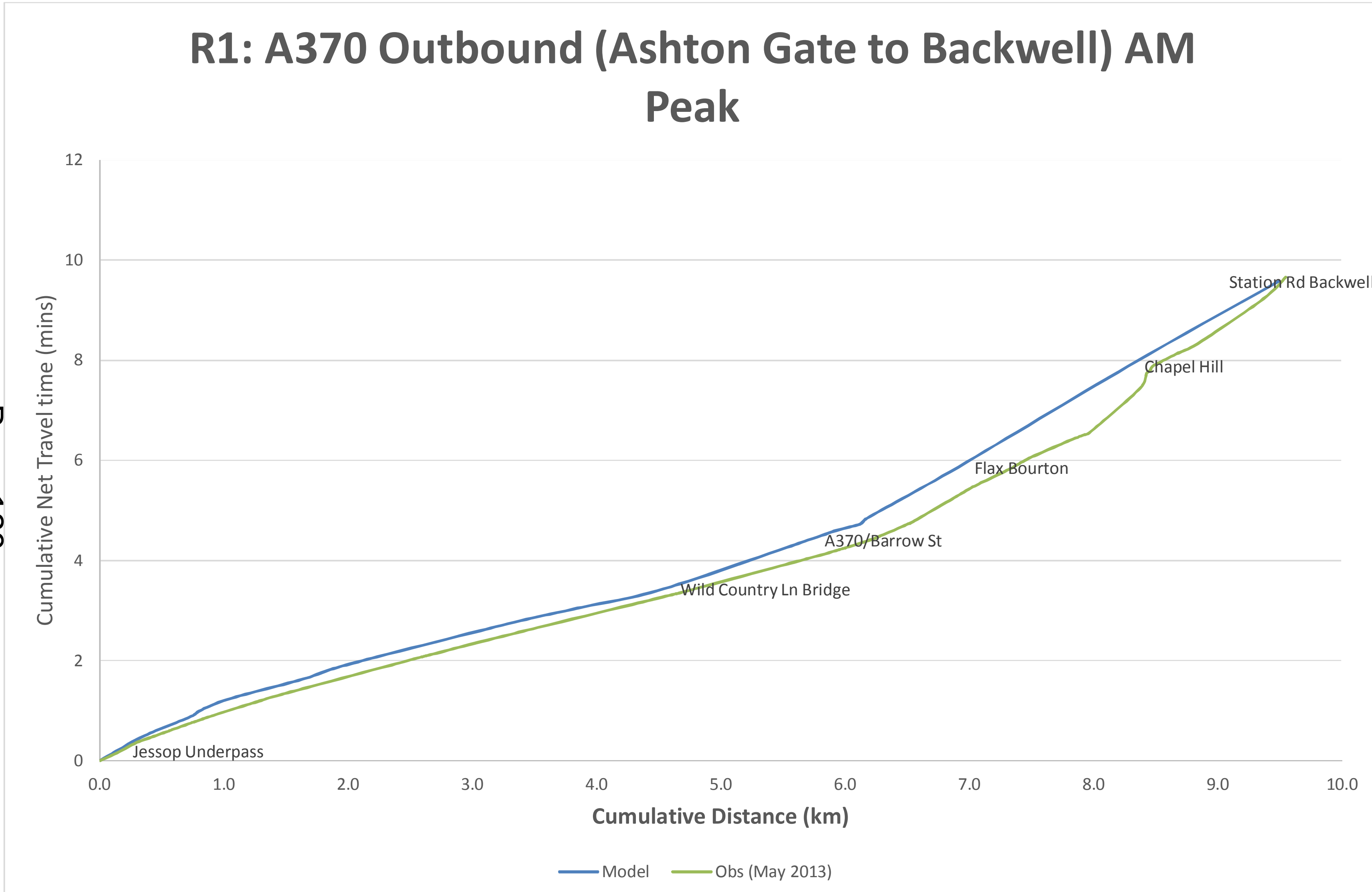
Ref No.	Road	Dir	A node	B node	Obs LV	Obs Total PCUs	Model LV	Model Total PCUs	GEH PCUs	GEH LVs
O1	A38 Bridgewater Road	IN	7147	3635	820	**916**	793	**820**	3.2	0.9
O2	A370 Long Ashton Bypass	IN	2703	1355	641	**700**	597	**617**	3.2	1.8
O3	B3128 Ashton Road	IN	1148	1149	413	**491**	401	**427**	3.0	0.6
O4	A369 Clanage Road	IN	1158	2471	534	**572**	628	**663**	3.7	3.9
O5	B3129 Clifton Suspension Bridge	IN	1159	1160	417	**435**	410	**410**	1.2	0.4
O6	A4 Portway	IN	3348	3591	754	**1089**	932	**1052**	1.1	6.1
O7	B4054 Shirehampton Road	IN	2223	3340	403	**427**	325	**399**	1.4	4.1
O8	Kings Weston Lane	IN	3389	3342	434	**439**	344	**362**	3.9	4.5
O9	Hallen Road	IN	3362	3363	307	**310**	269	**276**	2.0	2.2
O10	A4018 Cribbs Causeway	IN	3197	3324	887	**926**	929	**933**	0.2	1.4
O11	Merlin Road	IN	3193	3198	847	**943**	1073	**1141**	6.1	7.3
O12	Highwood Lane	IN	3191	3195	506	**566**	552	**587**	0.9	2.0
O13	A38 Gloucester Rd	IN	3162	3410	1512	**1600**	1747	**1794**	4.7	5.8
O14	B4427 Old Gloucester Road	IN	3030	3526	144	**161**	160	**164**	0.3	1.3
O15	B4057 Beacon Lane	IN	3037	3528	670	**748**	644	**672**	2.9	1.0
O16	M32	IN	3907	3951	3240	**3926**	3593	**3823**	1.7	6.0
O17	B4058 Bristol Road	IN	2371	3550	441	**476**	375	**390**	4.1	3.3
O18	A432 Badminton Road	IN	4236	3047	648	**691**	754	**797**	3.9	4.0
O19	Westerleigh Road	IN	4237	3685	740	**818**	630	**710**	3.9	4.2
O20	Shortwood Road	IN	1125	3055	530	**592**	506	**575**	0.7	1.1
O21	A420 London Rd	IN	3761	3760	862	**900**	798	**932**	1.1	2.2
O22	A431 Bath Road	IN	3798	3772	772	**863**	723	**801**	2.2	1.8
O23	A4 Bath Road	IN	1408	1407	1003	**1086**	1137	**1159**	2.2	4.1
O24	B3116 Wellsway	IN	3767	1404	545	**609**	456	**551**	2.4	3.9
O25	A37 Bristol Road	IN	3645	8052	687	**767**	638	**700**	2.5	1.9
O26	Queens Rd	IN	3636	7115	180	**188**	176	**191**	0.2	0.3
O1	A38 Bridgewater Road	OUT	3635	7147	977	**1091**	1106	**1133**	1.2	4.0
O2	A370 Long Ashton Bypass	OUT	1355	2703	1295	**1388**	1535	**1615**	5.9	6.4
O3	B3128 Ashton Road	OUT	1149	1148	919	**1003**	1108	**1150**	4.5	5.9
O4	A369 Clanage Road	OUT	2471	1158	560	**588**	623	**651**	2.5	2.6
O5	B3129 Clifton Suspension Bridge	OUT	1160	1159	642	**670**	721	**721**	1.9	3.0
O6	A4 Portway	OUT	3591	3348	886	**1060**	972	**1022**	1.2	2.8
O7	B4054 Shirehampton Road	OUT	3340	2223	359	**375**	309	**334**	2.1	2.8
O8	Kings Weston Lane	OUT	3342	3389	105	**107**	84	**98**	0.8	2.1
O9	Hallen Road	OUT	3363	3362	112	**116**	82	**94**	2.1	3.0
O10	A4018 Cribbs Causeway	OUT	3324	3197	1297	**1354**	1239	**1261**	2.6	1.6
O11	Merlin Road	OUT	3198	3193	1174	**1312**	1105	**1155**	4.5	2.1
O12	Highwood Lane	OUT	3195	3193	512	**572**	545	**580**	0.3	1.4
O13	A38 Gloucester Rd	OUT	3410	3162	2038	**2276**	2204	**2299**	0.5	3.6
O14	B4427 Old Gloucester Road	OUT	3526	3030	660	**738**	637	**656**	3.1	0.9
O15	B4057 Beacon Lane	OUT	3528	3037	888	**993**	1009	**1043**	1.6	3.9
O16	M32	OUT	3960	3908	3522	**4319**	3602	**3963**	5.5	1.3
O17	B4058 Bristol Road	OUT	3550	2371	490	**534**	356	**373**	7.5	6.5
O18	A432 Badminton Road	OUT	3047	4236	919	**981**	1058	**1084**	3.2	4.4
O19	Westerleigh Road	OUT	3685	4237	829	**926**	740	**824**	3.4	3.2
O20	Shortwood Road	OUT	3055	1125	415	**463**	465	**481**	0.8	2.4

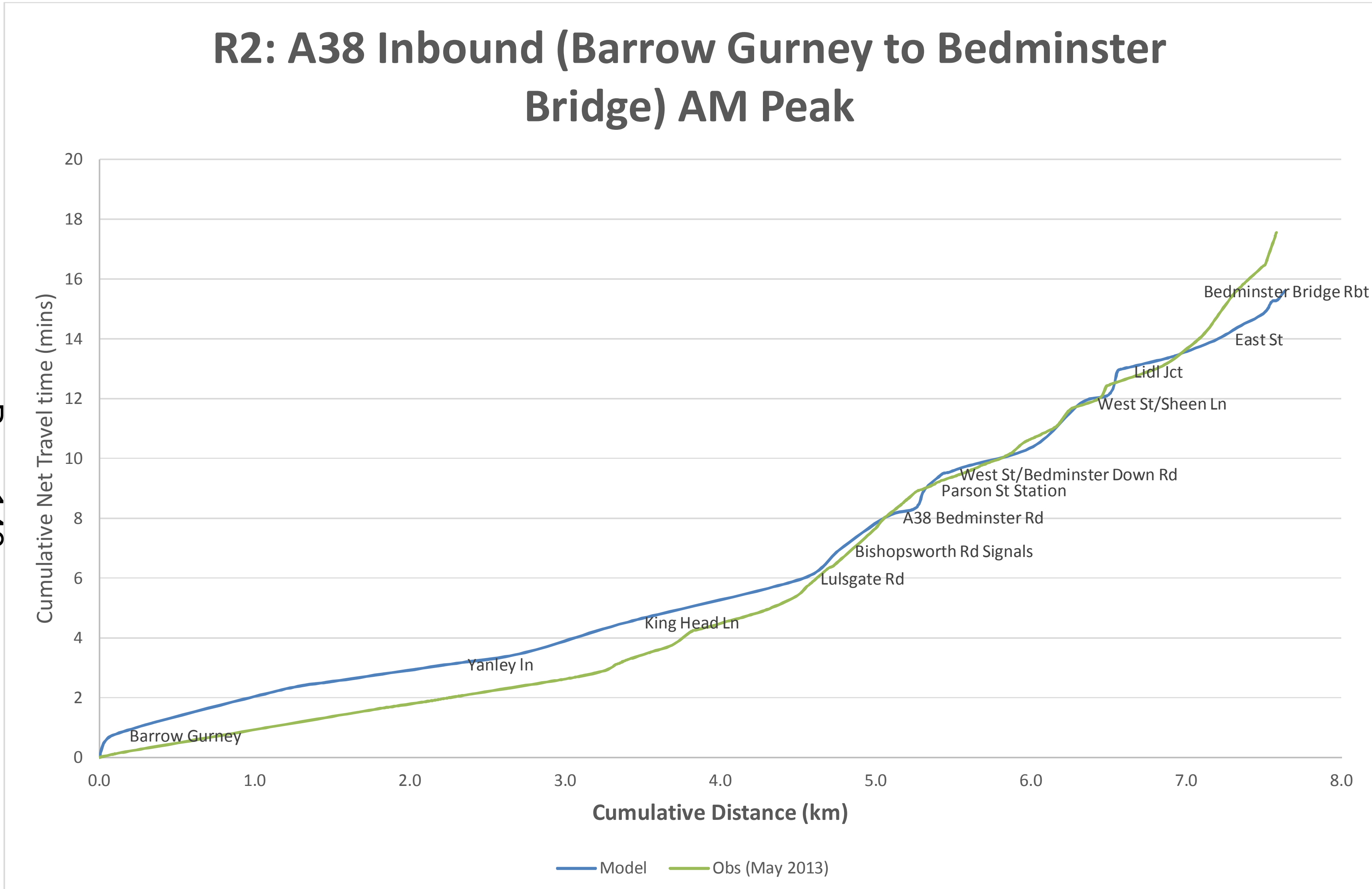
O21	A420 London Rd	OUT	3760	3761	614	656	483	540	4.8	5.6
O22	A431 Bath Road	OUT	3772	3798	306	342	357	385	2.3	2.8
O23	A4 Bath Road	OUT	1407	1408	1138	1186	1049	1074	3.3	2.7
O24	B3116 Wellsway	OUT	1404	3767	762	782	702	725	2.1	2.2
O25	A37 Bristol Road	OUT	8052	3645	616	688	662	721	1.3	1.8
O26	Queens Rd	OUT	7115	3636	305	309	296	297	0.7	0.6
M2	A4176 Portway	IN	1162	1582	1542	1659	1551	1593	1.6	0.2
M4	College Road	IN	1801	1160	470	515	512	530	0.7	1.9
M5	Pembroke Road	IN	1041	1803	183	200	177	189	0.8	0.4
M7	Whiteladies Road	IN	1809	1238	692	790	689	769	0.8	0.1
M8	Hampton Road	IN	1015	1881	235	235	245	246	0.7	0.7
M9	Redland Grove	IN	1659	1853	268	283	211	241	2.6	3.7
M10	Redland Road	IN	1034	1855	180	182	236	236	3.7	3.9
M11	A38 Cheltenham Road	IN	1030	1031	504	671	524	599	2.9	0.9
M12	North Road	IN	1146	1031	283	292	218	233	3.6	4.1
RW14	Ashley Hill	IN	1036	1917	572	572	581	585	0.5	0.4
MM12	Glenfrome Road	IN	1107	1919	506	565	429	446	5.3	3.6
M13	M32	IN	3971	3972	3048	3193	2763	2896	5.4	5.3
M14	Stapleton Road	IN	1437	1440	457	577	573	618	1.7	5.1
M15	Easton Road	IN	2005	1995	267	276	270	275	0.0	0.1
M16	A420 Lawrence Hill	IN	1251	1466	801	850	798	855	0.2	0.1
M17	Ducie Road	IN	1763	1250	86	98	139	151	4.7	5.0
M18	Barrow Road	IN	1283	1747	663	684	756	826	5.2	3.5
M19	A4320 St Phillips Causeway	IN	1290	1549	1111	1334	1323	1393	1.6	6.1
M20	Feeder Road	IN	1751	1741	404	423	484	499	3.5	3.8
M21	Albert Road	IN	1290	1755	444	513	392	456	2.6	2.5
M22	Bath Road	IN	2087	4038	575	663	581	649	0.5	0.2
M23	Wells Road	IN	2131	2085	455	534	427	481	2.4	1.4
MM23	Redcatch Road	IN	1185	2125	351	373	411	417	2.2	3.1
M24	Wedmore Vale	IN	2213	2159	236	243	184	201	2.8	3.6
M25	Novers Hill	IN	2469	2211	172	176	134	135	3.2	3.1
M26	A4174 Hartcliffe Way	IN	2728	1361	824	904	949	1018	3.7	4.2
M27	A38 Bedminster Down Road	IN	1183	1433	1222	1332	1101	1147	5.3	3.6
M28	South Liberty Lane	IN	7166	3607	153	167	185	230	4.5	2.4
M29	Ashton Drive	IN	10005	4082	219	285	261	274	0.6	2.7
M30	A370 Ashton Road	IN	1153	1154	1065	1189	1057	1116	2.2	0.2
M2	A4176 Portway	OUT	1582	1162	1560	1713	1508	1592	3.0	1.3
M4	College Road	OUT	1160	1801	159	159	143	166	0.6	1.2
M5	Pembroke Road	OUT	1803	1041	251	265	232	244	1.3	1.2
M7	Whiteladies Road	OUT	1238	1809	759	834	721	803	1.1	1.4
M8	Hampton Road	OUT	1881	1015	554	557	543	555	0.1	0.5
M9	Redland Grove	OUT	1853	1659	464	473	448	477	0.2	0.8
M10	Redland Road	OUT	1855	1034	137	140	199	199	4.5	4.8
M11	A38 Cheltenham Road	OUT	1031	1030	515	635	607	686	2.0	3.9
M12	North Road	OUT	1031	1146	37	49	28	39	1.4	1.7
RW14	Ashley Hill	OUT	1917	1036	836	839	946	947	3.6	3.7
MM12	Glenfrome Road	OUT	1919	1107	382	427	345	363	3.2	1.9
M13	M32	OUT	3981	3965	3882	4088	3462	3552	8.7	6.9
M14	Stapleton Road	OUT	1440	1437	548	602	502	558	1.8	2.0
M15	Easton Road	OUT	1995	2005	403	412	411	432	1.0	0.4
M16	A420 Lawrence Hill	OUT	1466	1251	924	1078	1170	1235	4.6	7.6

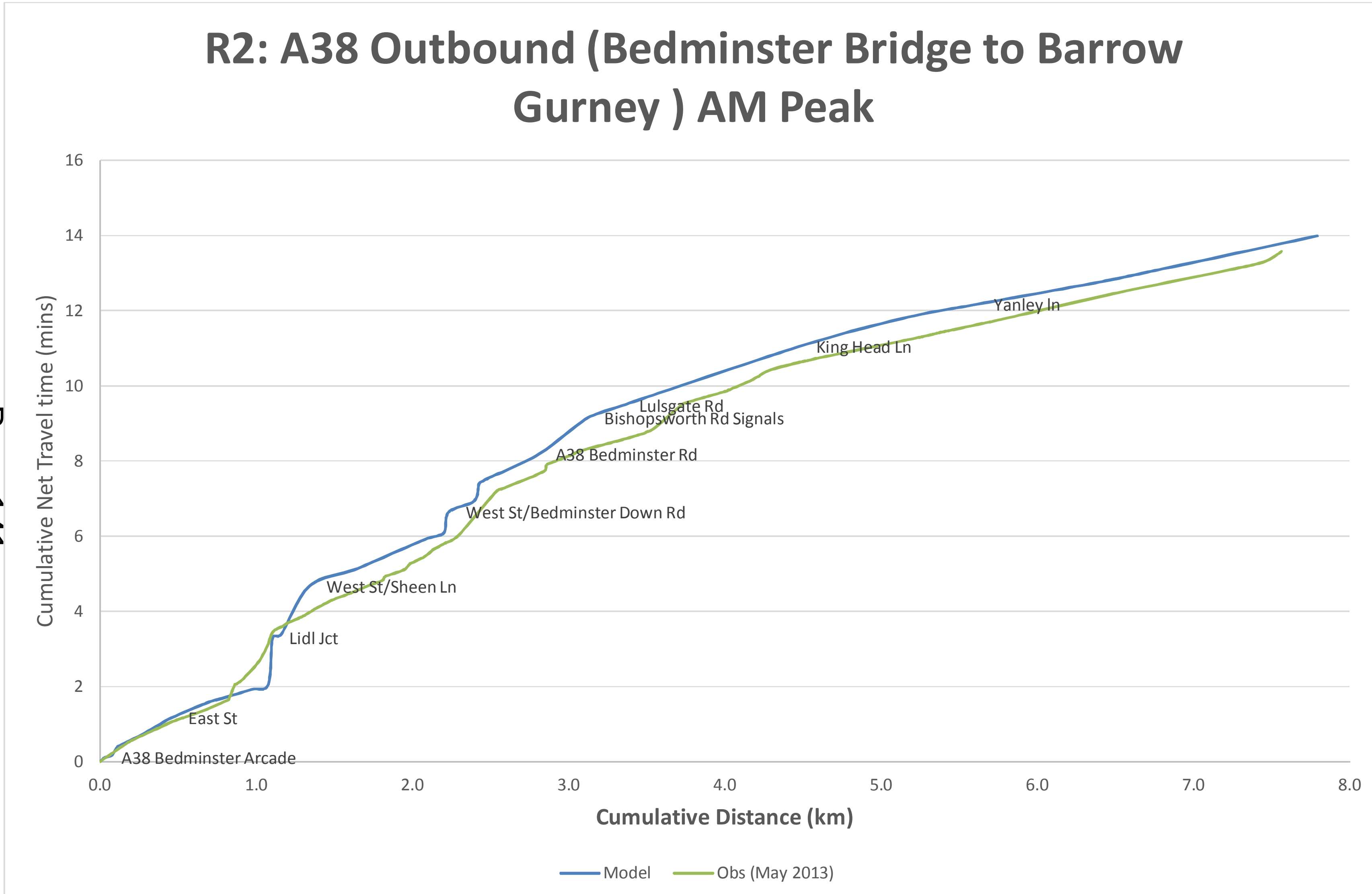
M17	Ducie Road	OUT	1250	1763	19	43	29	41	0.2	2.0
M18	Barrow Road	OUT	1747	1283	210	235	189	218	1.1	1.5
M19	A4320 St Phillips Causeway	OUT	1549	1290	1011	1394	1676	1744	8.8	18.1
M20	Feeder Road	OUT	1741	1751	775	801	625	706	3.4	5.7
M21	Albert Road	OUT	1755	1290	418	440	444	482	1.9	1.3
M22	Bath Road	OUT	4038	2087	654	826	829	884	2.0	6.4
M23	Wells Road	OUT	2085	2131	828	909	856	922	0.4	1.0
MM23	Redcatch Road	OUT	2125	1185	614	641	532	561	3.3	3.4
M24	Wedmore Vale	OUT	2159	2213	313	346	282	317	1.6	1.8
M25	Novers Hill	OUT	2211	2469	374	374	321	366	0.4	2.8
M26	A4174 Hartcliffe Way	OUT	1361	2728	970	1190	1271	1338	4.2	9.0
M27	A38 Bedminster Down Road	OUT	1433	1183	855	1014	1259	1299	8.4	12.4
M28	South Liberty Lane	OUT	3607	7166	95	120	97	101	1.7	0.2
M29	Ashton Drive	OUT	4082	10005	237	249	127	147	7.2	8.2
M30	A370 Ashton Road	OUT	1530	1531	1960	2272	2161	2297	0.5	4.4
NWO1	M5	IN	3192	3201	4206	5104	4323	4708	5.6	1.8
NWO2	A4018 Cribbs Causeway	IN	4351	3347	1347	1505	1318	1373	3.5	0.8
NWO4	Gloucester Rd North	IN	3496	1651	1184	1365	1562	1623	6.7	10.2
NWO5	Great Stoke Way	IN	3488	4386	778	869	719	775	3.3	2.1
NWO6	M32	IN	3951	3954	1936	2379	2107	2286	1.9	3.8
NWO7	Bristol Rd	IN	3487	3560	726	860	779	801	2.1	1.9
NWO1	M5	OUT	3216	3183	3627	4458	3885	4564	1.6	4.2
NWO2	A4018 Cribbs Causeway	OUT	3347	4351	1427	1625	1636	1708	2.0	5.4
NWO4	Gloucester Rd North	OUT	1651	3496	1419	1585	1546	1640	1.4	3.3
NWO5	Great Stoke Way	OUT	4386	3488	686	766	770	810	1.6	3.1
NWO6	M32	OUT	3956	3959	2119	2211	1952	2123	1.9	3.7
NWO7	Bristol Rd	OUT	3560	3487	971	1022	1042	1076	1.7	2.2
NE1	Frenchay park Rd	IN	2355	1094	853	935	922	961	0.8	2.3
NE2	Blackberry Hill	IN	1094	2393	576	661	643	674	0.5	2.7
NE3	Fishponds Road	IN	1985	1062	743	808	676	751	2.1	2.5
NE4	Berkley Rd	IN	1077	2025	391	437	358	366	3.5	1.7
NE5	Charlton Road	IN	2027	1098	423	436	383	391	2.2	2.0
NE6	Lodge Rd	IN	1097	1080	339	368	252	273	5.3	5.1
NE7	Downend Rd	IN	1612	2724	314	324	361	377	2.8	2.5
NE8	Syston Way	IN	1541	2031	363	375	358	384	0.5	0.2
NE9	Lees Hill	IN	2490	2409	193	204	133	142	4.7	4.7
NE10	Pound Rd	IN	2405	1685	214	218	219	226	0.6	0.4
NE12	Station Rd	IN	1089	1087	455	508	521	546	1.6	3.0
NE1	Frenchay park Rd	OUT	1094	2355	491	519	481	536	0.7	0.5
NE2	Blackberry Hill	OUT	2393	1094	572	593	611	656	2.5	1.6
NE3	Fishponds Road	OUT	1062	1985	800	877	795	856	0.7	0.2
NE4	Berkley Rd	OUT	2025	1077	554	593	420	445	6.5	6.1
NE5	Charlton Road	OUT	1098	2027	401	417	308	348	3.5	4.9
NE6	Lodge Rd	OUT	1080	1097	263	269	316	350	4.6	3.2
NE7	Downend Rd	OUT	2724	1612	239	246	179	191	3.7	4.1
NE8	Syston Way	OUT	2031	1541	420	444	490	512	3.1	3.2
NE9	Lees Hill	OUT	2409	2490	229	239	225	229	0.6	0.3
NE10	Pound Rd	OUT	1685	2405	221	228	91	167	4.3	10.5
NE12	Station Rd	OUT	1087	1089	444	496	481	502	0.2	1.7

Appendix F: Distance-Travel Time Graphs

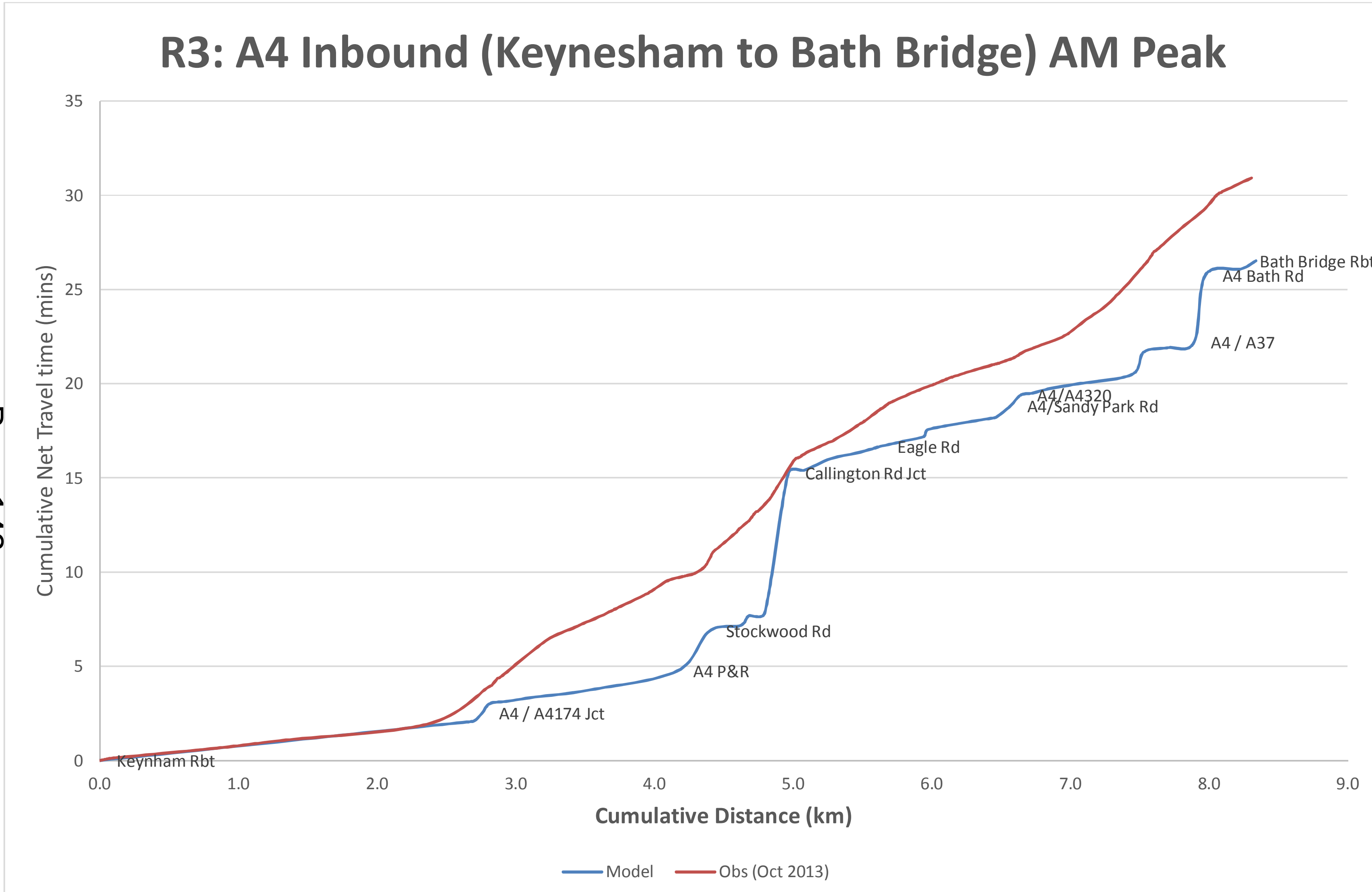

R1: A370 Inbound (Backwell to Ashton Gate) AM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
2
4
6
8
10
12
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Station Rd Backwell
Chapel Hill
Flax Bourton
A370/Barrow St
Wild Country Ln Bridge
A370 P&R
A370 / A369
Jessop Underpass / Brunel Way
Model
Obs (May 2013)

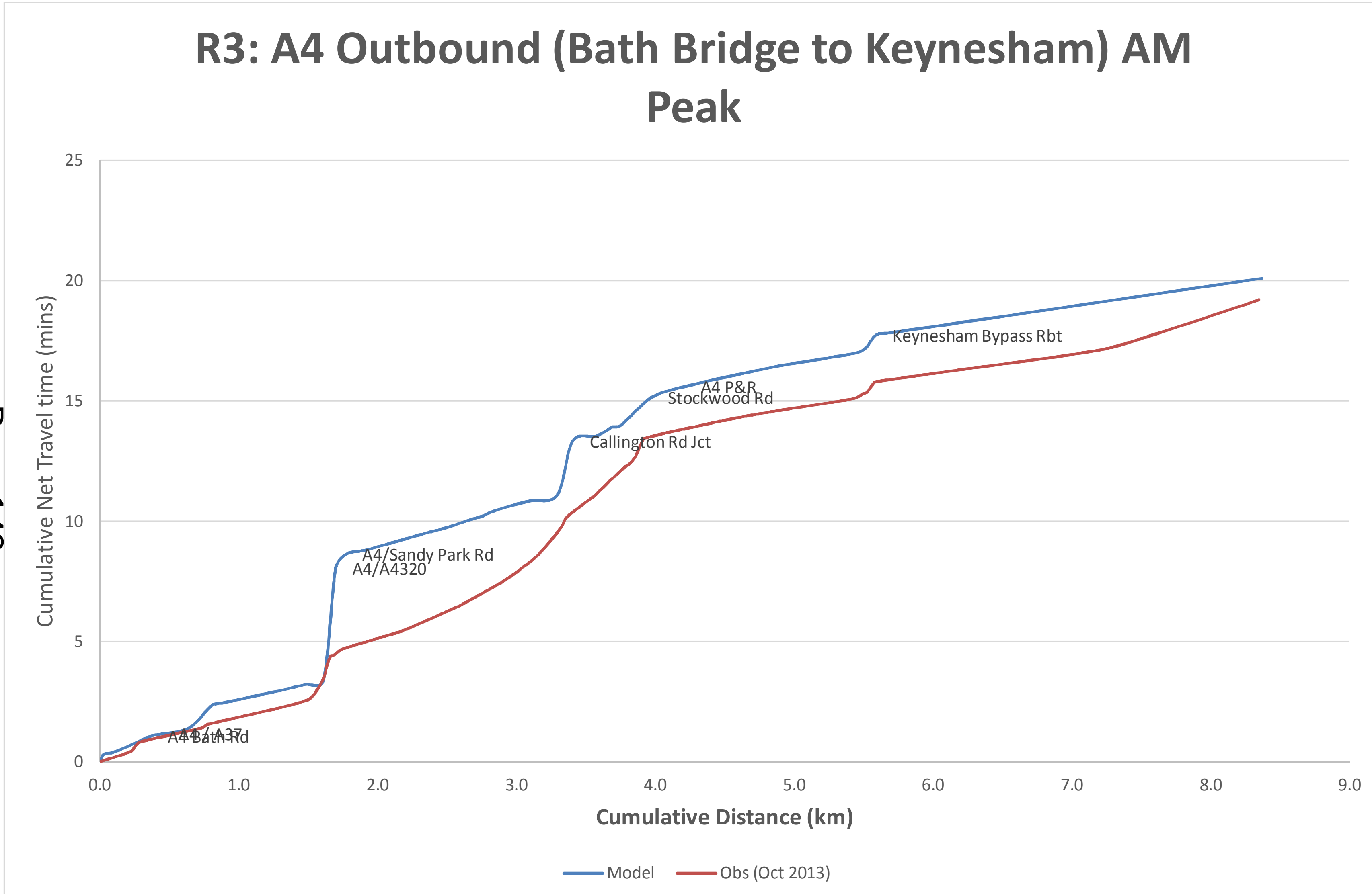

R1: A370 Outbound (Ashton Gate to Backwell) AM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
2
4
6
8
10
12
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Jessop Underpass
Wild Country Ln Bridge
A370/Barrow St
Flax Bourton
Chapel Hill
Station Rd Backwell
Model
Obs (May 2013)


R2: A38 Inbound (Barrow Gurney to Bedminster Bridge) AM Peak
Cumulative Net Travel time (mins)
20
18
16
14
12
10
8
6
4
2
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Cumulative Distance (km)
Barrow Gurney
Yanley In
King Head Ln
Lulsgate Rd
Bishopsworth Rd Signals
A38 Bedminster Rd
Parson St Station
West St/Bedminster Down Rd
West St/Sheen Ln
Lidl Jct
East St
Bedminster Bridge Rbt
Model
Obs (May 2013)

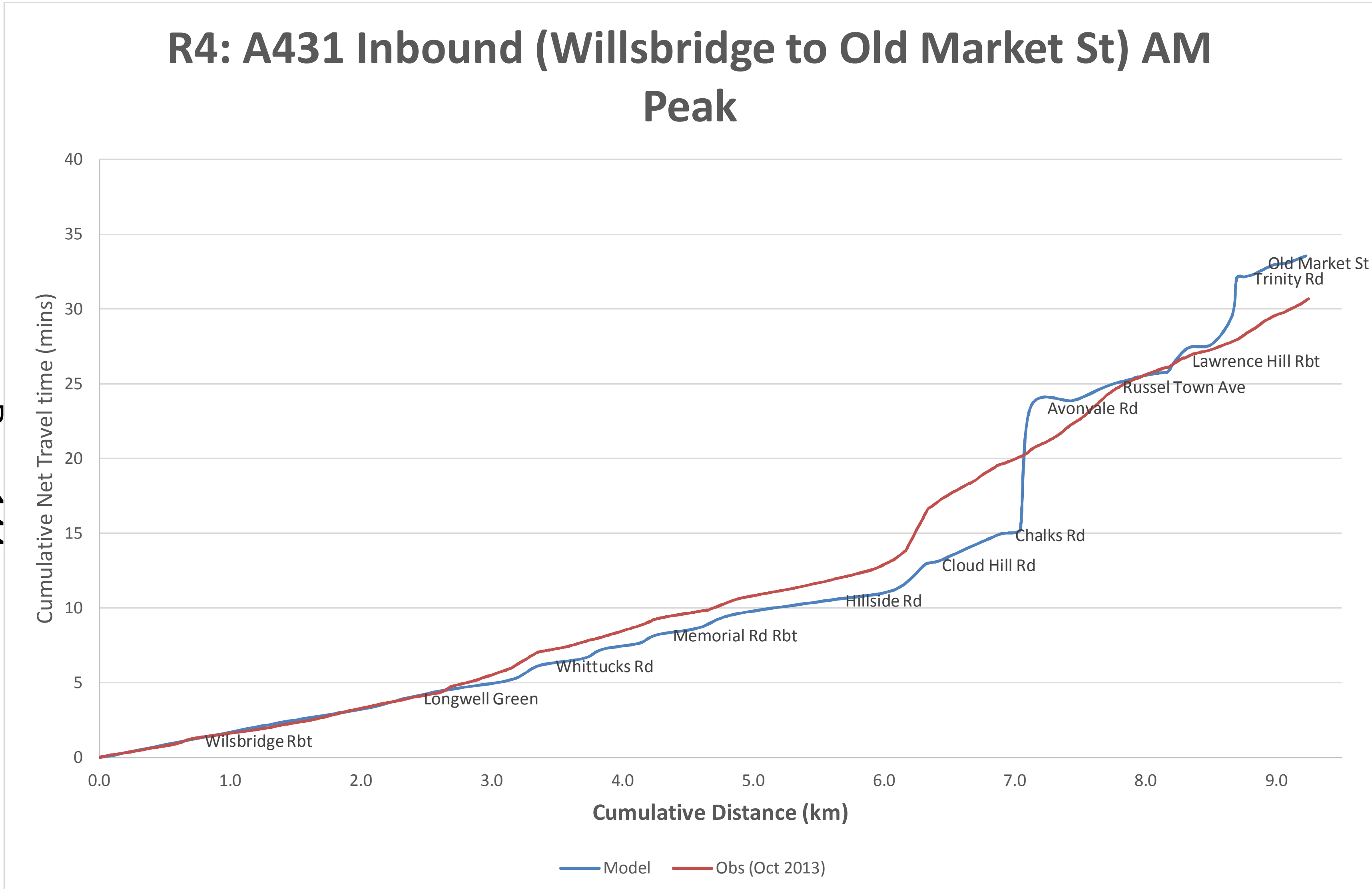


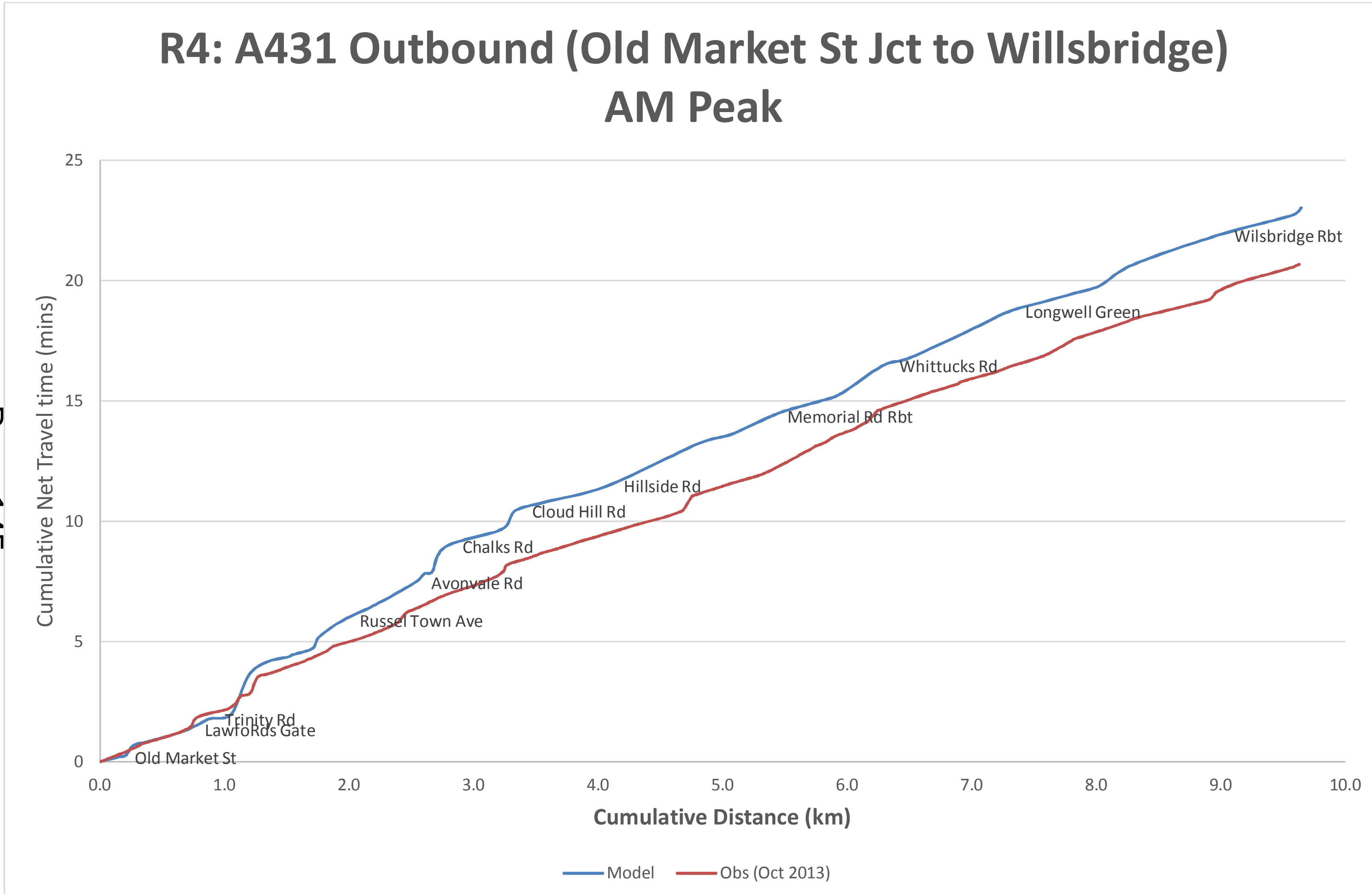
R2: A38 Outbound (Bedminster Bridge to Barrow Gurney) AM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
2
4
6
8
10
12
14
16
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
A38 Bedminster Arcade
East St
Lidl Jct
West St/Sheen Ln
West St/Bedminster Down Rd
A38 Bedminster Rd
Lulsgate Rd
Bishopsworth Rd Signals
King Head Ln
Yanley ln
Model
Obs (May 2013)

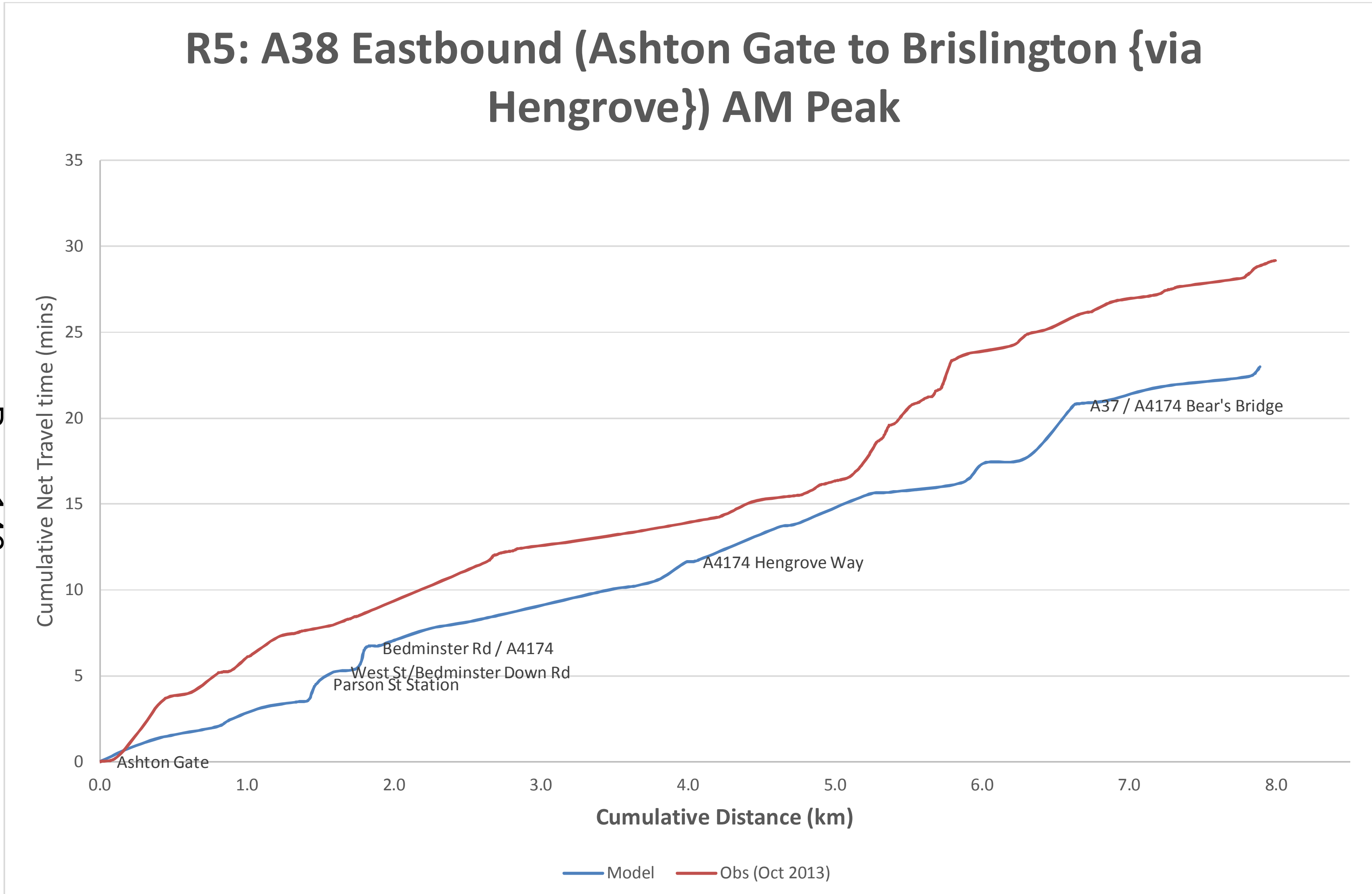

R3: A4 Inbound (Keynesham to Bath Bridge) AM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
30
35
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Keynham Rbt
A4 / A4174 Jct
A4 P&R
Stockwood Rd
Callington Rd Jct
Eagle Rd
A4/A4320
A4/Sandy Park Rd
A4 / A37
A4 Bath Rd
Bath Bridge Rbt
Model
Obs (Oct 2013)



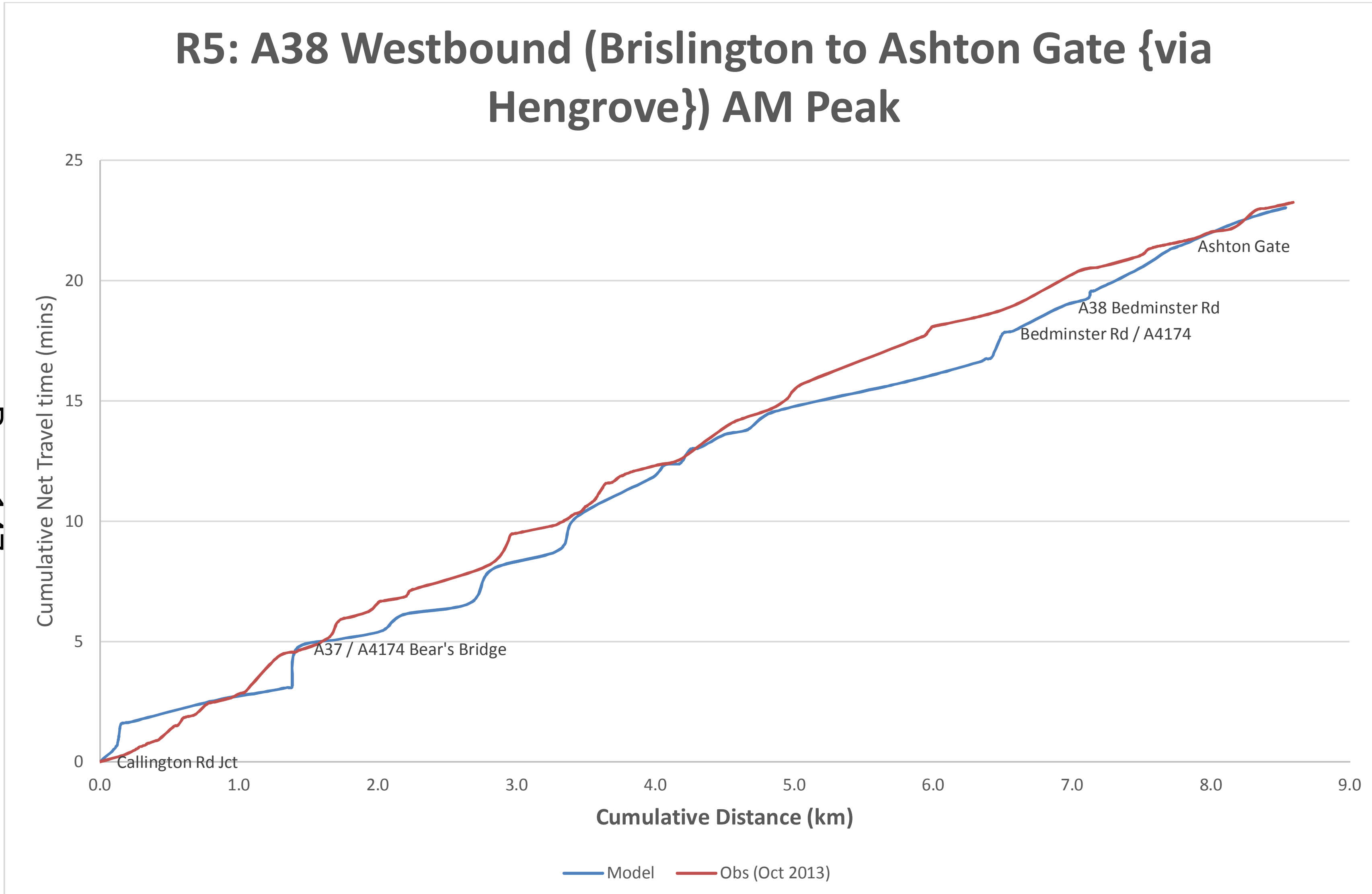
R3: A4 Outbound (Bath Bridge to Keynesham) AM Peak
Cumulative Net Travel time (mins)
25
20
15
10
5
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Cumulative Distance (km)
A4 Bath Rd
A4/A37
A4/Sandy Park Rd
A4/A4320
Callington Rd Jct
A4 P&R
Stockwood Rd
Keynesham Bypass Rbt
Model
Obs (Oct 2013)

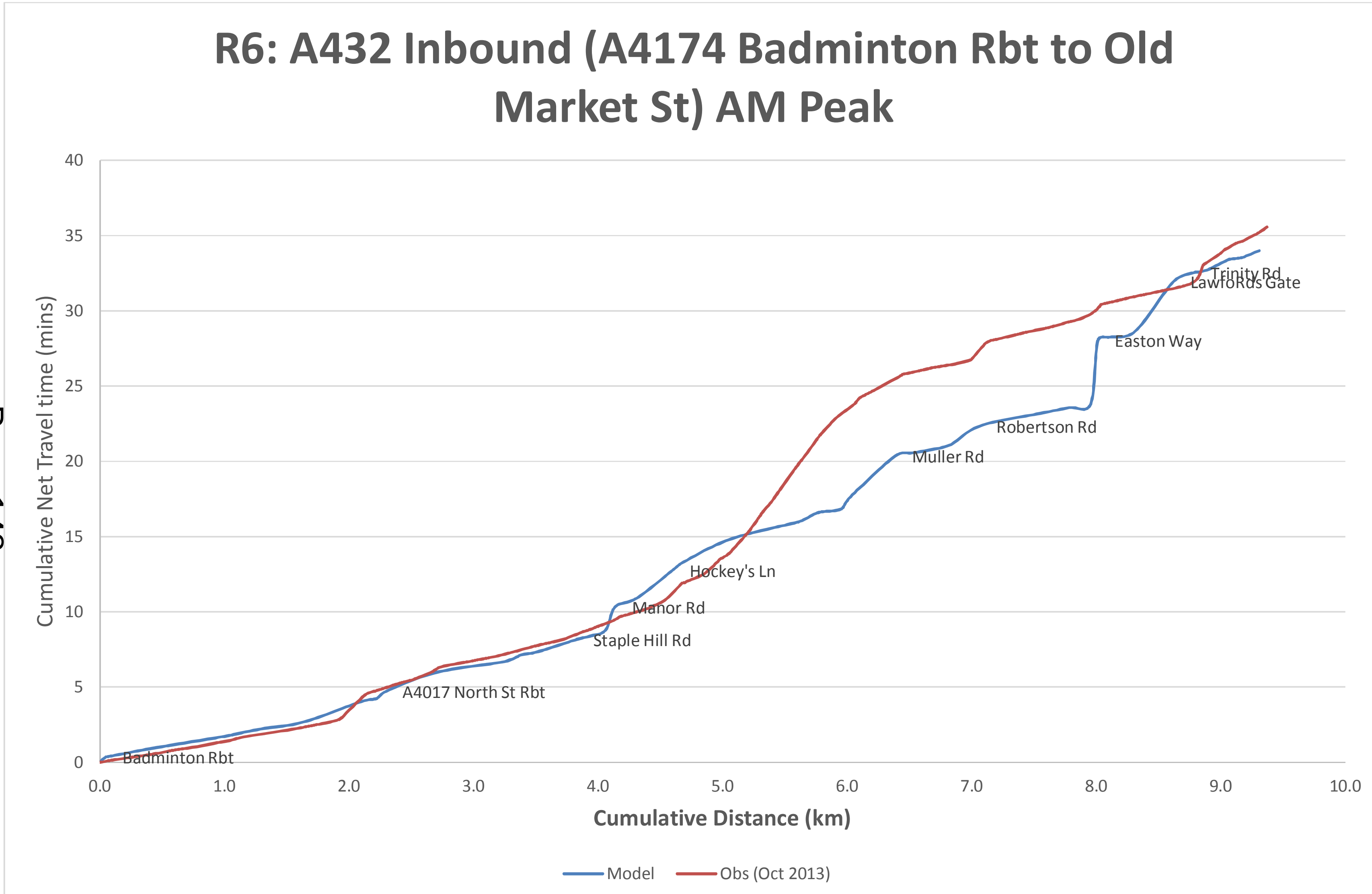

R4: A431 Inbound (Willsbridge to Old Market St) AM Peak
Cumulative Net Travel time (mins)
40
35
30
25
20
15
10
5
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Cumulative Distance (km)
Wilsbridge Rbt
Longwell Green
Whittucks Rd
Memorial Rd Rbt
Hillside Rd
Cloud Hill Rd
Chalks Rd
Avonvale Rd
Russel Town Ave
Lawrence Hill Rbt
Trinity Rd
Old Market St
Model
Obs (Oct 2013)

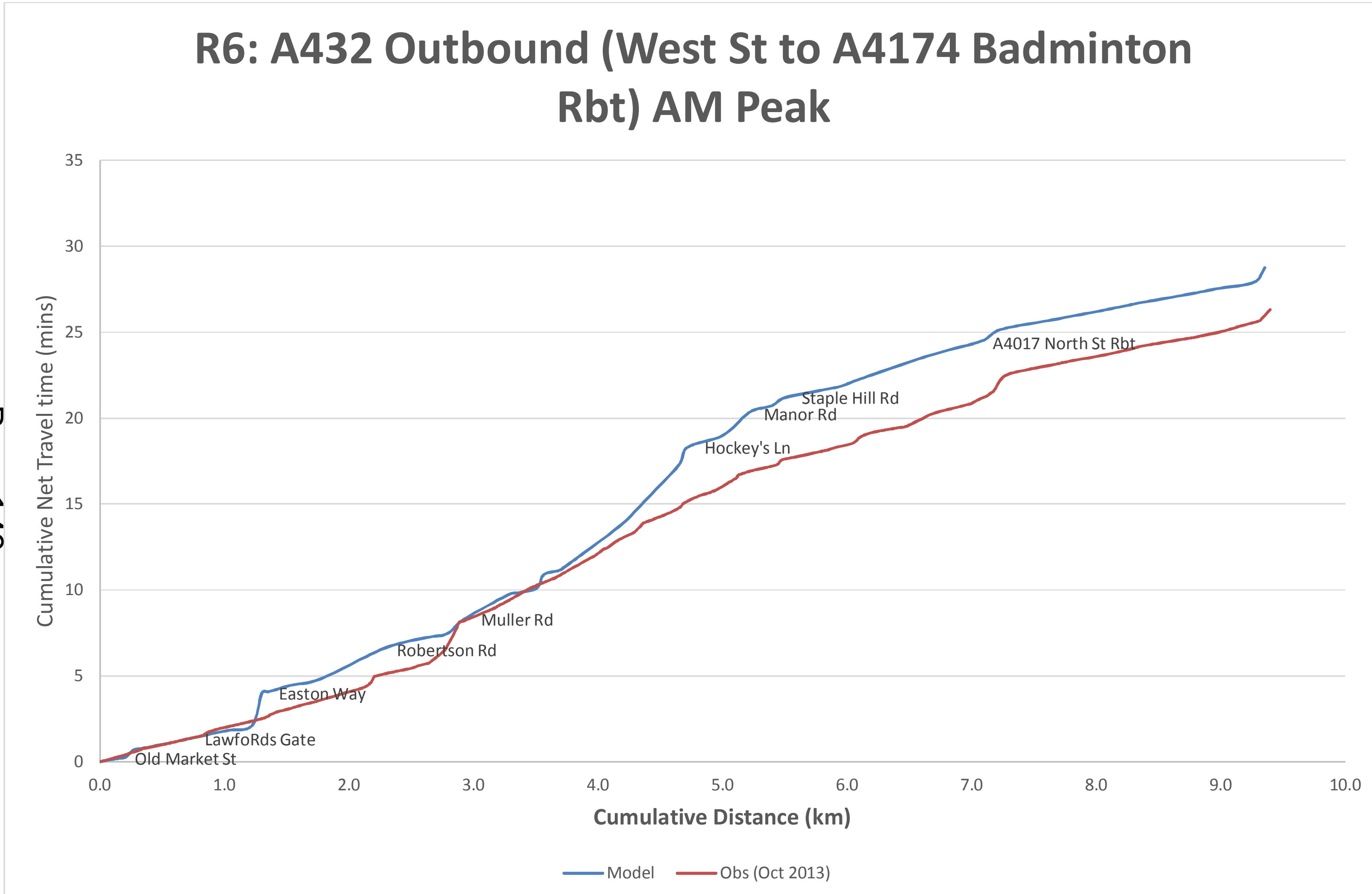

R4: A431 Outbound (Old Market St Jct to Willsbridge)
AM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Old Market St
Trinity Rd
LawfoRds Gate
Russel Town Ave
Avonvale Rd
Chalks Rd
Cloud Hill Rd
Hillside Rd
Memorial Rd Rbt
Whittucks Rd
Longwell Green
Wilsbridge Rbt
Model
Obs (Oct 2013)

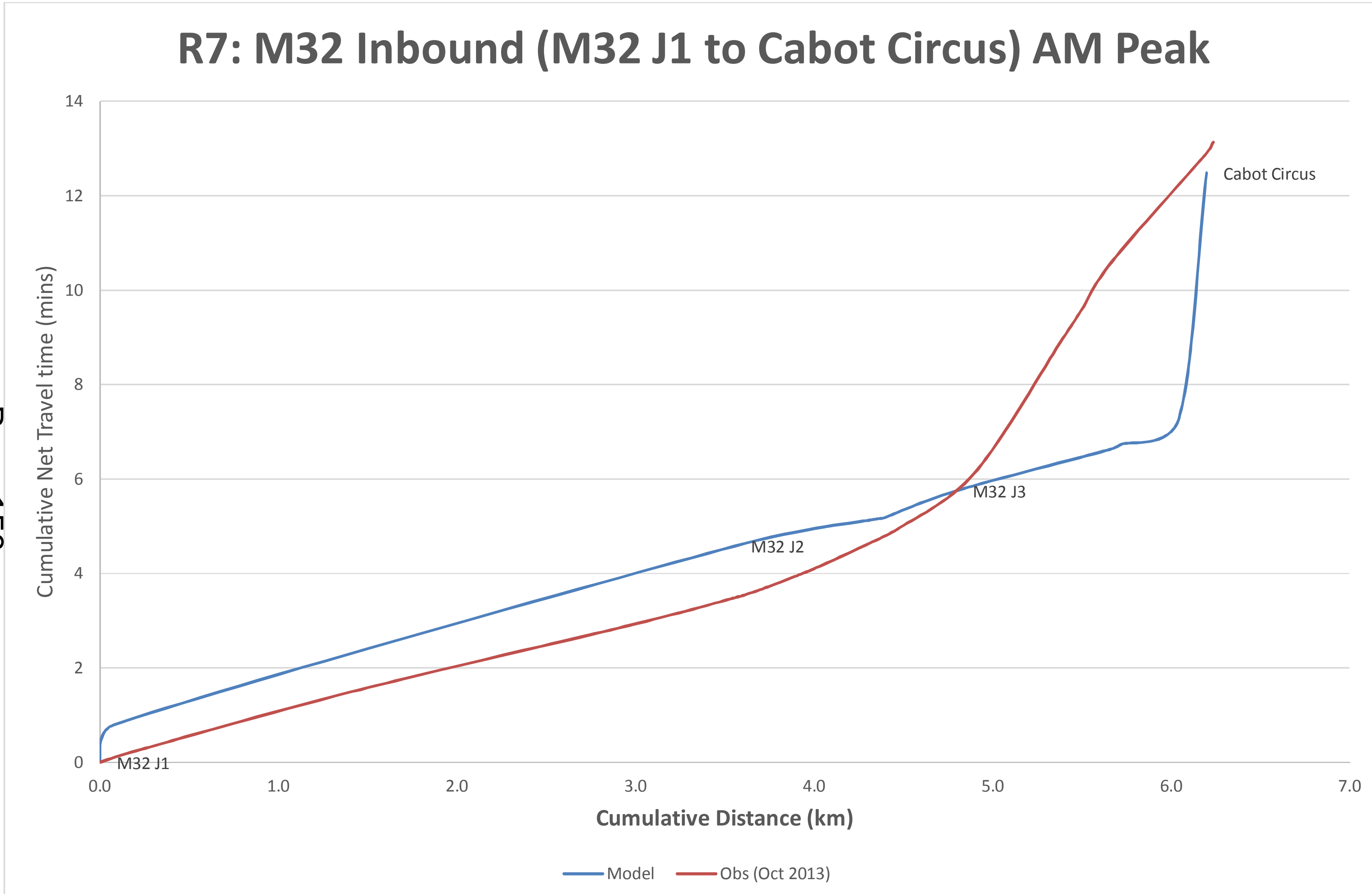


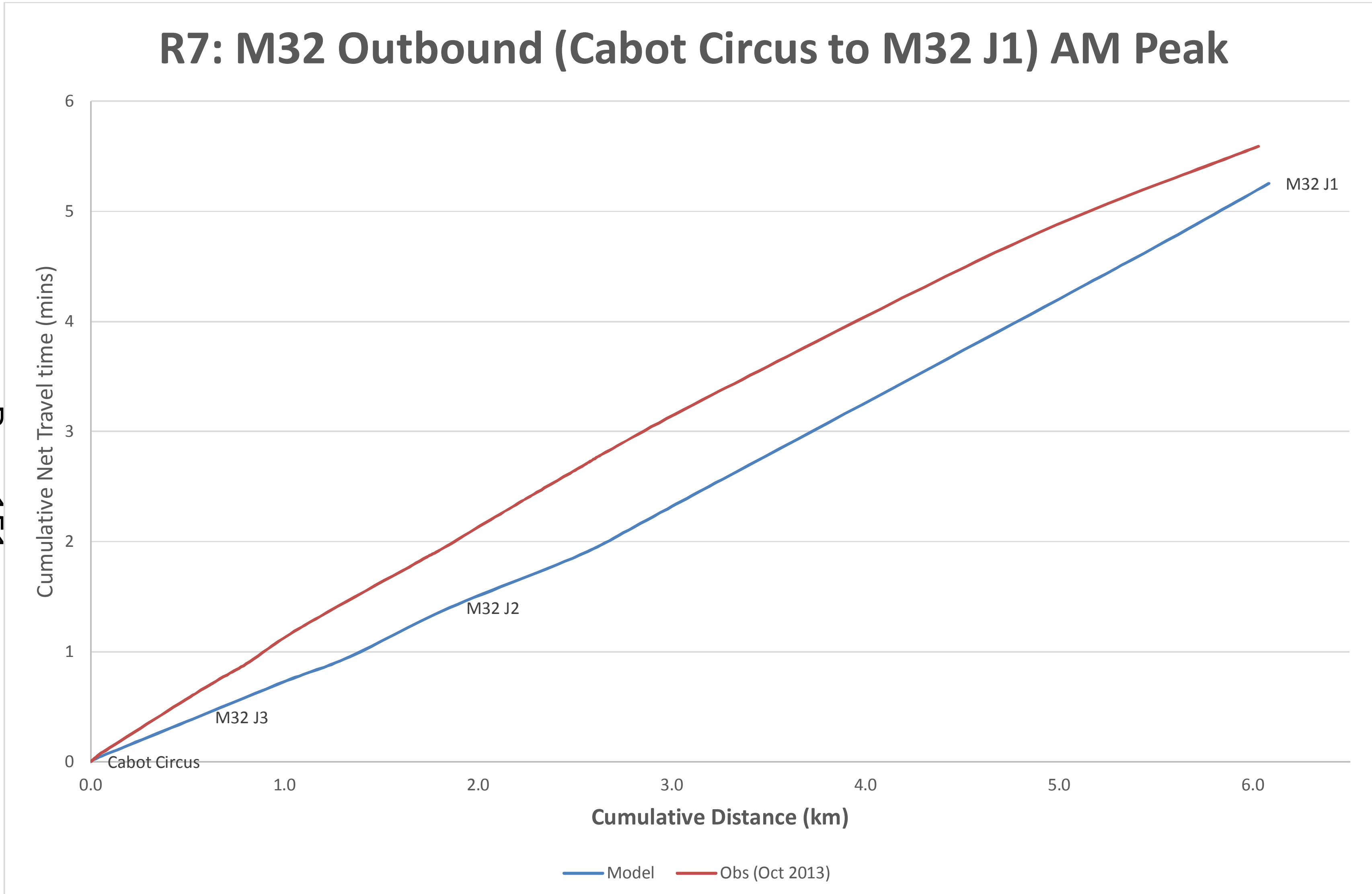
R5: A38 Eastbound (Ashton Gate to Brislington {via Hengrove}) AM Peak
Cumulative Net Travel time (mins)
35
30
25
20
15
10
5
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Cumulative Distance (km)
Ashton Gate
Parson St Station
West St/Bedminster Down Rd
Bedminster Rd / A4174
A4174 Hengrove Way
A37 / A4174 Bear's Bridge
Model
Obs (Oct 2013)

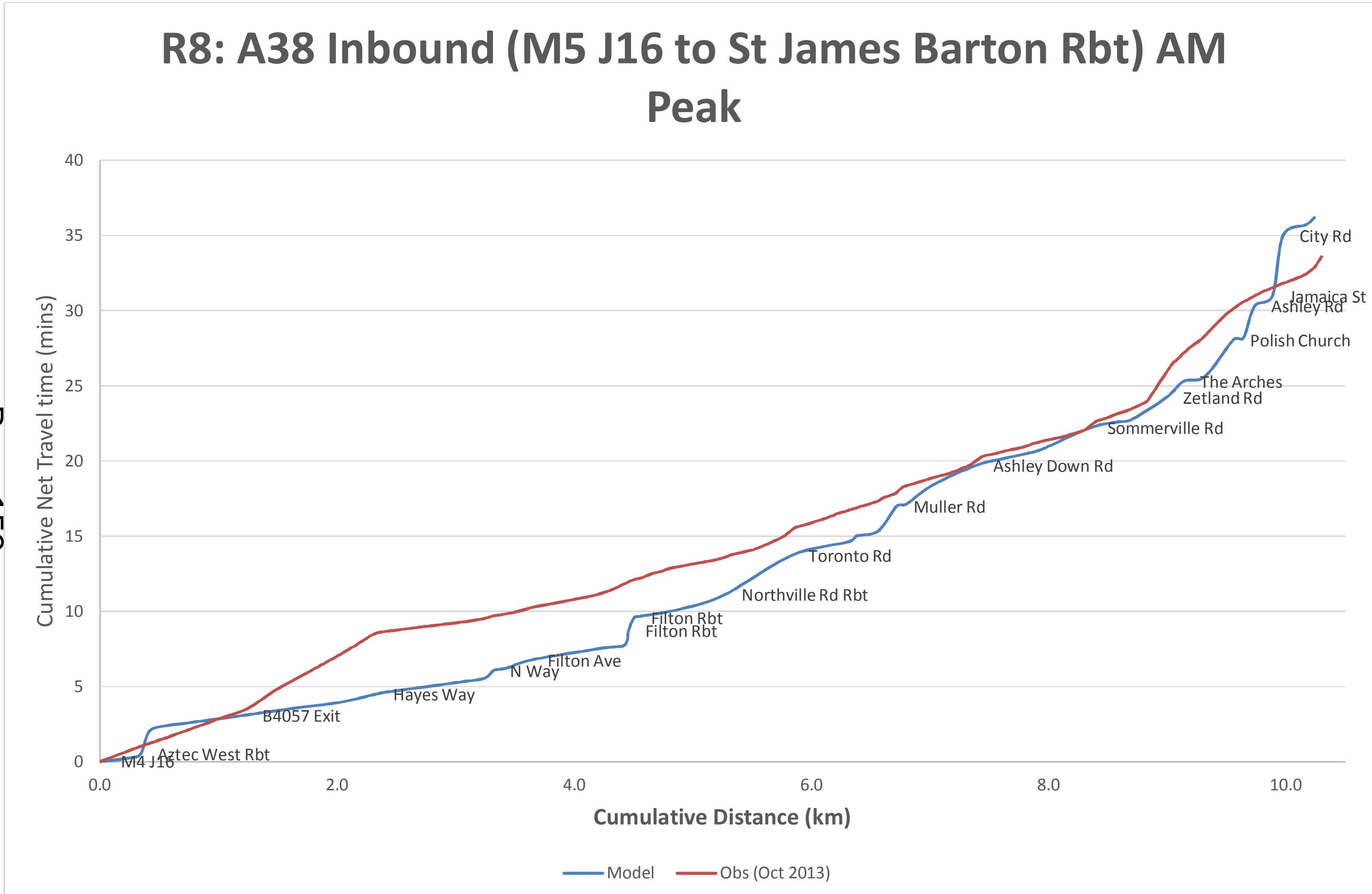

R5: A38 Westbound (Brislington to Ashton Gate {via Hengrove}) AM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Callington Rd Jct
A37 / A4174 Bear's Bridge
Bedminster Rd / A4174
A38 Bedminster Rd
Ashton Gate
Model
Obs (Oct 2013)

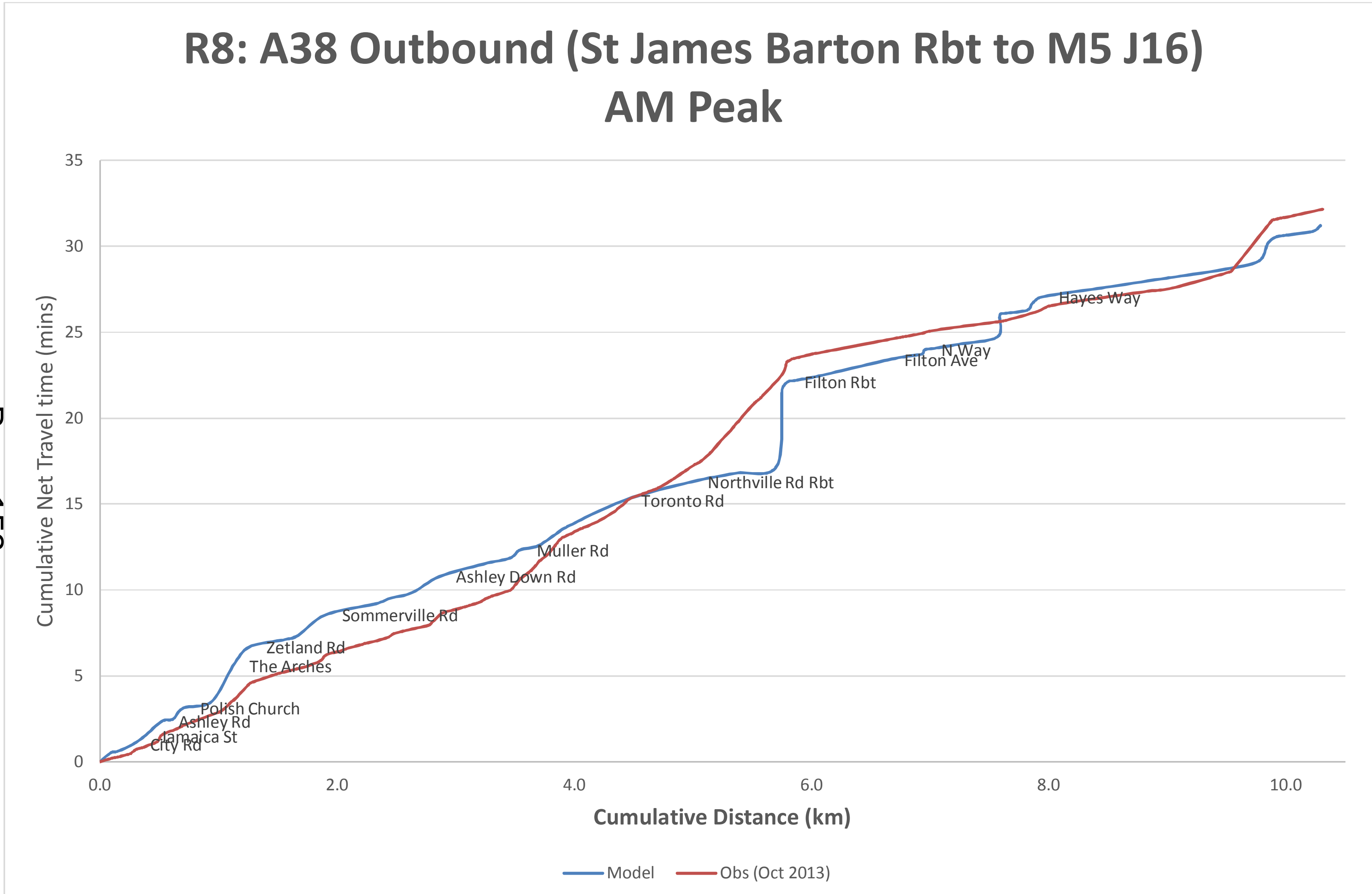

R6: A432 Inbound (A4174 Badminton Rbt to Old Market St) AM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
30
35
40
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Badminton Rbt
A4017 North St Rbt
Staple Hill Rd
Manor Rd
Hockey's Ln
Muller Rd
Robertson Rd
Easton Way
Trinity Rd
Lawford's Gate
Model
Obs (Oct 2013)


R6: A432 Outbound (West St to A4174 Badminton Rbt) AM Peak
Cumulative Net Travel time (mins)
35
30
25
20
15
10
5
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Cumulative Distance (km)
Old Market St
LawfoRds Gate
Easton Way
Robertson Rd
Muller Rd
Hockey's Ln
Manor Rd
Staple Hill Rd
A4017 North St Rbt
Model
Obs (Oct 2013)

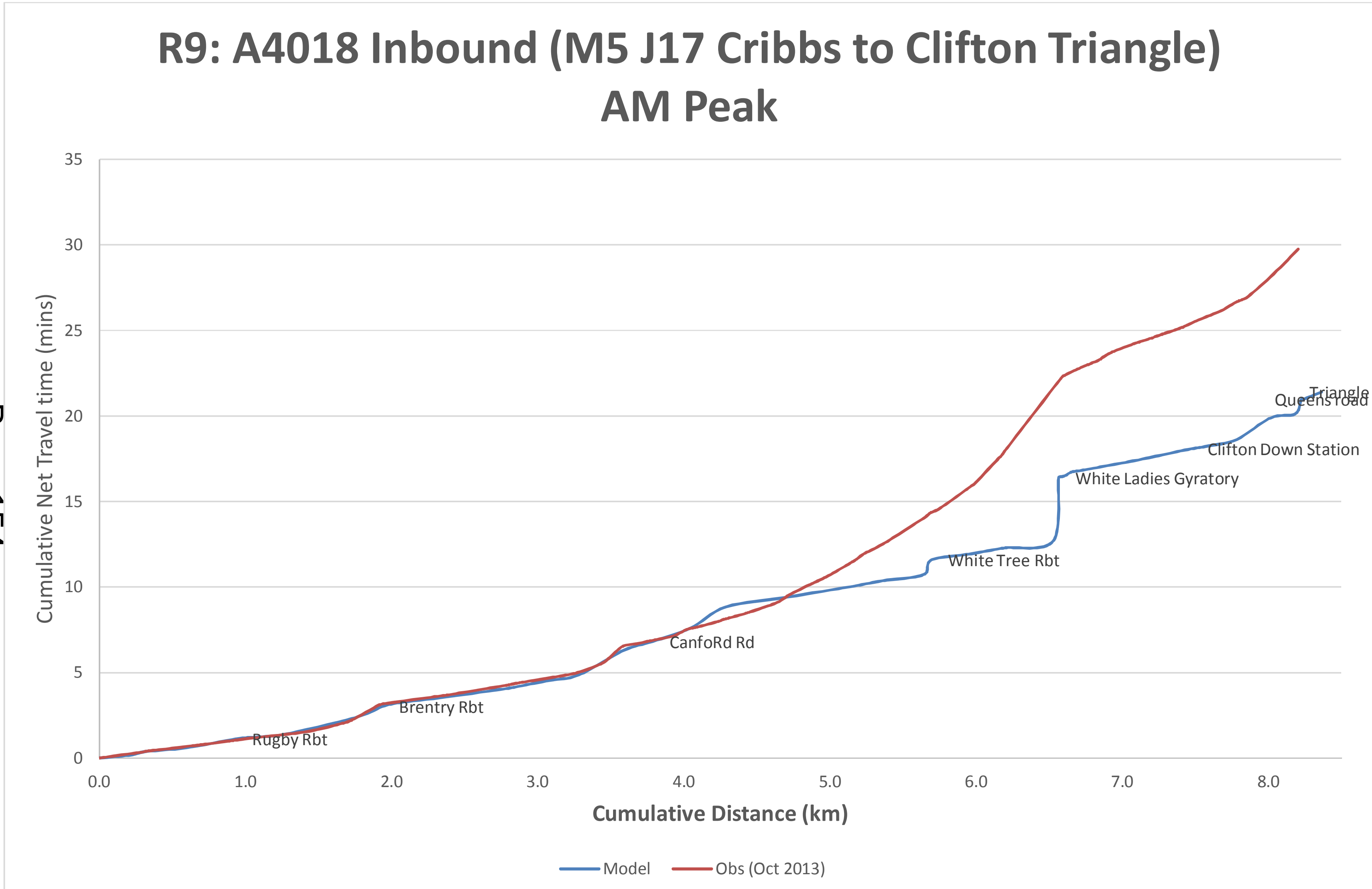

R7: M32 Inbound (M32 J1 to Cabot Circus) AM Peak
Cumulative Net Travel time (mins)
0
2
4
6
8
10
12
14
Cumulative Distance (km)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
M32 J1
M32 J2
M32 J3
Cabot Circus
Model
Obs (Oct 2013)


R7: M32 Outbound (Cabot Circus to M32 J1) AM Peak
Cumulative Net Travel time (mins)
6
5
4
3
2
1
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
Cumulative Distance (km)
Cabot Circus
M32 J3
M32 J2
M32 J1
Model
Obs (Oct 2013)

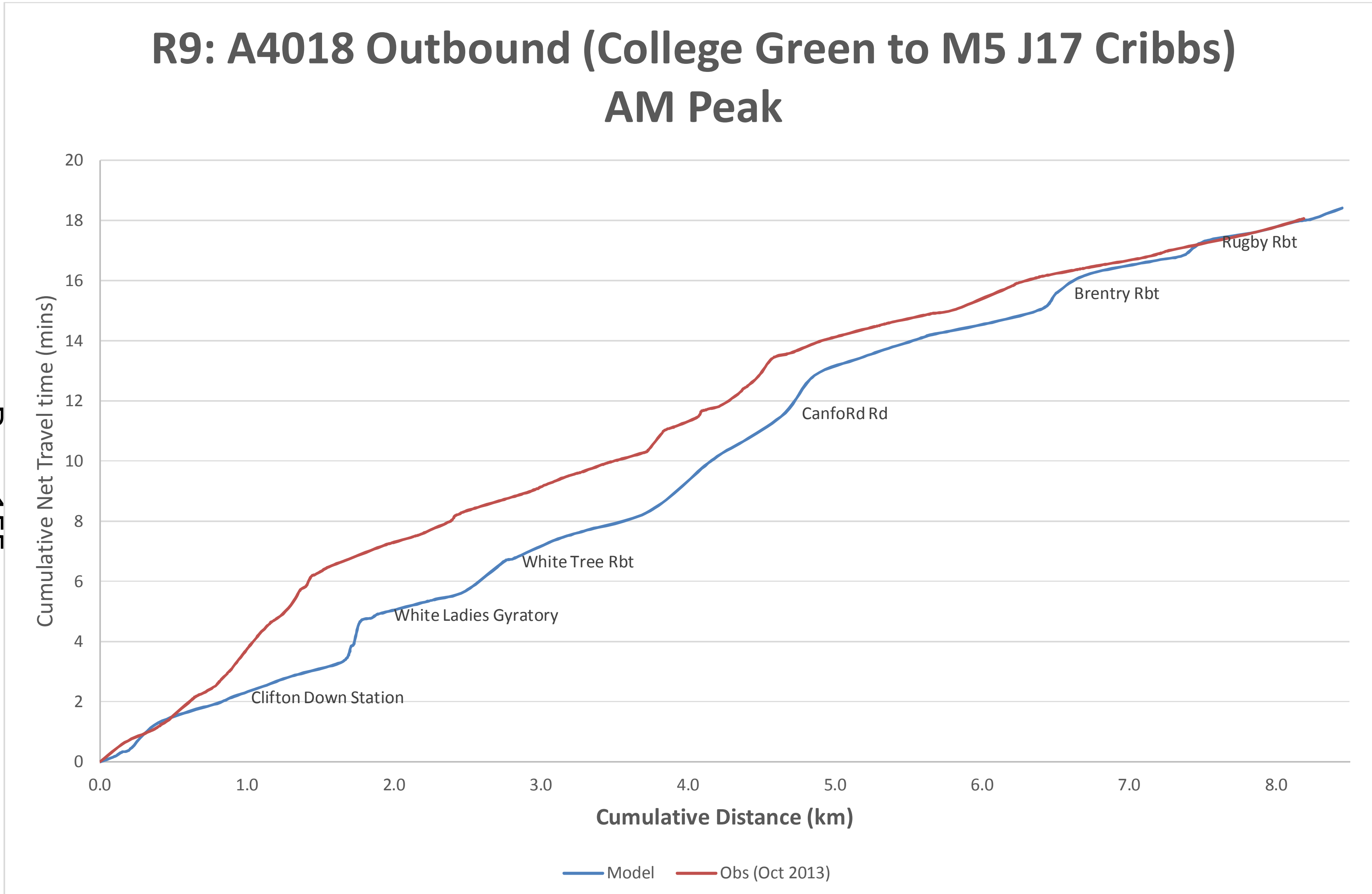

R8: A38 Inbound (M5 J16 to St James Barton Rbt) AM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
30
35
40
0.0
2.0
4.0
6.0
8.0
10.0
M4 J16
Aztec West Rbt
B4057 Exit
Hayes Way
N Way
Filton Ave
Filton Rbt
Filton Rbt
Northville Rd Rbt
Toronto Rd
Muller Rd
Ashley Down Rd
Sommerville Rd
Zetland Rd
The Arches
Polish Church
Ashley Rd
Jamaica St
City Rd
Model
Obs (Oct 2013)

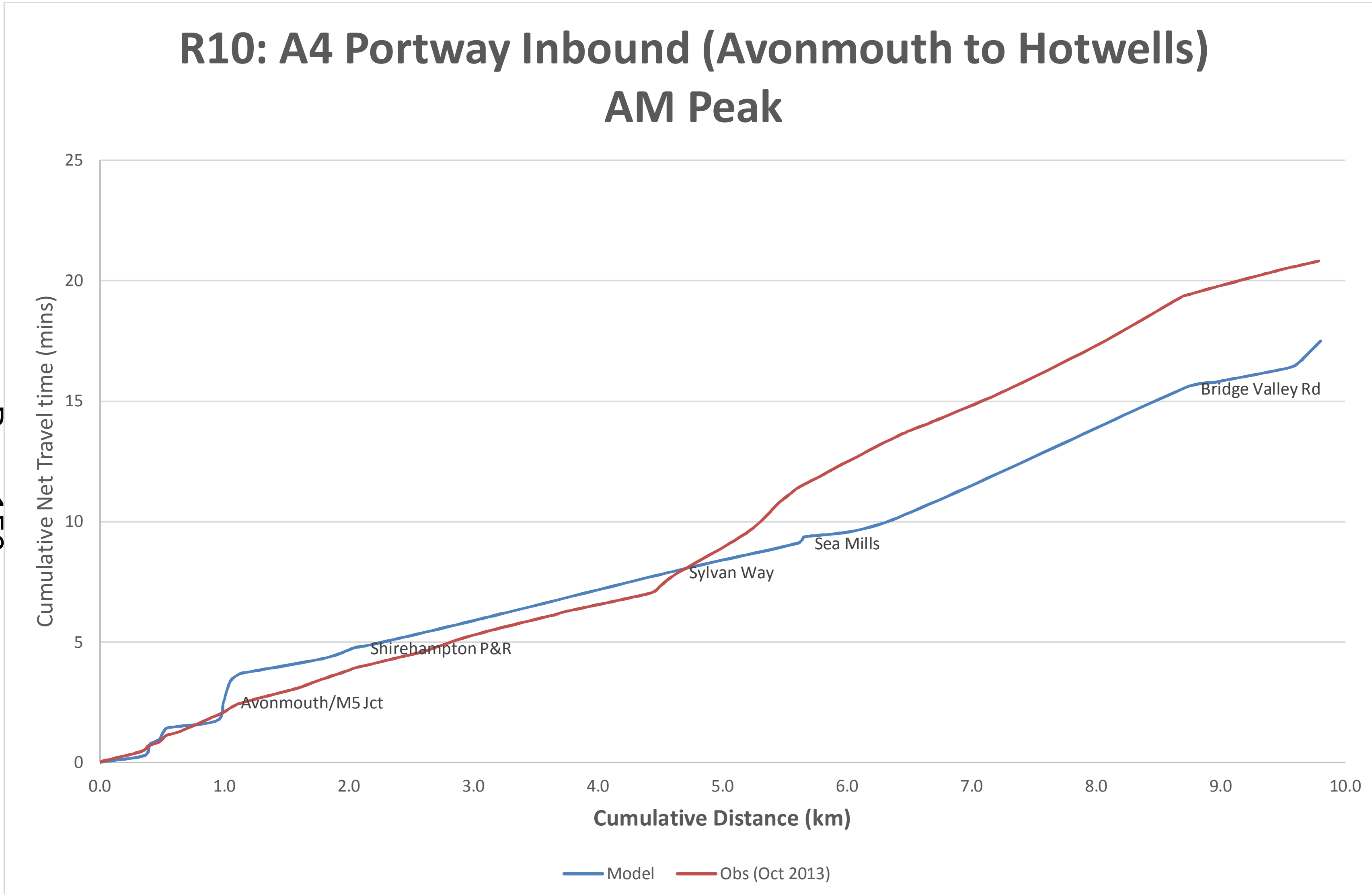


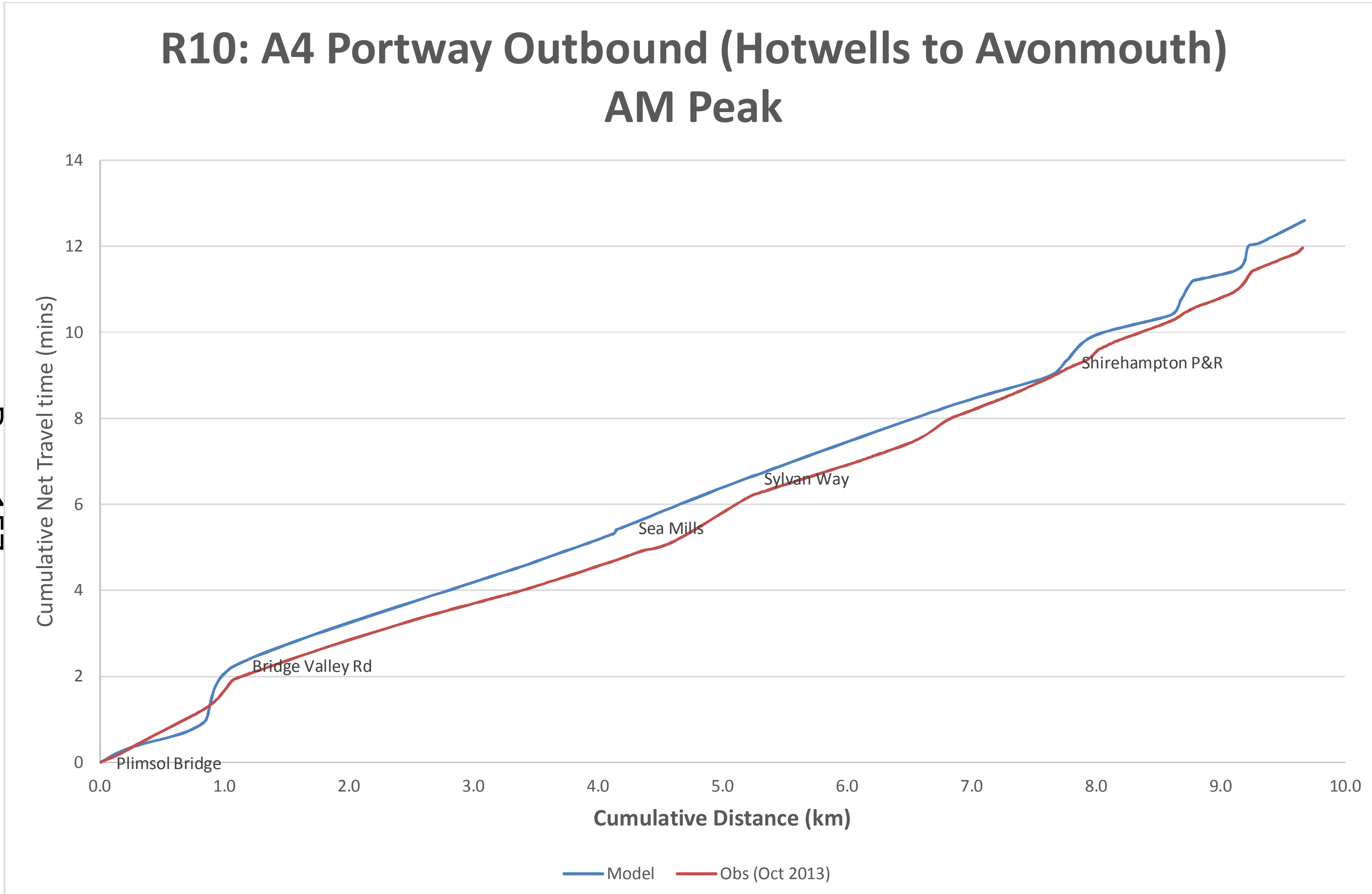
R8: A38 Outbound (St James Barton Rbt to M5 J16)
AM Peak
Cumulative Net Travel time (mins)
35
30
25
20
15
10
5
0
0.0
2.0
4.0
6.0
8.0
10.0
Cumulative Distance (km)
Hayes Way
N Way
Filton Ave
Filton Rbt
Northville Rd Rbt
Toronto Rd
Muller Rd
Ashley Down Rd
Sommerville Rd
Zetland Rd
The Arches
Polish Church
Ashley Rd
Jamaica St
City Rd
Model
Obs (Oct 2013)

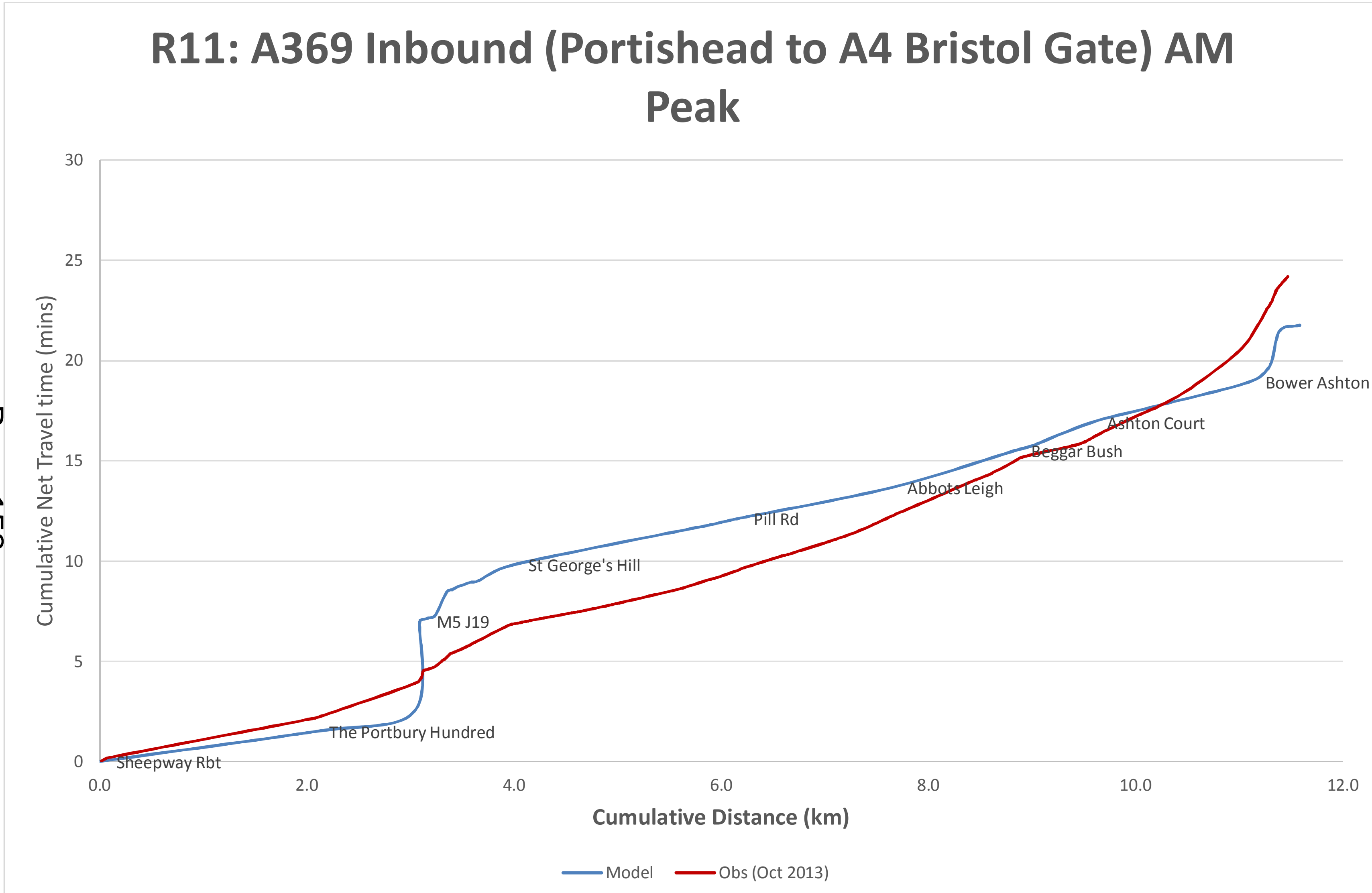


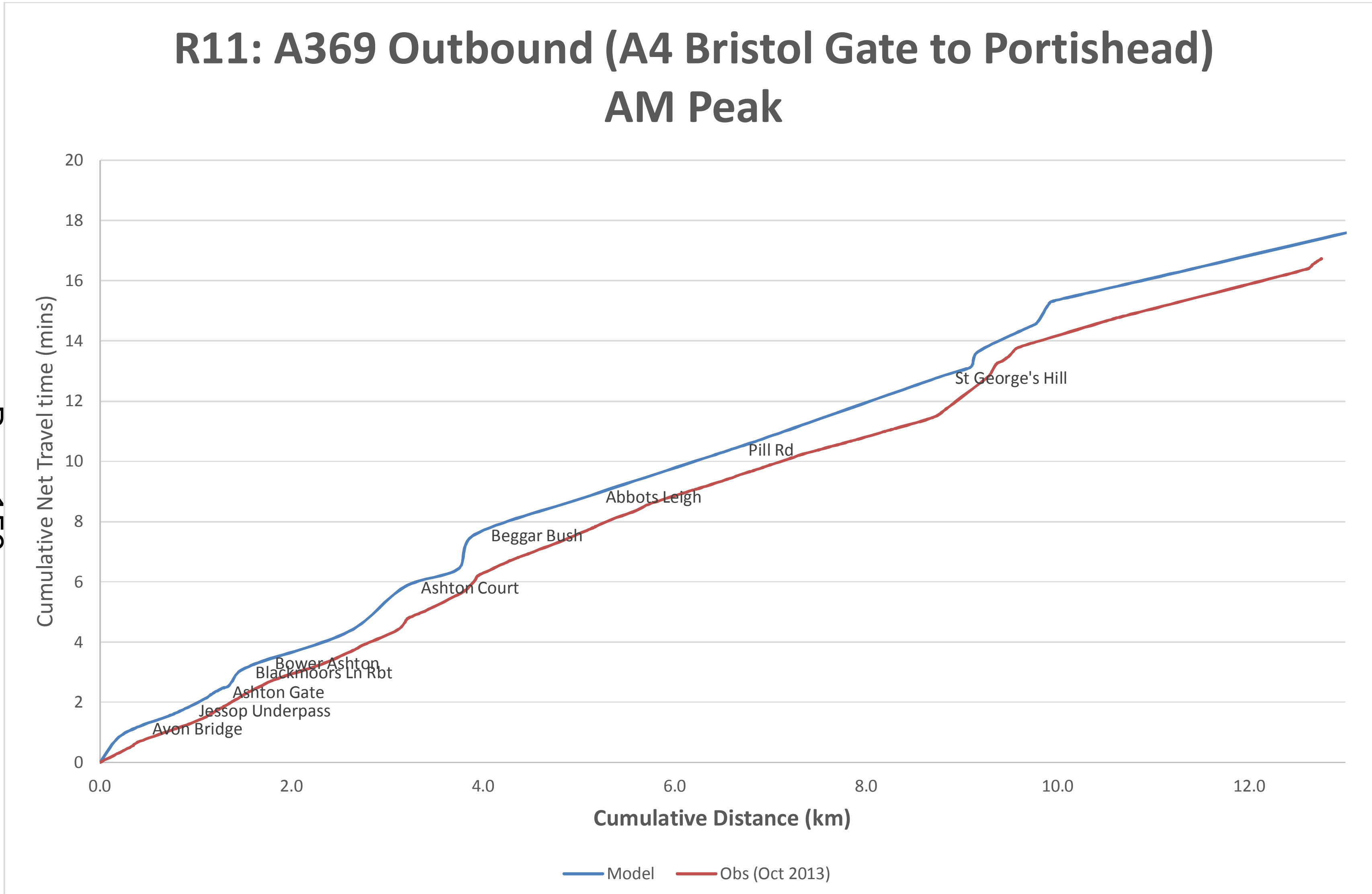
R9: A4018 Inbound (M5 J17 Cribbs to Clifton Triangle)
AM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
30
35
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Rugby Rbt
Brentry Rbt
CanfoRd Rd
White Tree Rbt
White Ladies Gyratory
Clifton Down Station
Queens road
Triangle
Model
Obs (Oct 2013)

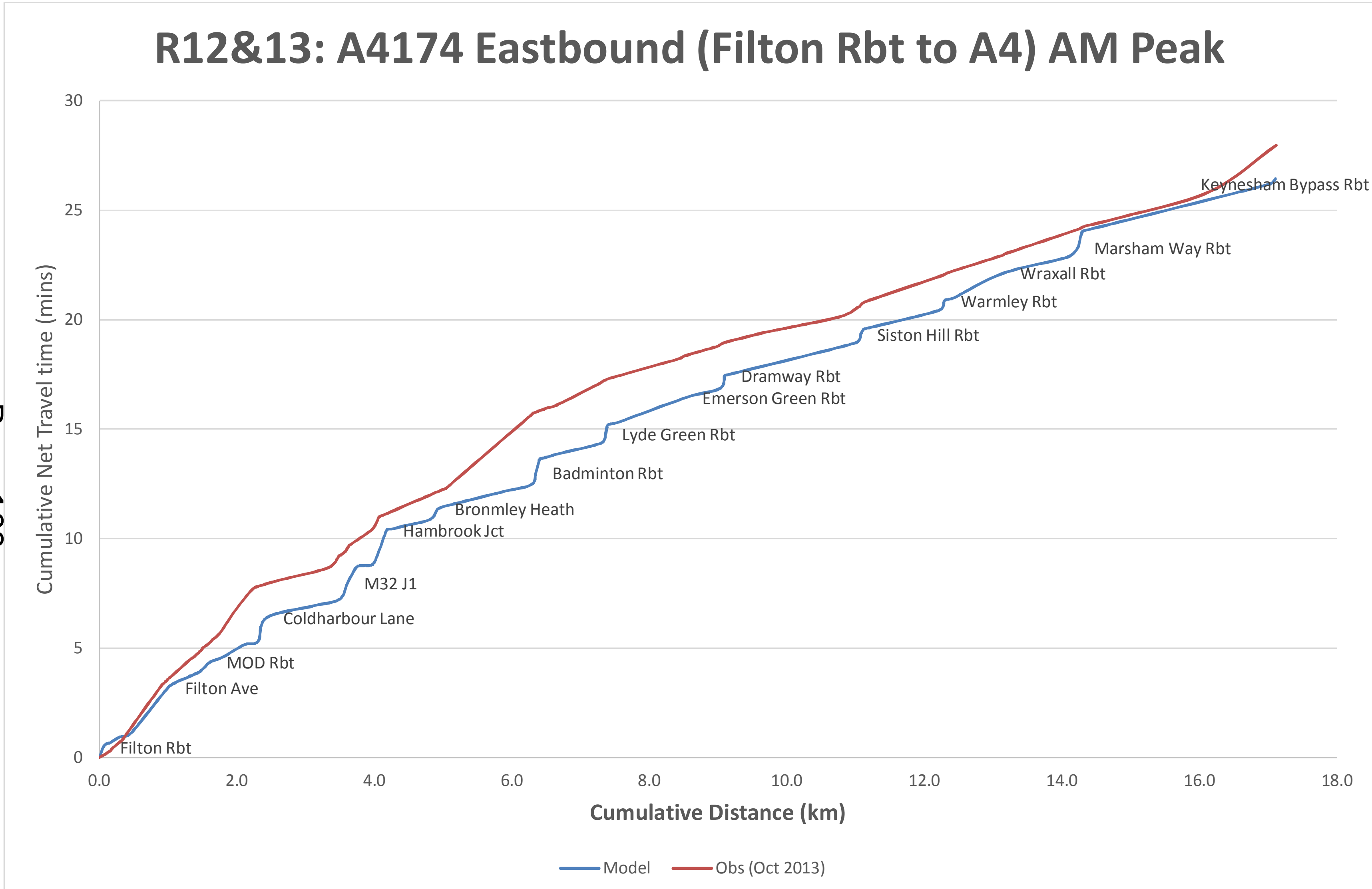

R9: A4018 Outbound (College Green to M5 J17 Cribbs)
AM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
2
4
6
8
10
12
14
16
18
20
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Clifton Down Station
White Ladies Gyratory
White Tree Rbt
CanfoRd Rd
Brentry Rbt
Rugby Rbt
Model
Obs (Oct 2013)

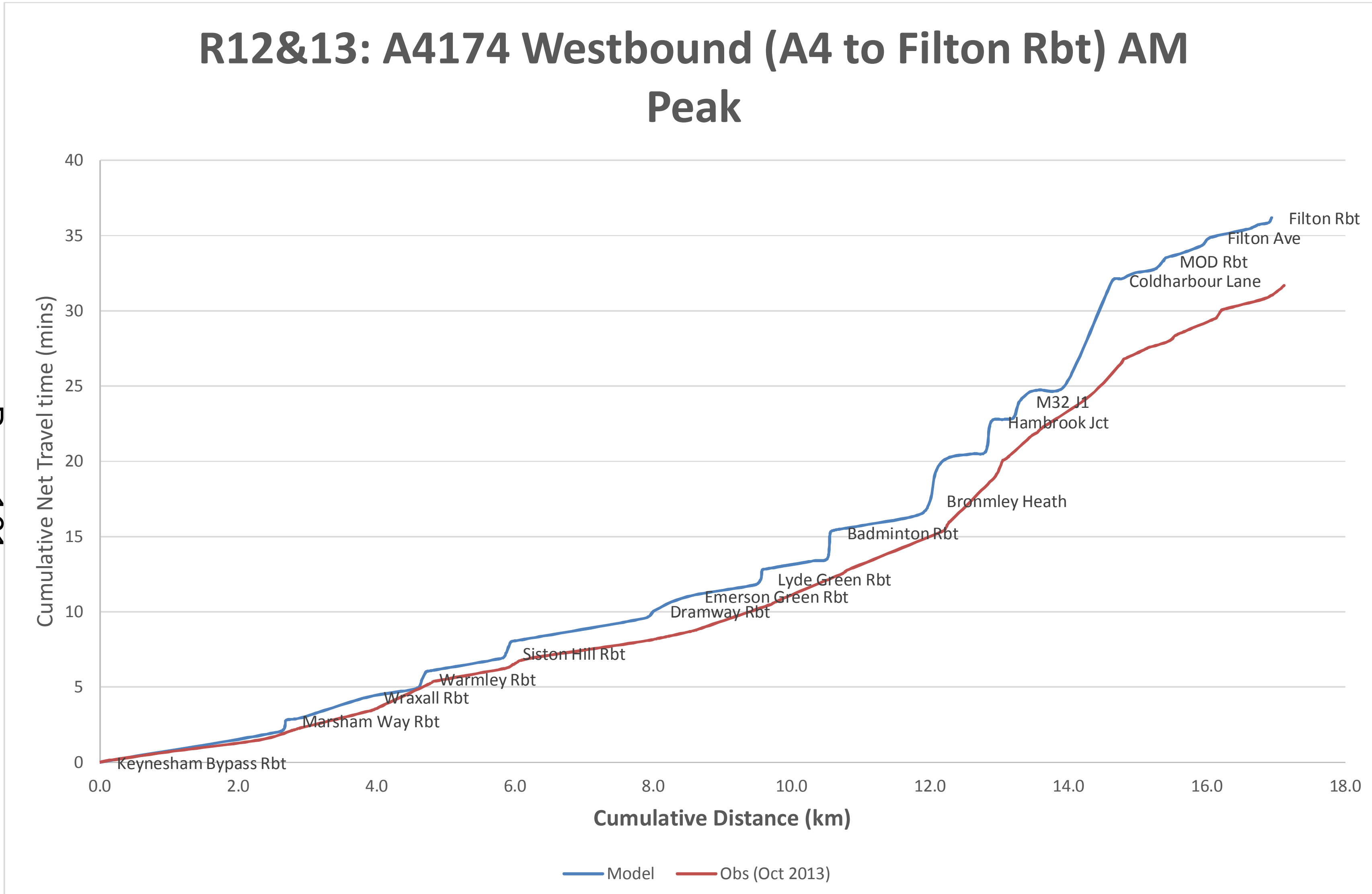

R10: A4 Portway Inbound (Avonmouth to Hotwells)
AM Peak
Cumulative Net Travel time (mins)
25
20
15
10
5
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Cumulative Distance (km)
Avonmouth/M5 Jct
Shirehampton P&R
Sylvan Way
Sea Mills
Bridge Valley Rd
Model
Obs (Oct 2013)

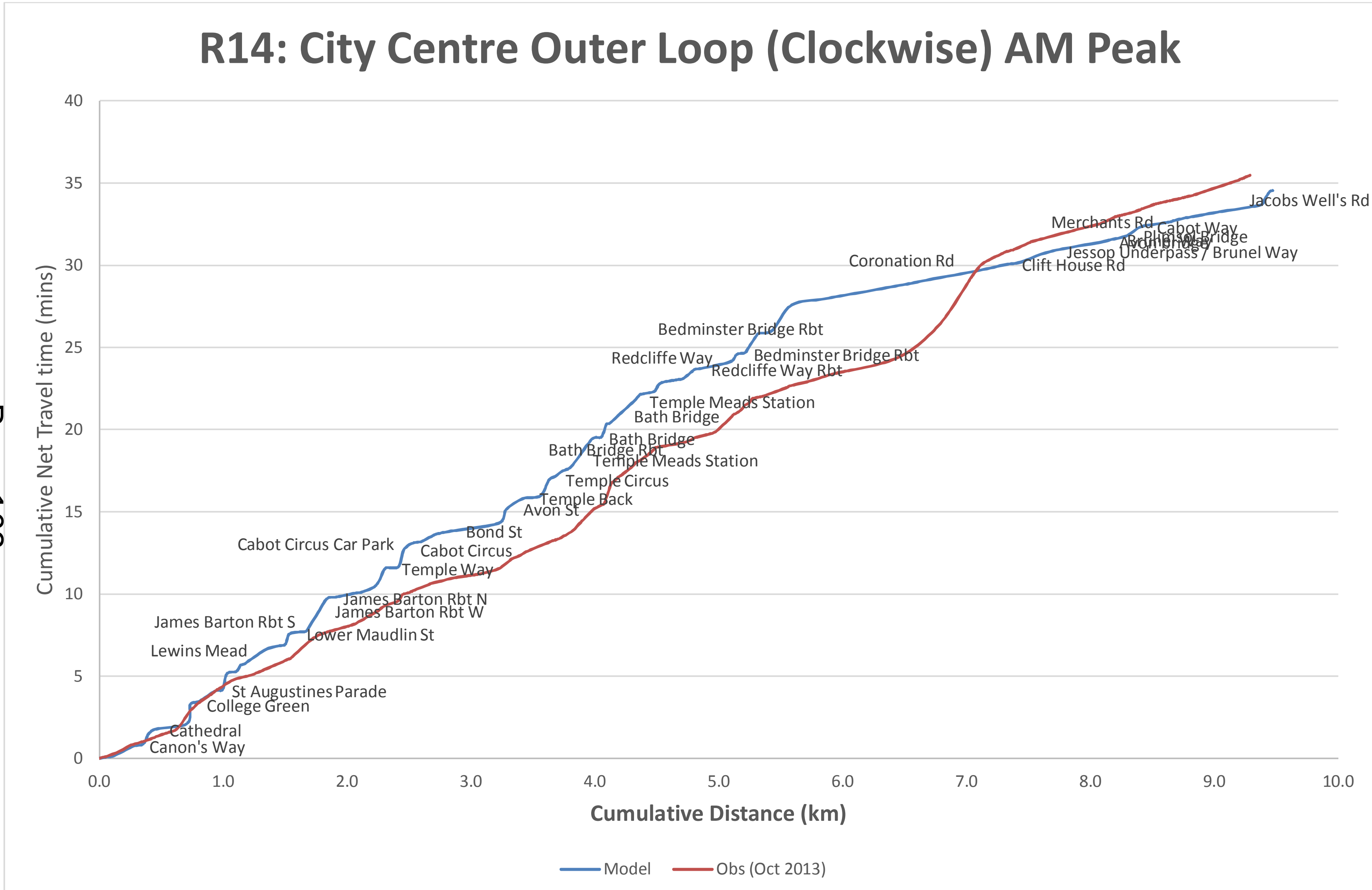

R10: A4 Portway Outbound (Hotwells to Avonmouth)
AM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
Plimsol Bridge
Bridge Valley Rd
Sea Mills
Sylvan Way
Shirehampton P&R
Model
Obs (Oct 2013)

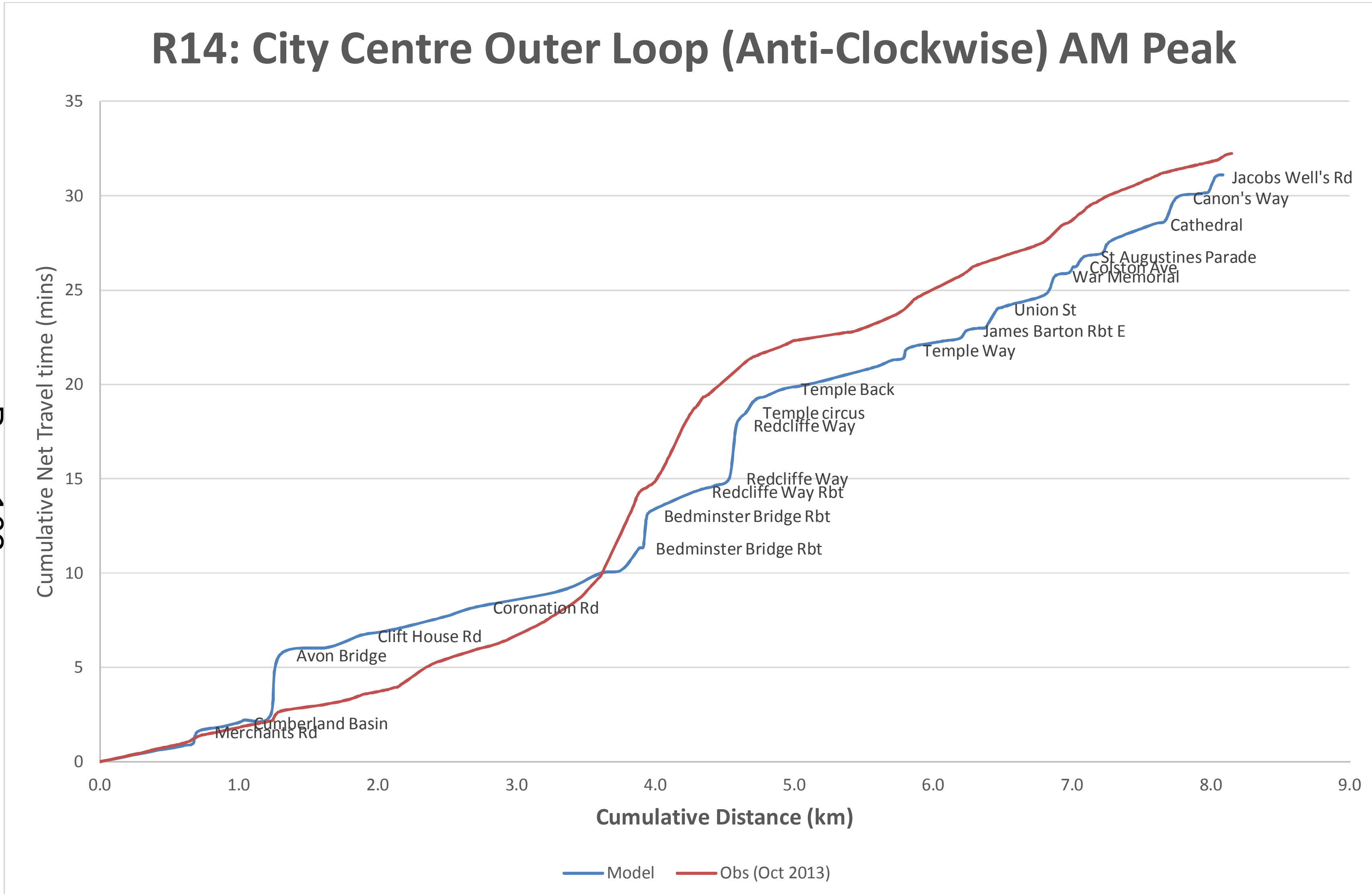

R11: A369 Inbound (Portishead to A4 Bristol Gate) AM Peak
Cumulative Net Travel time (mins)
30
25
20
15
10
5
0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Cumulative Distance (km)
Sheepway Rbt
The Portbury Hundred
M5 J19
St George's Hill
Pill Rd
Abbots Leigh
Beggar Bush
Ashton Court
Bower Ashton
Model
Obs (Oct 2013)

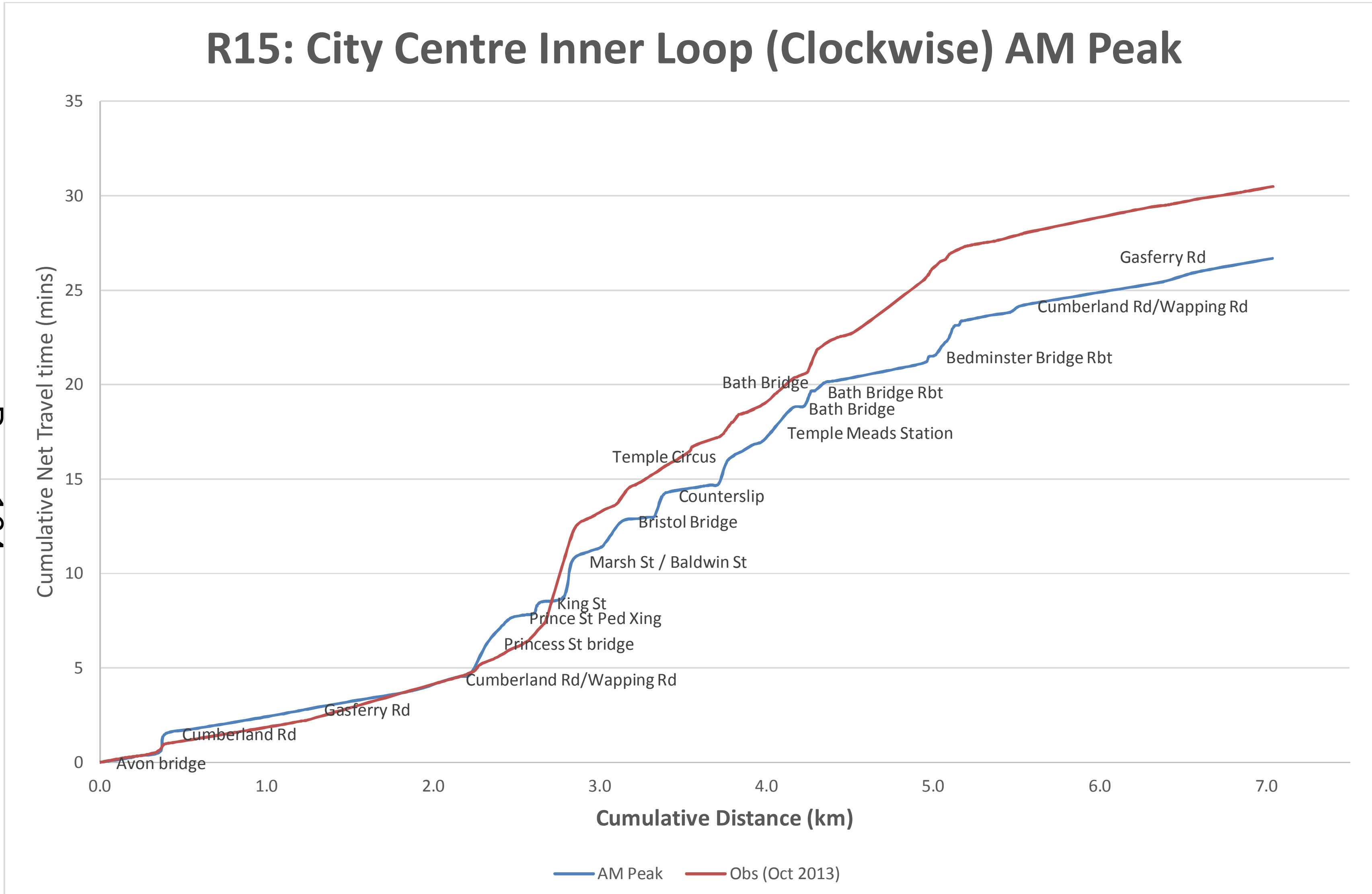

R11: A369 Outbound (A4 Bristol Gate to Portishead)
AM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
2
4
6
8
10
12
14
16
18
20
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Avon Bridge
Jessop Underpass
Ashton Gate
Blackmoors Ln Rbt
Bower Ashton
Ashton Court
Beggar Bush
Abbots Leigh
Pill Rd
St George's Hill
Model
Obs (Oct 2013)

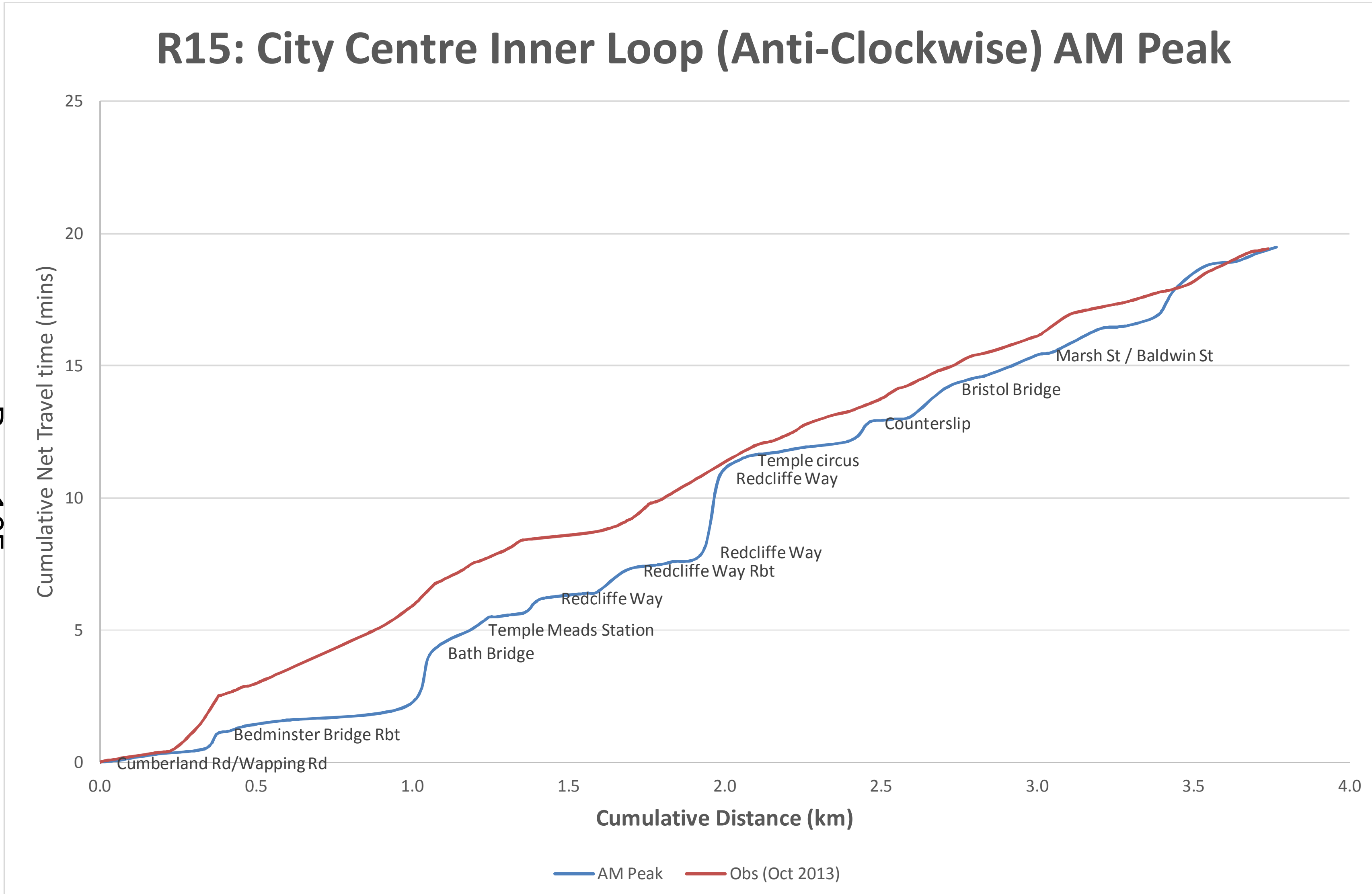

R12&13: A4174 Eastbound (Filton Rbt to A4) AM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
30
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
Filton Rbt
Filton Ave
MOD Rbt
Coldharbour Lane
M32 J1
Hambrook Jct
Bronmley Heath
Badminton Rbt
Lyde Green Rbt
Emerson Green Rbt
Dramway Rbt
Siston Hill Rbt
Warmley Rbt
Wraxall Rbt
Marsham Way Rbt
Keynesham Bypass Rbt
Model
Obs (Oct 2013)

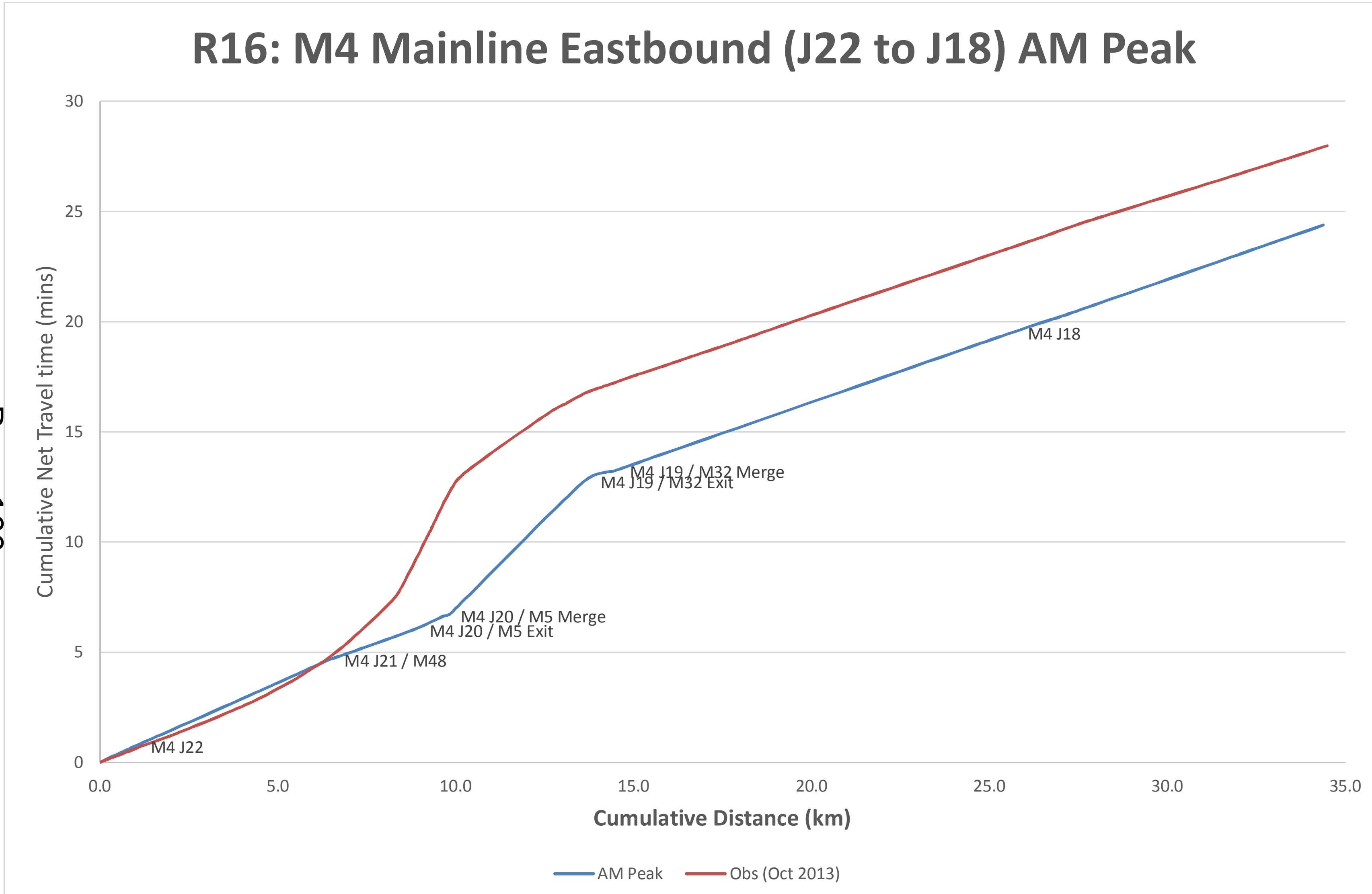

R12&13: A4174 Westbound (A4 to Filton Rbt) AM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
30
35
40
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
Keynesham Bypass Rbt
Marsham Way Rbt
Wraxall Rbt
Warmley Rbt
Siston Hill Rbt
Dramway Rbt
Emerson Green Rbt
Lyde Green Rbt
Badminton Rbt
Bromnley Heath
Hambrook Jct
M32 J1
Coldharbour Lane
MOD Rbt
Filton Ave
Filton Rbt
Model
Obs (Oct 2013)

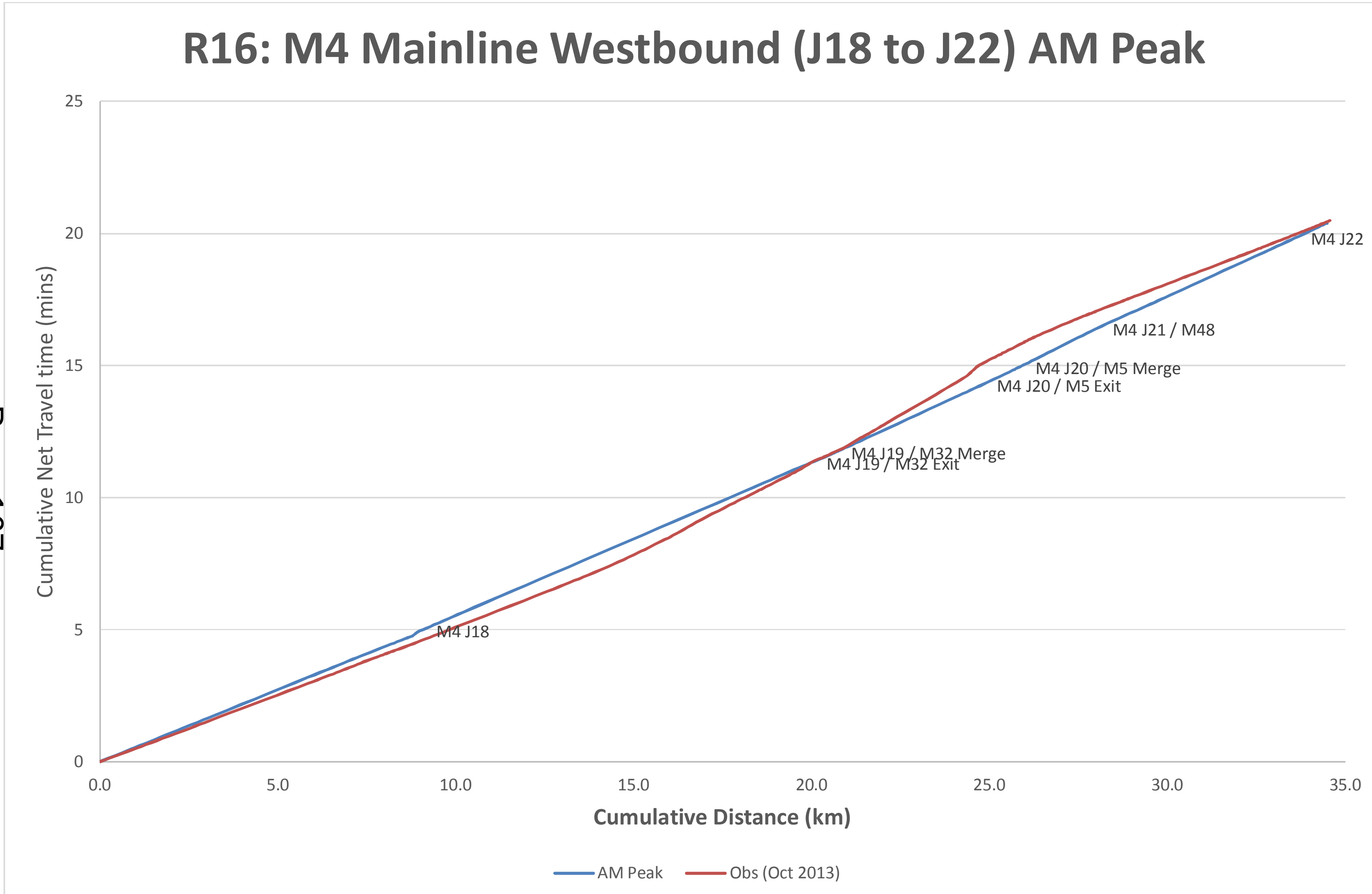

R14: City Centre Outer Loop (Clockwise) AM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
Model
Obs (Oct 2013)
Canon's Way
Cathedral
College Green
St Augustines Parade
Lewins Mead
James Barton Rbt S
Lower Maudlin St
James Barton Rbt W
James Barton Rbt N
Temple Way
Cabot Circus
Cabot Circus Car Park
Bond St
Avon St
Temple Back
Temple Circus
Temple Meads Station
Bath Bridge Rbt
Bath Bridge
Bath Bridge
Temple Meads Station
Redcliffe Way Rbt
Redcliffe Way
Bedminster Bridge Rbt
Bedminster Bridge Rbt
Coronation Rd
Clift House Rd
Jessop Underpass / Brunel Way
Merchants Rd
Cabot Way
Jacobs Well's Rd

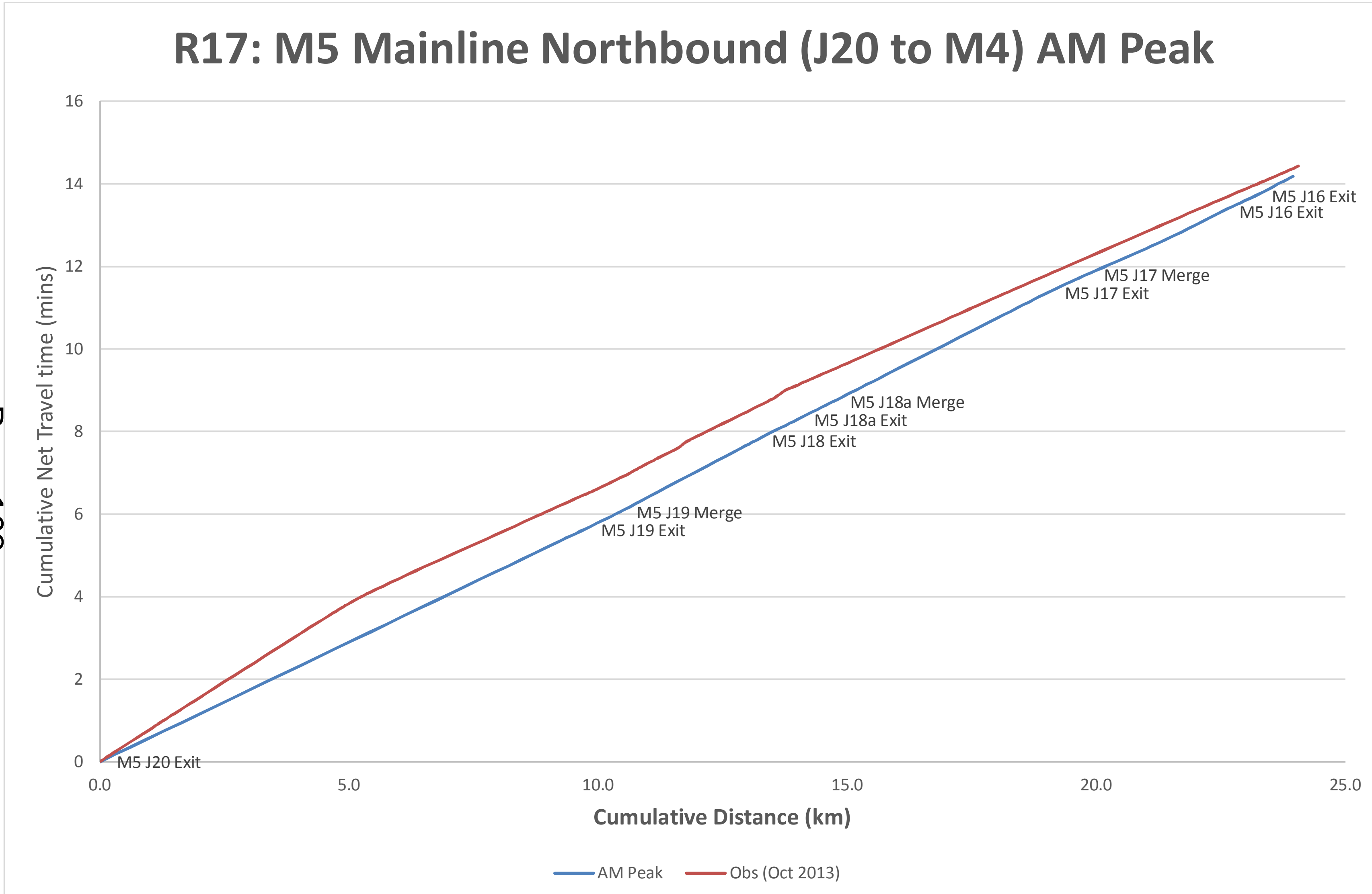

R14: City Centre Outer Loop (Anti-Clockwise) AM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
30
35
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Jacobs Well's Rd
Canon's Way
Cathedral
St Augustines Parade
Colston Ave
War Memorial
Union St
James Barton Rbt E
Temple Way
Temple Back
Temple circus
Redcliffe Way
Redcliffe Way
Redcliffe Way Rbt
Bedminster Bridge Rbt
Bedminster Bridge Rbt
Coronation Rd
Clift House Rd
Avon Bridge
Cumberland Basin
Merchants Rd
Model
Obs (Oct 2013)

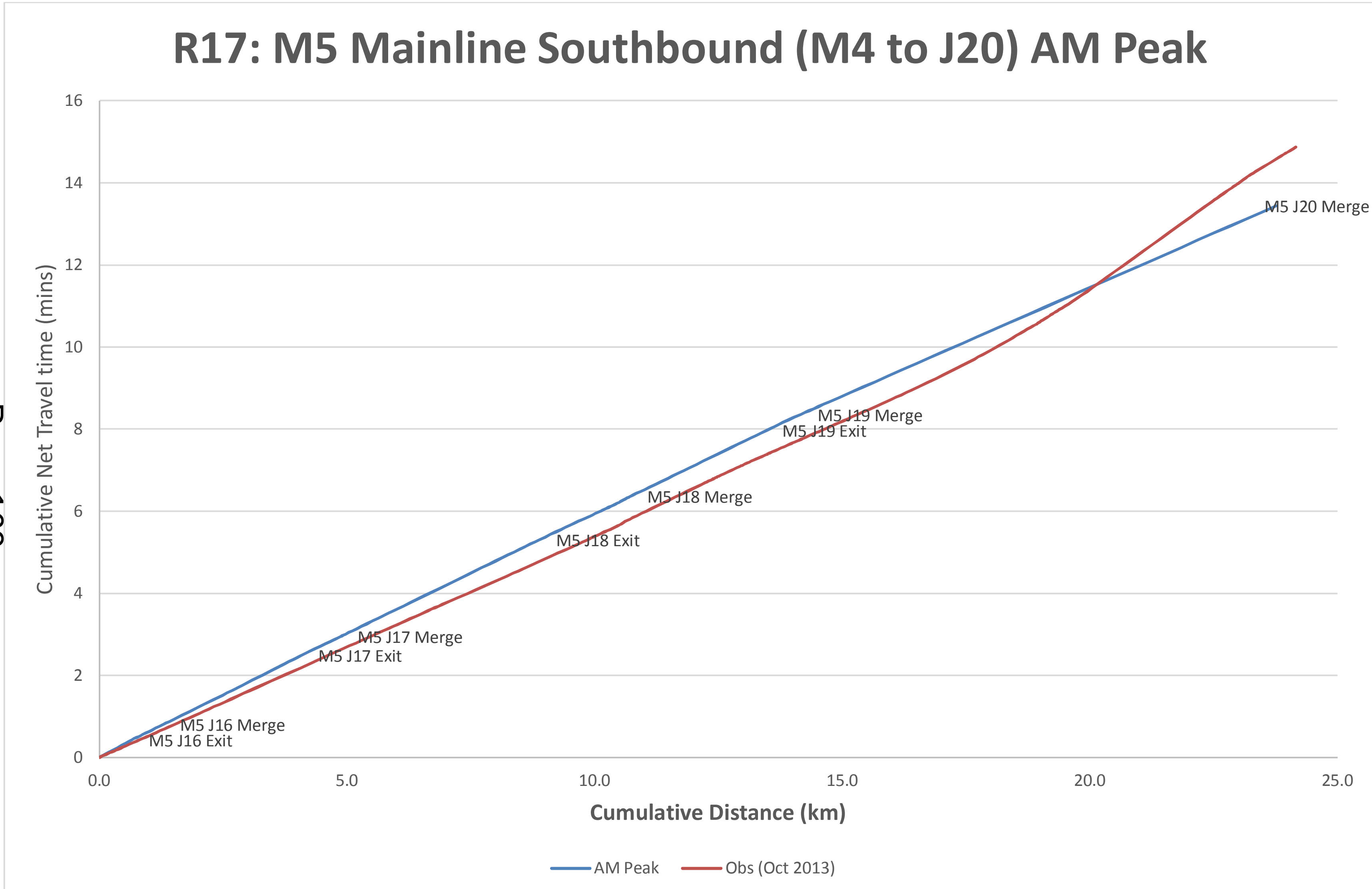

R15: City Centre Inner Loop (Clockwise) AM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
30
35
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Avon bridge
Cumberland Rd
Gasferry Rd
Cumberland Rd/Wapping Rd
Princess St bridge
Prince St Ped Xing
King St
Marsh St / Baldwin St
Bristol Bridge
Counterslip
Temple Circus
Temple Meads Station
Bath Bridge
Bath Bridge Rbt
Bath Bridge
Bedminster Bridge Rbt
Cumberland Rd/Wapping Rd
Gasferry Rd
AM Peak
Obs (Oct 2013)

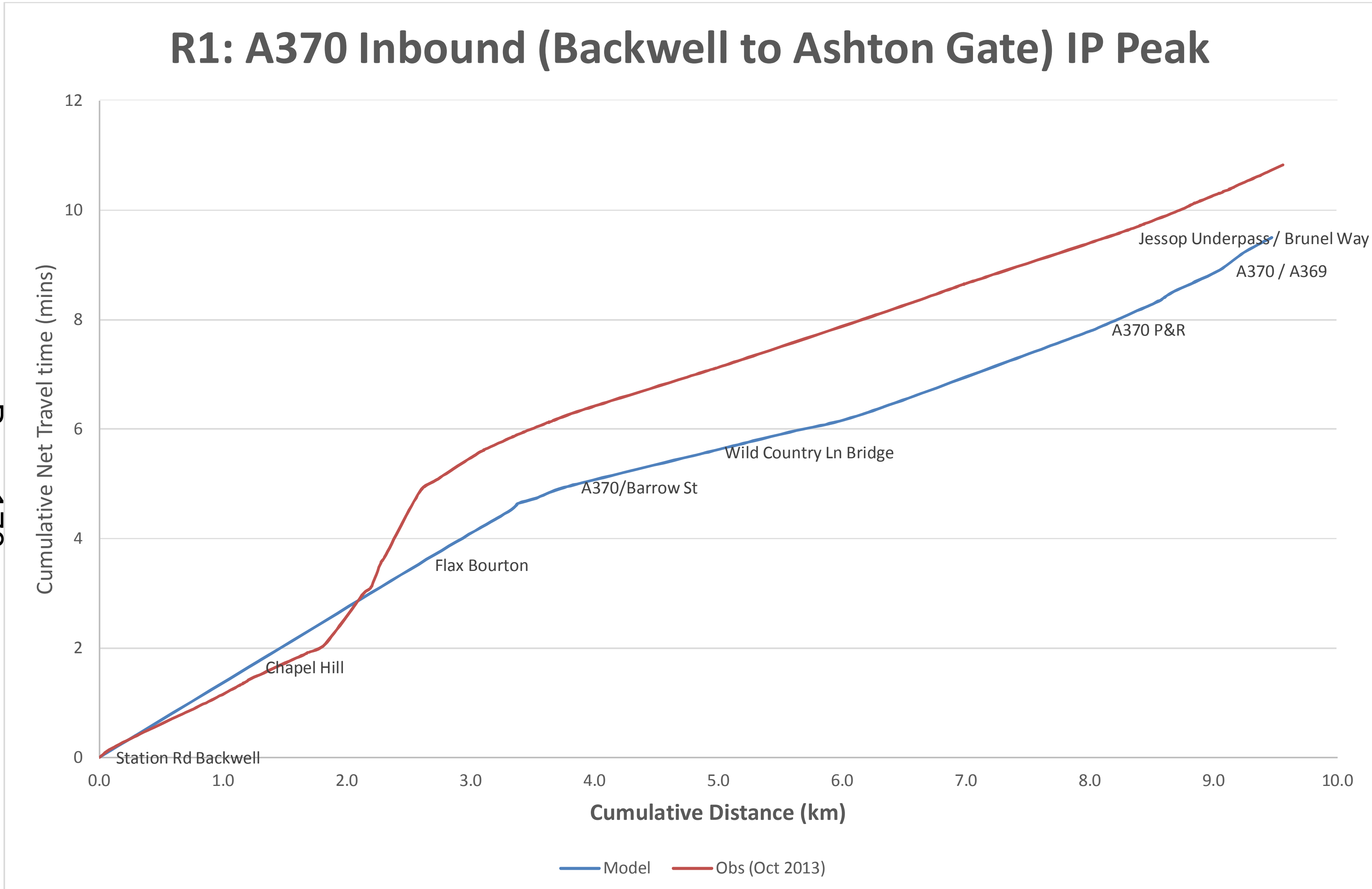

R15: City Centre Inner Loop (Anti-Clockwise) AM Peak
Cumulative Net Travel time (mins)
25
20
15
10
5
0
Cumulative Distance (km)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Cumberland Rd/Wapping Rd
Bedminster Bridge Rbt
Bath Bridge
Temple Meads Station
Redcliffe Way
Redcliffe Way Rbt
Redcliffe Way
Redcliffe Way
Temple circus
Counterslip
Bristol Bridge
Marsh St / Baldwin St
AM Peak
Obs (Oct 2013)

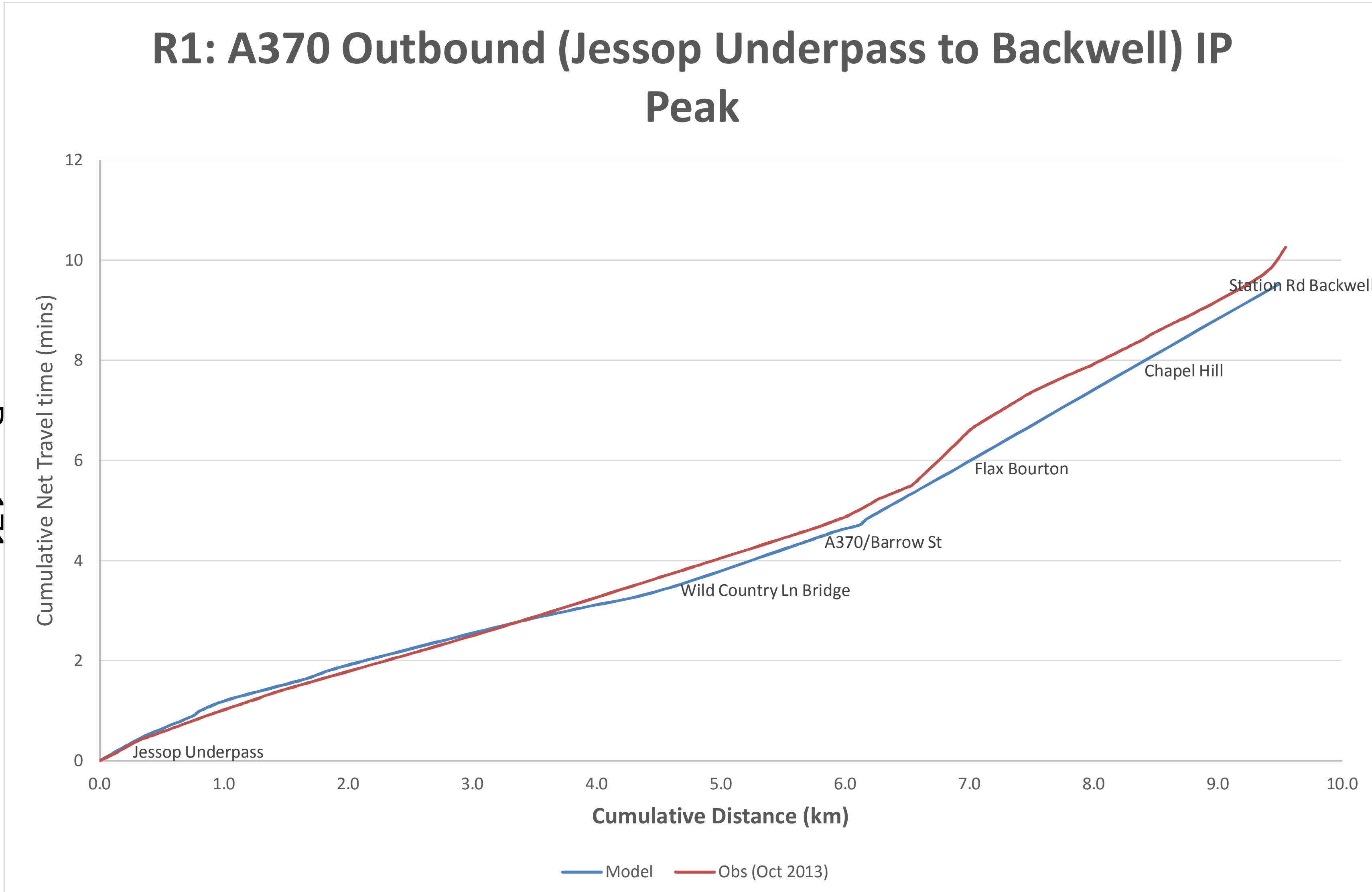

R16: M4 Mainline Eastbound (J22 to J18) AM Peak
Cumulative Net Travel time (mins)
30
25
20
15
10
5
0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Cumulative Distance (km)
M4 J22
M4 J21 / M48
M4 J20 / M5 Merge
M4 J20 / M5 Exit
M4 J19 / M32 Merge
M4 J19 / M32 Exit
M4 J18
AM Peak
Obs (Oct 2013)

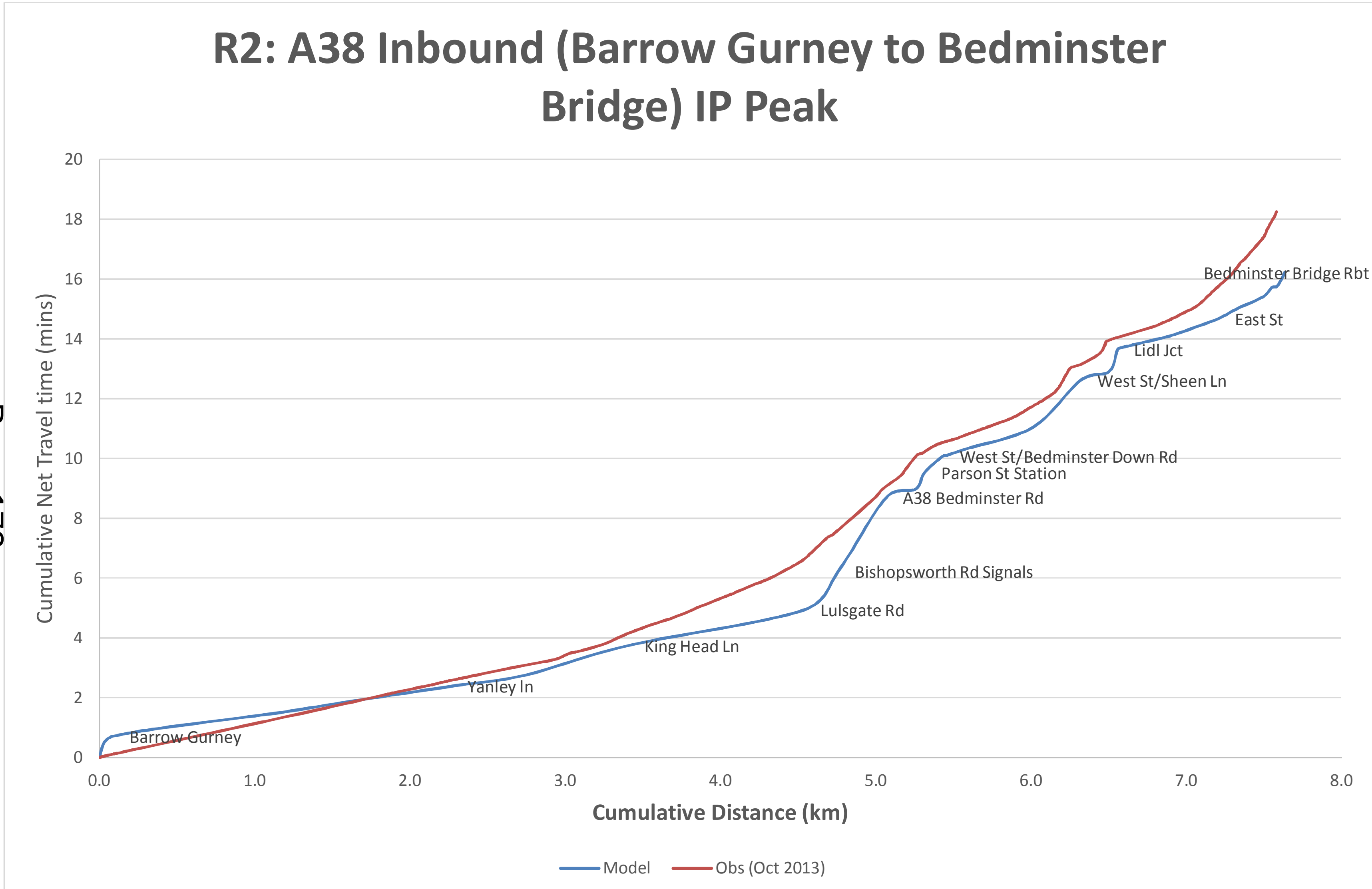

R16: M4 Mainline Westbound (J18 to J22) AM Peak
Cumulative Net Travel time (mins)
25
20
15
10
5
0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Cumulative Distance (km)
M4 J18
M4 J19 / M32 Merge
M4 J19 / M32 Exit
M4 J20 / M5 Merge
M4 J20 / M5 Exit
M4 J21 / M48
M4 J22
AM Peak
Obs (Oct 2013)


R17: M5 Mainline Northbound (J20 to M4) AM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
2
4
6
8
10
12
14
16
0.0
5.0
10.0
15.0
20.0
25.0
M5 J20 Exit
M5 J19 Merge
M5 J19 Exit
M5 J18a Merge
M5 J18a Exit
M5 J18 Exit
M5 J17 Merge
M5 J17 Exit
M5 J16 Exit
M5 J16 Exit
AM Peak
Obs (Oct 2013)

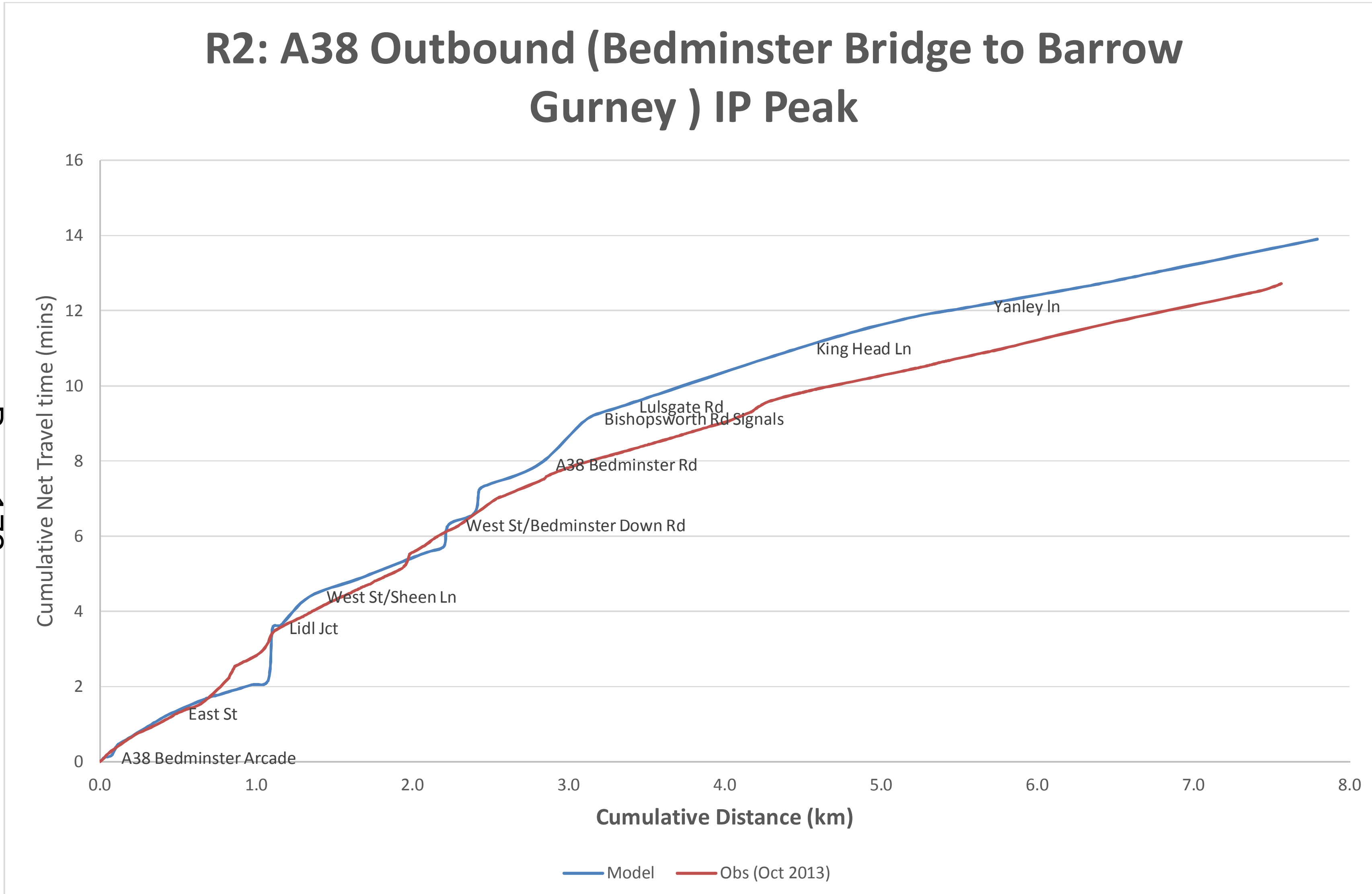

R17: M5 Mainline Southbound (M4 to J20) AM Peak
Cumulative Net Travel time (mins)
16
14
12
10
8
6
4
2
0
0.0
5.0
10.0
15.0
20.0
25.0
Cumulative Distance (km)
M5 J16 Exit
M5 J16 Merge
M5 J17 Exit
M5 J17 Merge
M5 J18 Exit
M5 J18 Merge
M5 J19 Exit
M5 J19 Merge
M5 J20 Merge
AM Peak
Obs (Oct 2013)

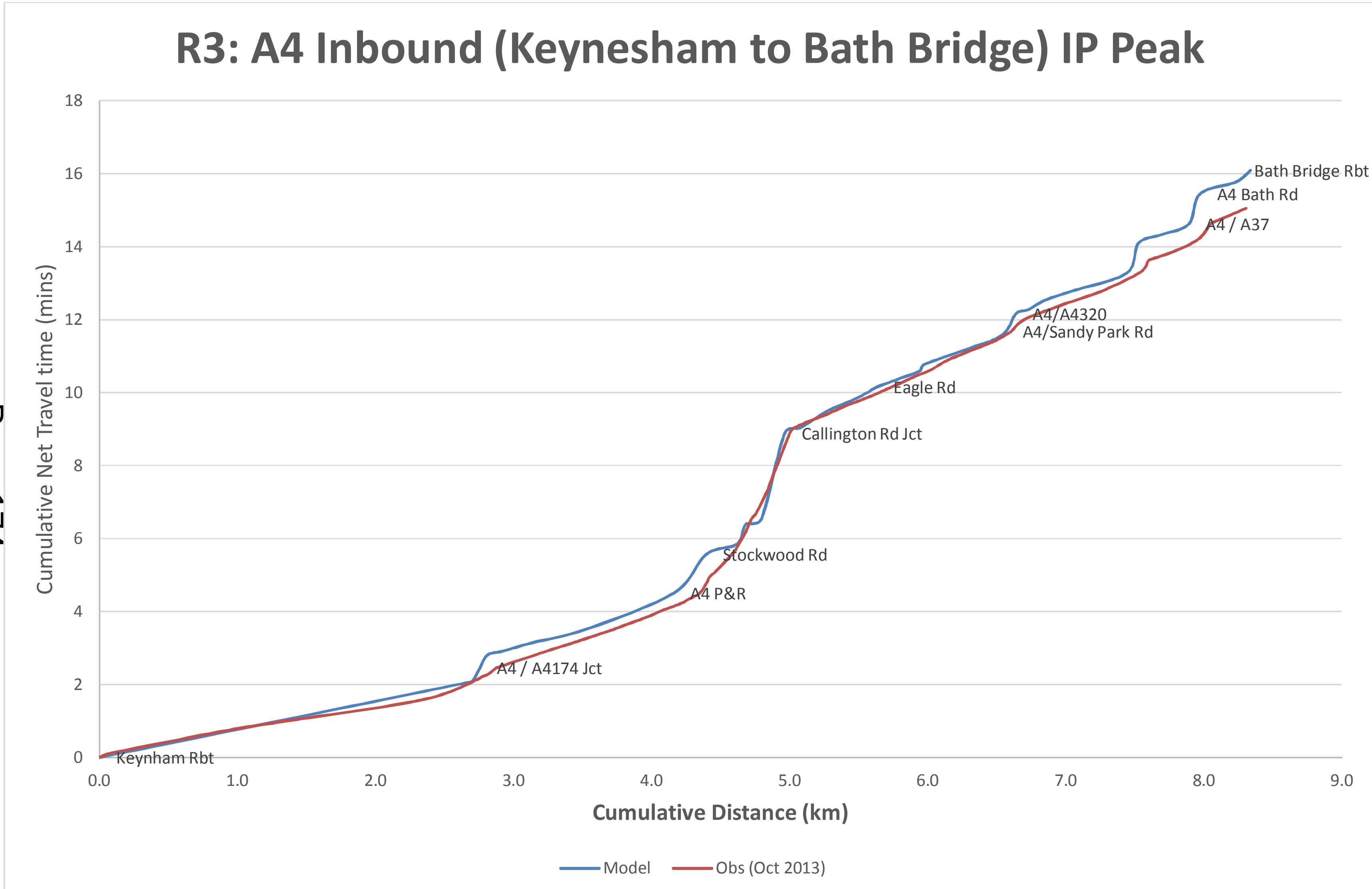

R1: A370 Inbound (Backwell to Ashton Gate) IP Peak
Cumulative Net Travel time (mins)
12
10
8
6
4
2
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Cumulative Distance (km)
Station Rd Backwell
Chapel Hill
Flax Bourton
A370/Barrow St
Wild Country Ln Bridge
A370 P&R
A370 / A369
Jessop Underpass / Brunel Way
Model
Obs (Oct 2013)

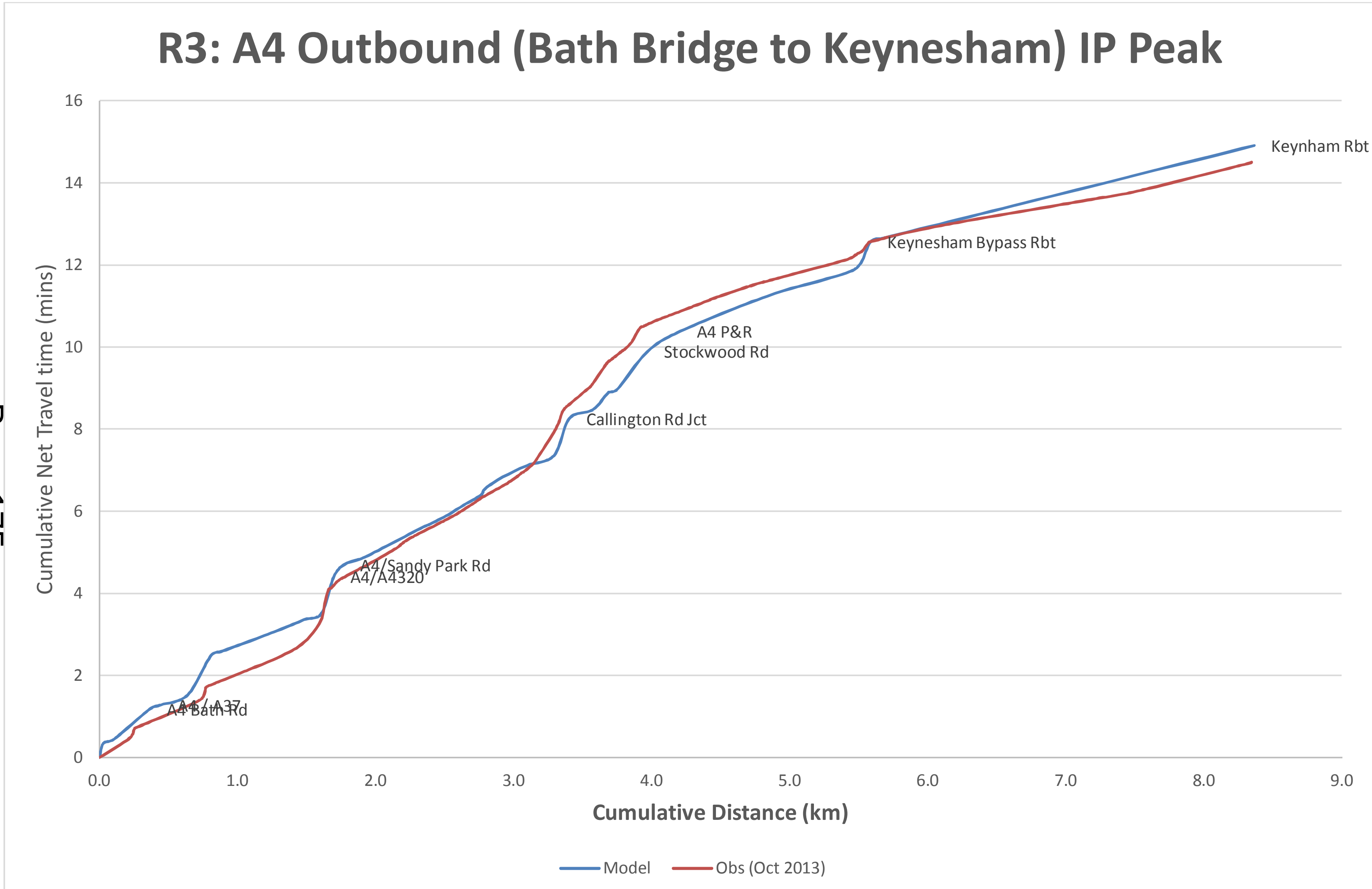

R1: A370 Outbound (Jessop Underpass to Backwell) IP Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
2
4
6
8
10
12
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Jessop Underpass
Wild Country Ln Bridge
A370/Barrow St
Flax Bourton
Chapel Hill
Station Rd Backwell
Model
Obs (Oct 2013)

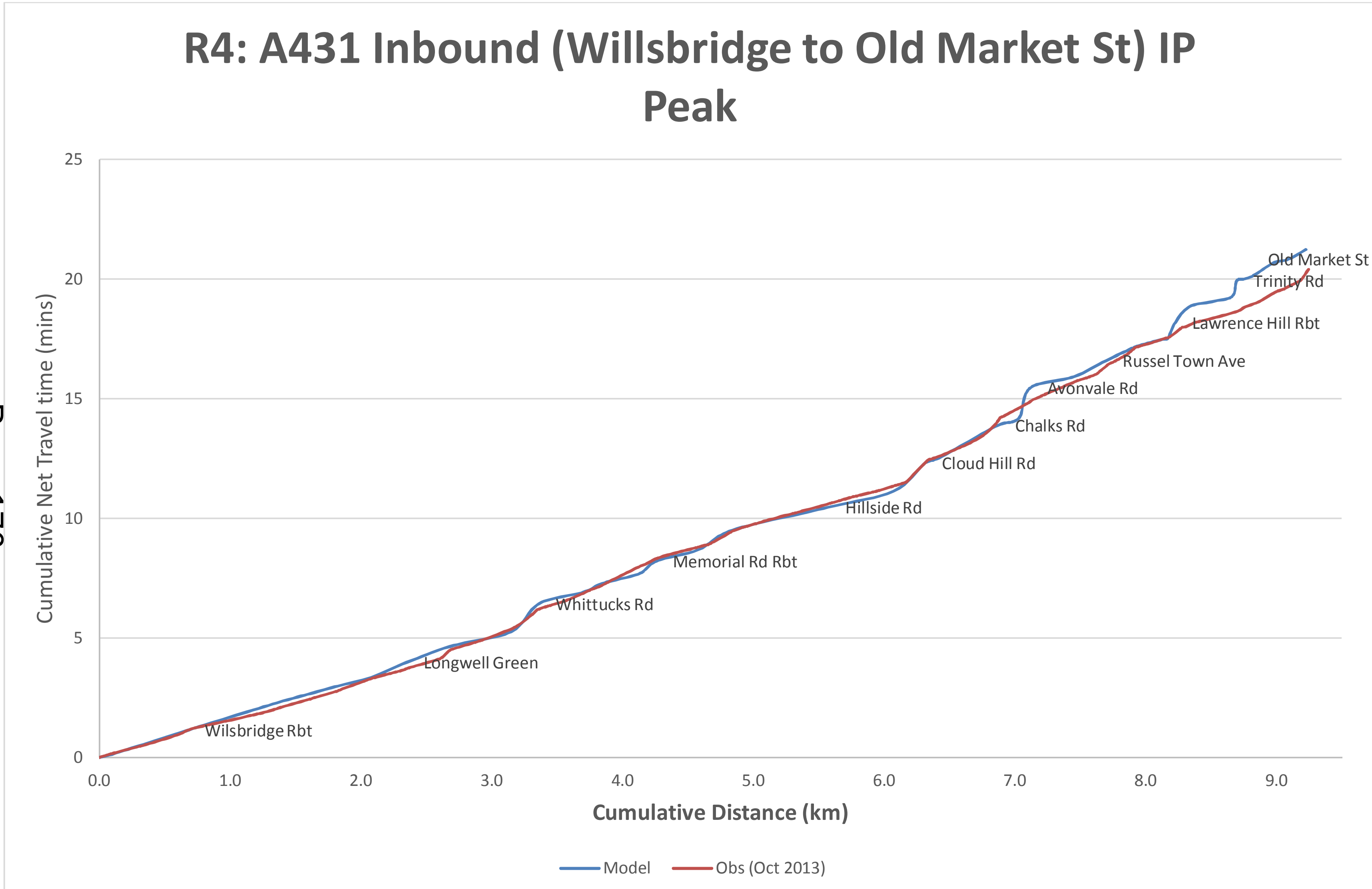


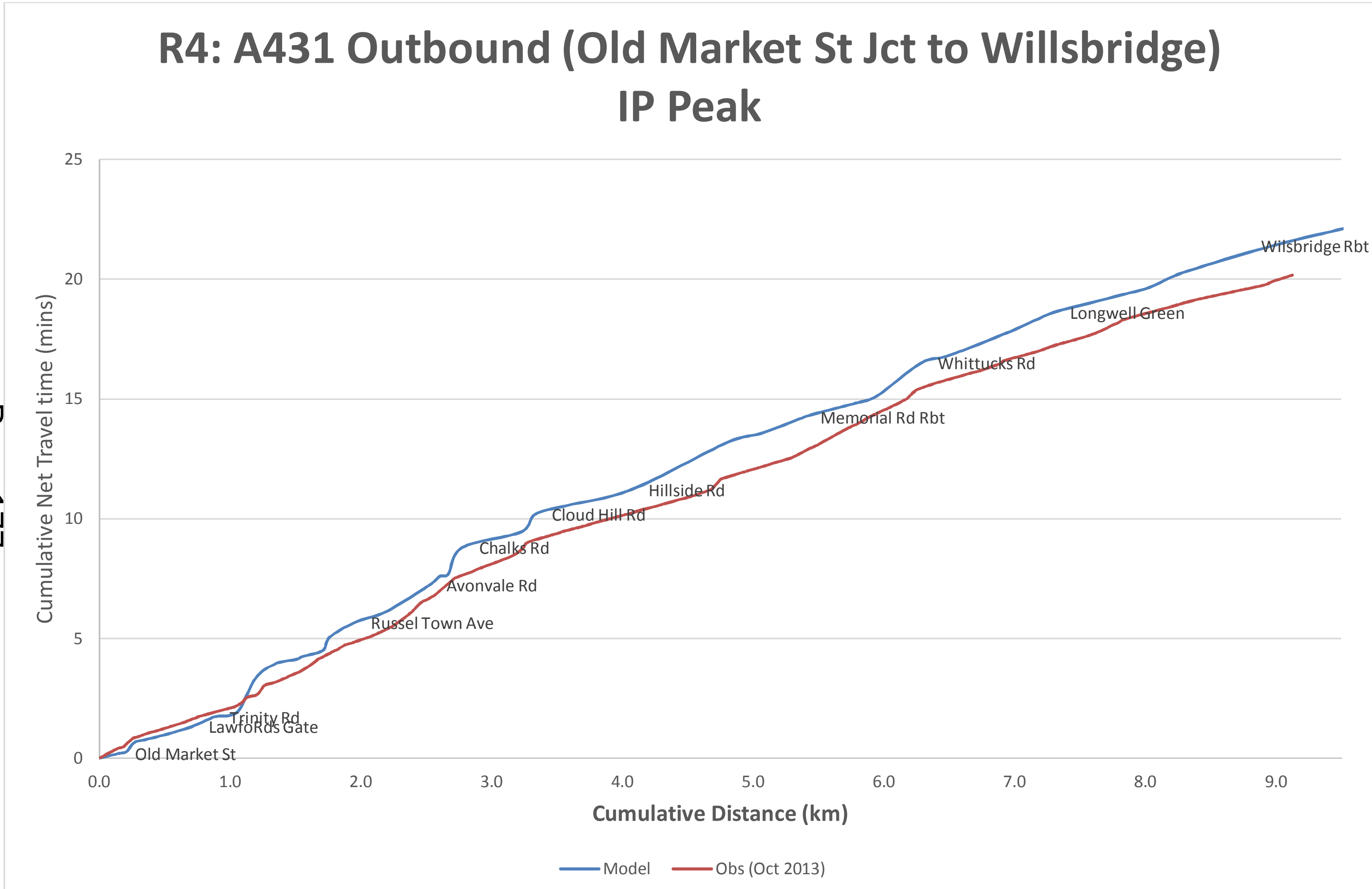
R2: A38 Inbound (Barrow Gurney to Bedminster Bridge) IP Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
2
4
6
8
10
12
14
16
18
20
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Barrow Gurney
Yanley ln
King Head Ln
Lulsgate Rd
Bishopsworth Rd Signals
A38 Bedminster Rd
Parson St Station
West St/Bedminster Down Rd
West St/Sheen Ln
Lidl Jct
East St
Bedminster Bridge Rbt
Model
Obs (Oct 2013)


R2: A38 Outbound (Bedminster Bridge to Barrow Gurney) IP Peak
Cumulative Net Travel time (mins)
16
14
12
10
8
6
4
2
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Cumulative Distance (km)
A38 Bedminster Arcade
East St
Lidl Jct
West St/Sheen Ln
West St/Bedminster Down Rd
A38 Bedminster Rd
Lulsgate Rd
Bishopsworth Rd Signals
King Head Ln
Yanley ln
Model
Obs (Oct 2013)

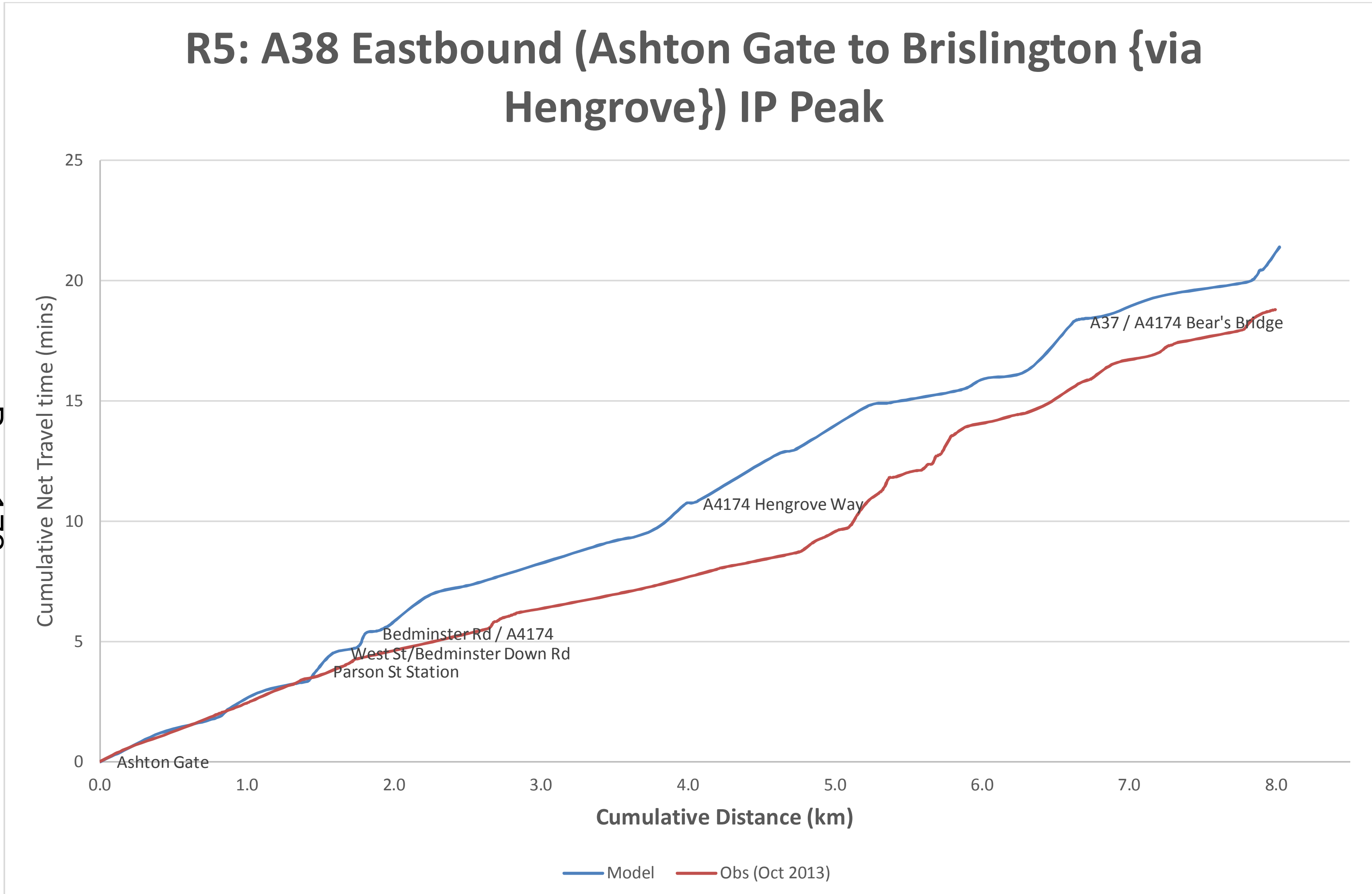

R3: A4 Inbound (Keynesham to Bath Bridge) IP Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
2
4
6
8
10
12
14
16
18
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Keynham Rbt
A4 / A4174 Jct
A4 P&R
Stockwood Rd
Callington Rd Jct
Eagle Rd
A4/A4320
A4/Sandy Park Rd
A4 / A37
A4 Bath Rd
Bath Bridge Rbt
Model
Obs (Oct 2013)

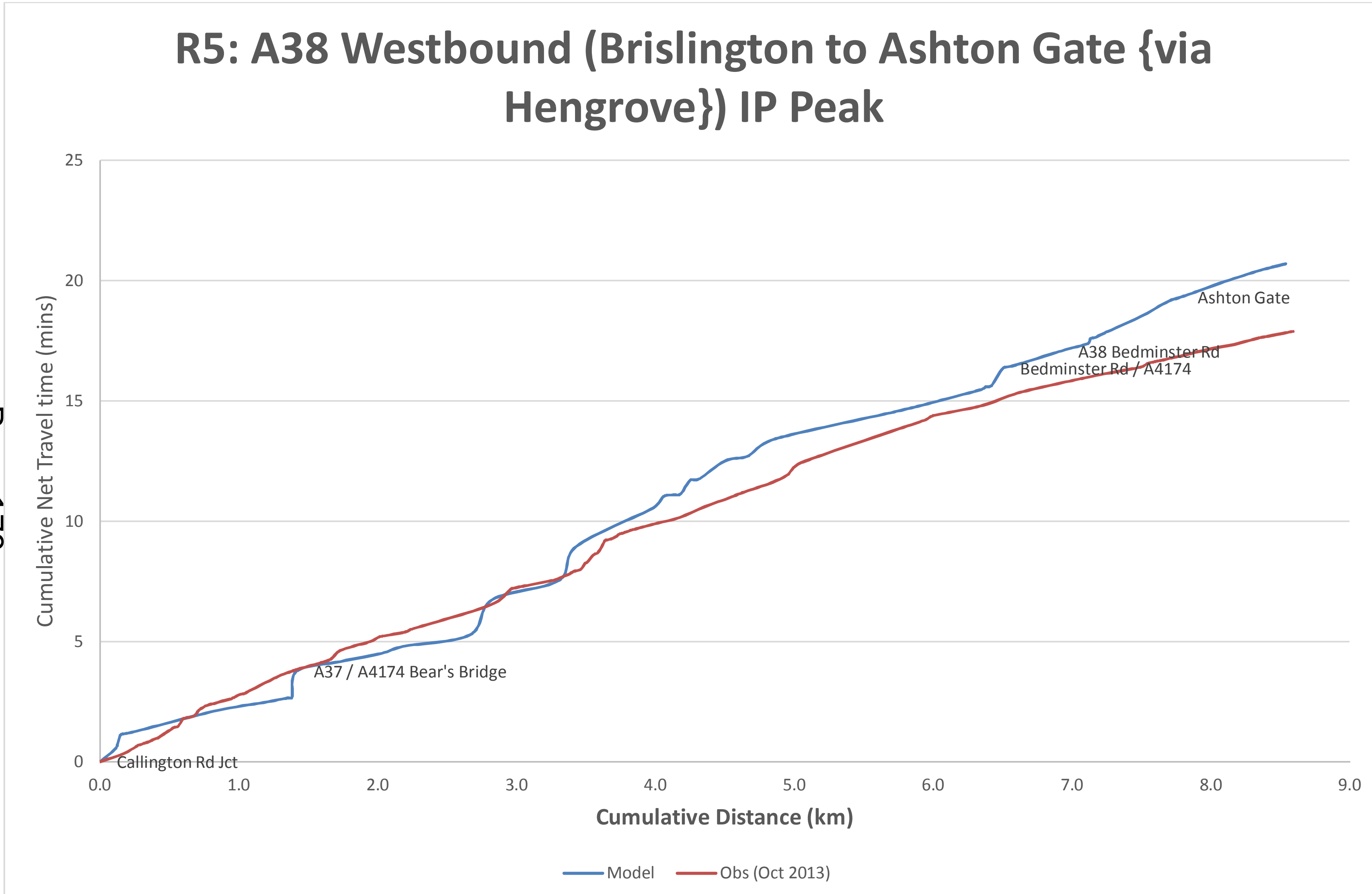

R3: A4 Outbound (Bath Bridge to Keynesham) IP Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
2
4
6
8
10
12
14
16
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Keynham Rbt
Keynesham Bypass Rbt
A4 P&R
Stockwood Rd
Callington Rd Jct
A4/Sandy Park Rd
A4/A4320
A4 / A37
A4 Bath Rd
Model
Obs (Oct 2013)

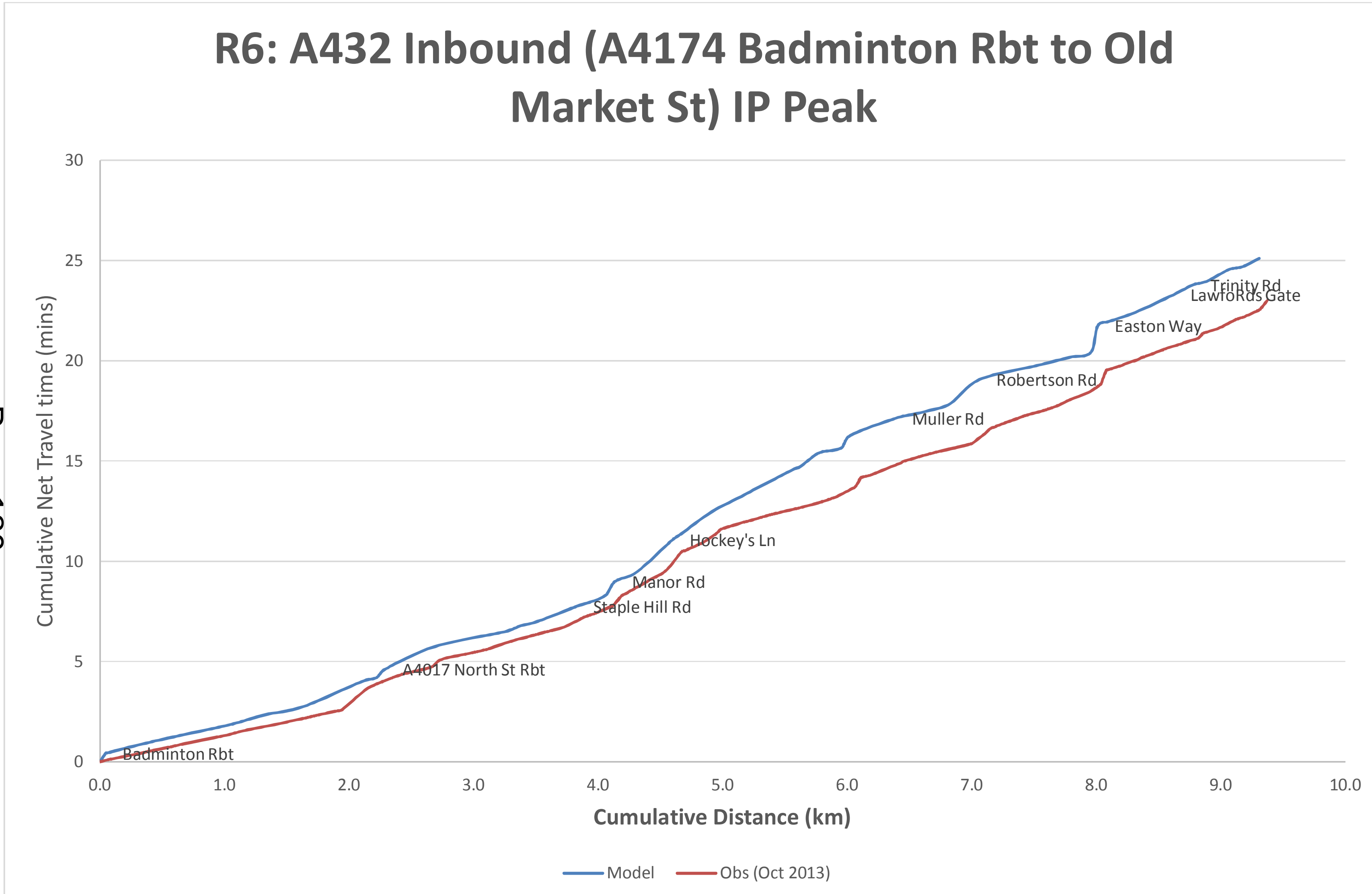

R4: A431 Inbound (Willsbridge to Old Market St) IP Peak
Cumulative Net Travel time (mins)
25
20
15
10
5
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Cumulative Distance (km)
Wilsbridge Rbt
Longwell Green
Whittucks Rd
Memorial Rd Rbt
Hillside Rd
Cloud Hill Rd
Chalks Rd
Avonvale Rd
Russel Town Ave
Lawrence Hill Rbt
Trinity Rd
Old Market St
Model
Obs (Oct 2013)

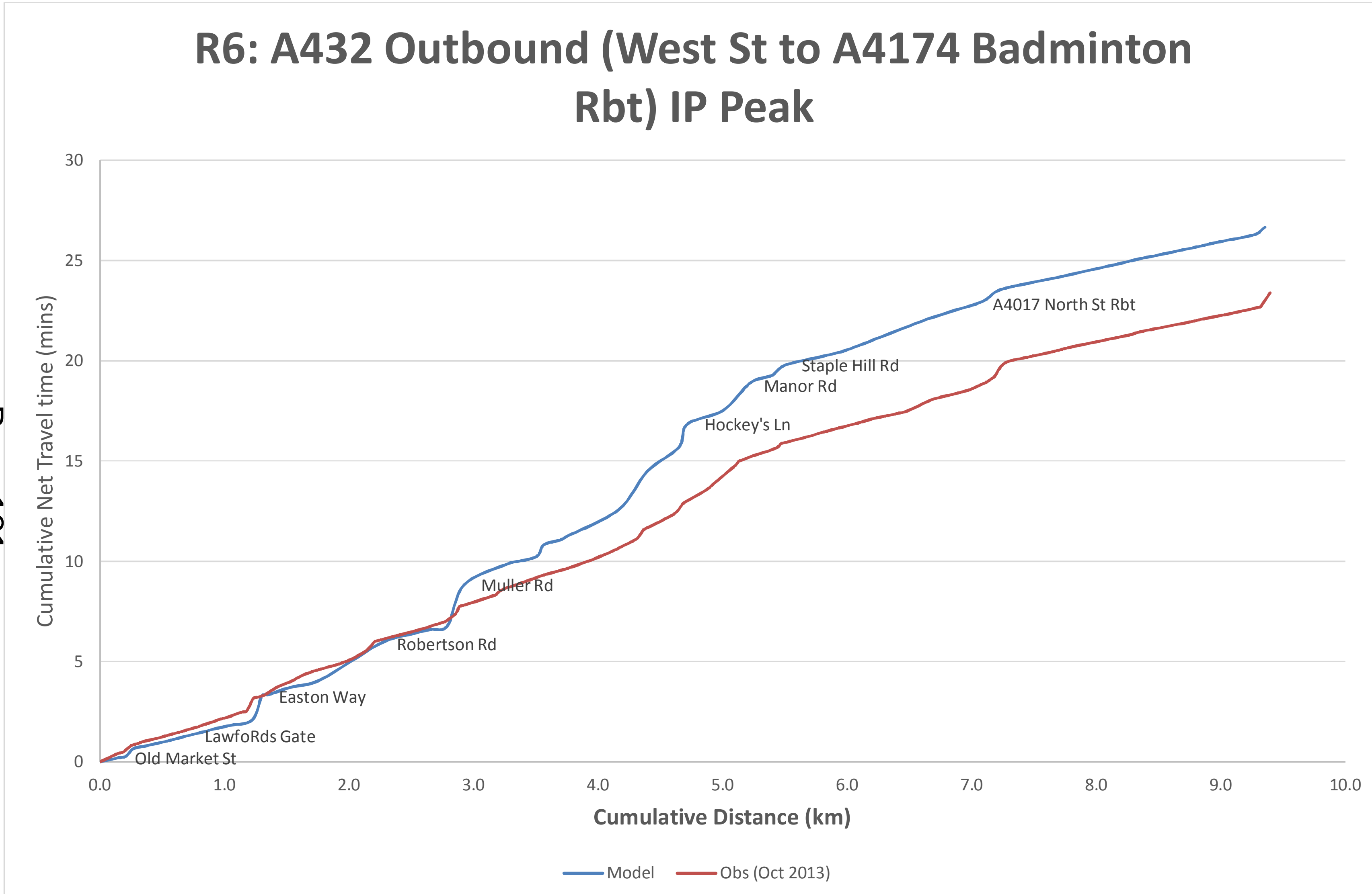


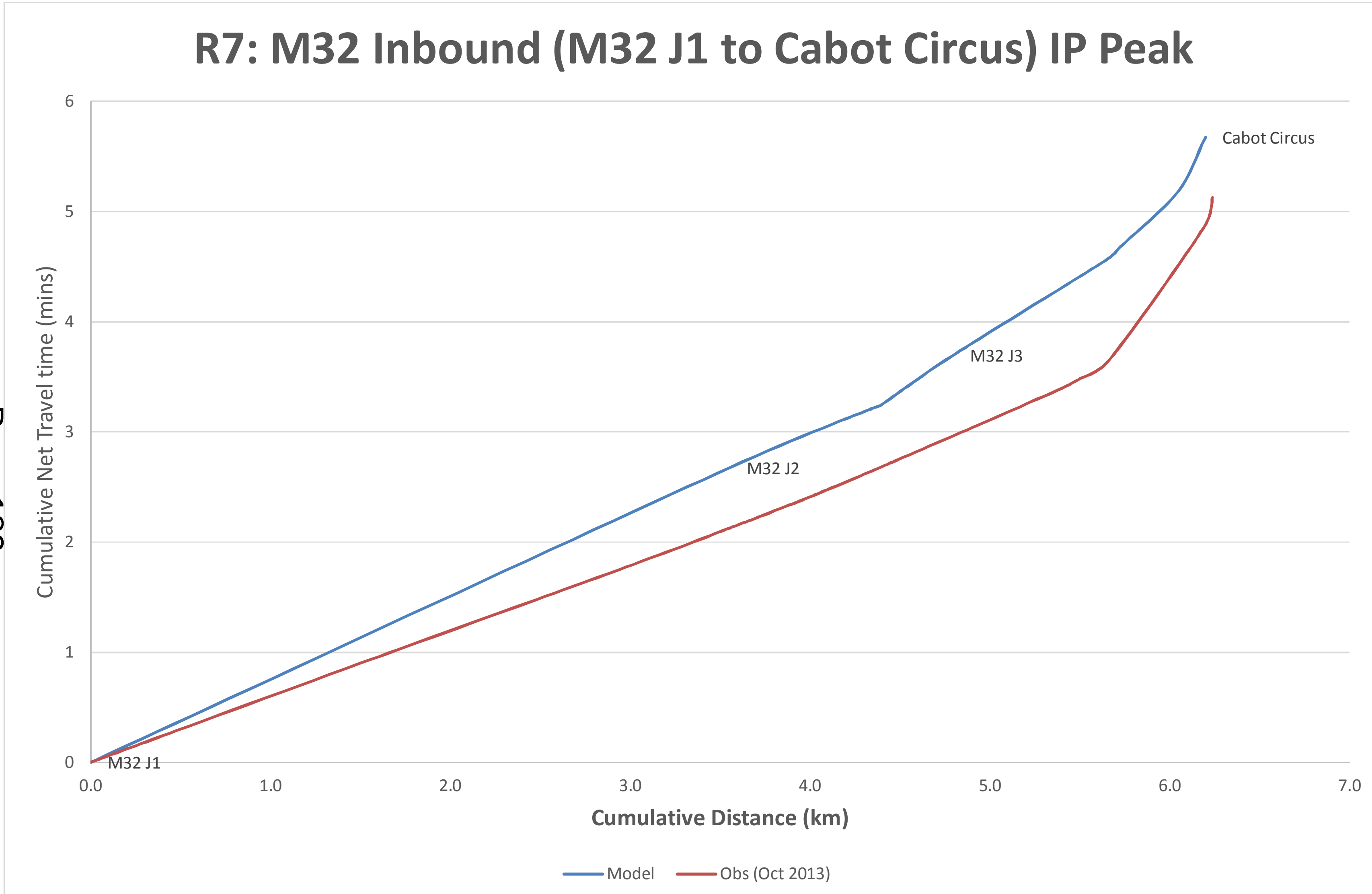
R4: A431 Outbound (Old Market St Jct to Willsbridge)
IP Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Old Market St
LawfoRds Gate
Trinity Rd
Russel Town Ave
Avonvale Rd
Chalks Rd
Cloud Hill Rd
Hillside Rd
Memorial Rd Rbt
Whittucks Rd
Longwell Green
Wilsbridge Rbt
Model
Obs (Oct 2013)

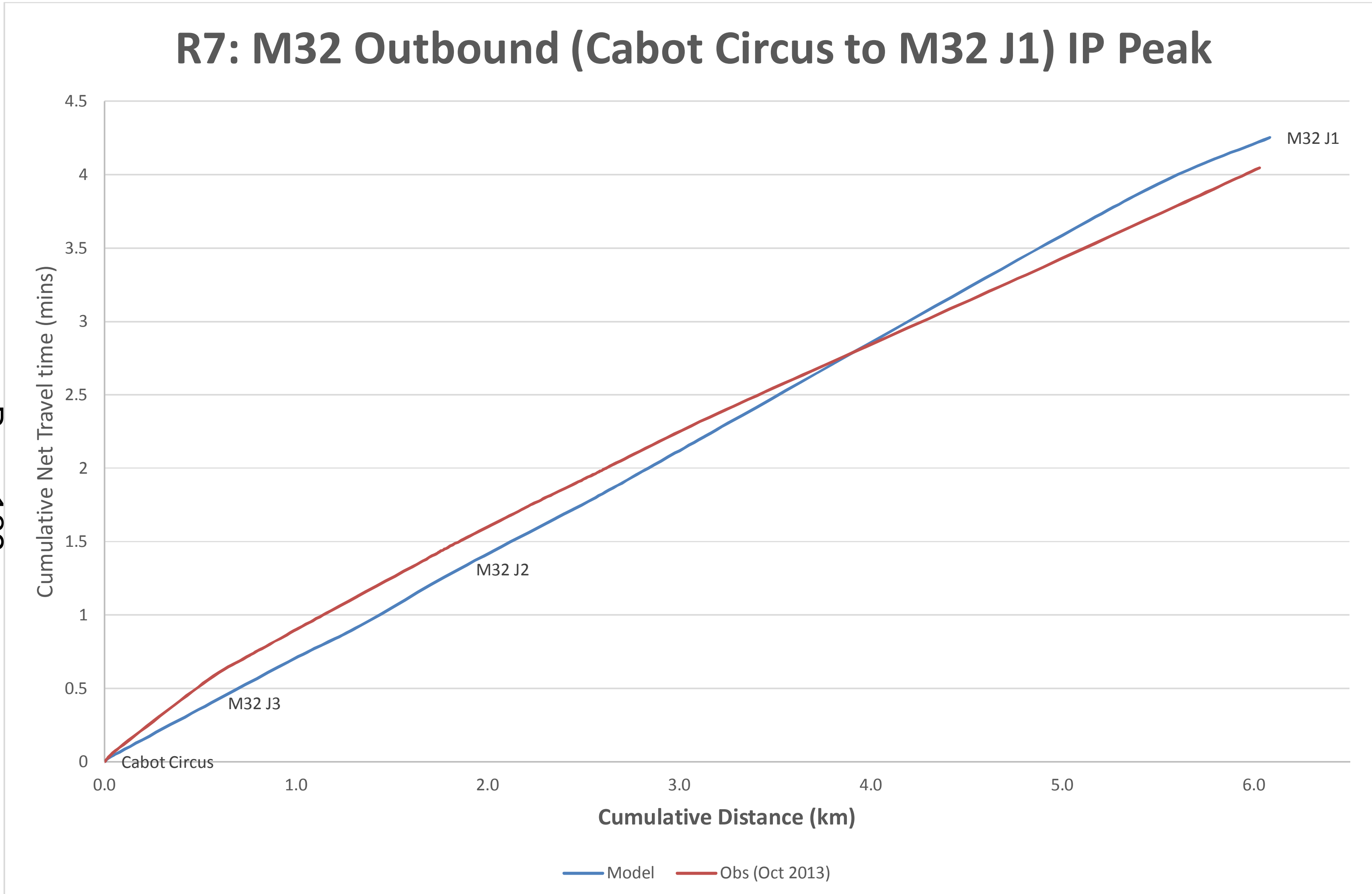

R5: A38 Eastbound (Ashton Gate to Brislington {via Hengrove}) IP Peak
25
20
15
10
5
0
Cumulative Net Travel time (mins)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Cumulative Distance (km)
Ashton Gate
Parson St Station
West St/Bedminster Down Rd
Bedminster Rd / A4174
A4174 Hengrove Way
A37 / A4174 Bear's Bridge
Model
Obs (Oct 2013)

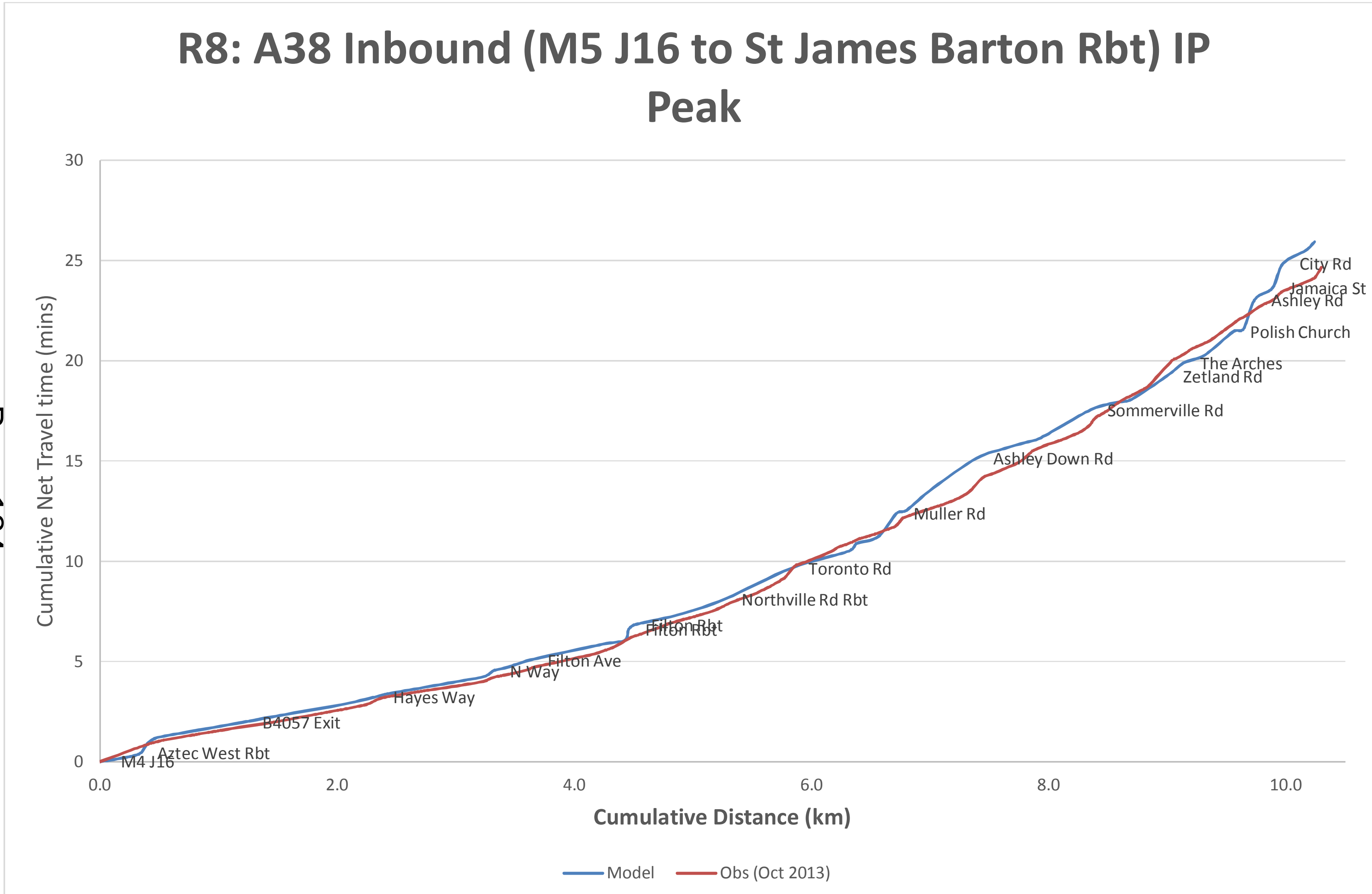

R5: A38 Westbound (Brislington to Ashton Gate {via Hengrove}) IP Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
25
20
15
10
5
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Callington Rd Jct
A37 / A4174 Bear's Bridge
Bedminster Rd / A4174
A38 Bedminster Rd
Ashton Gate
Model
Obs (Oct 2013)

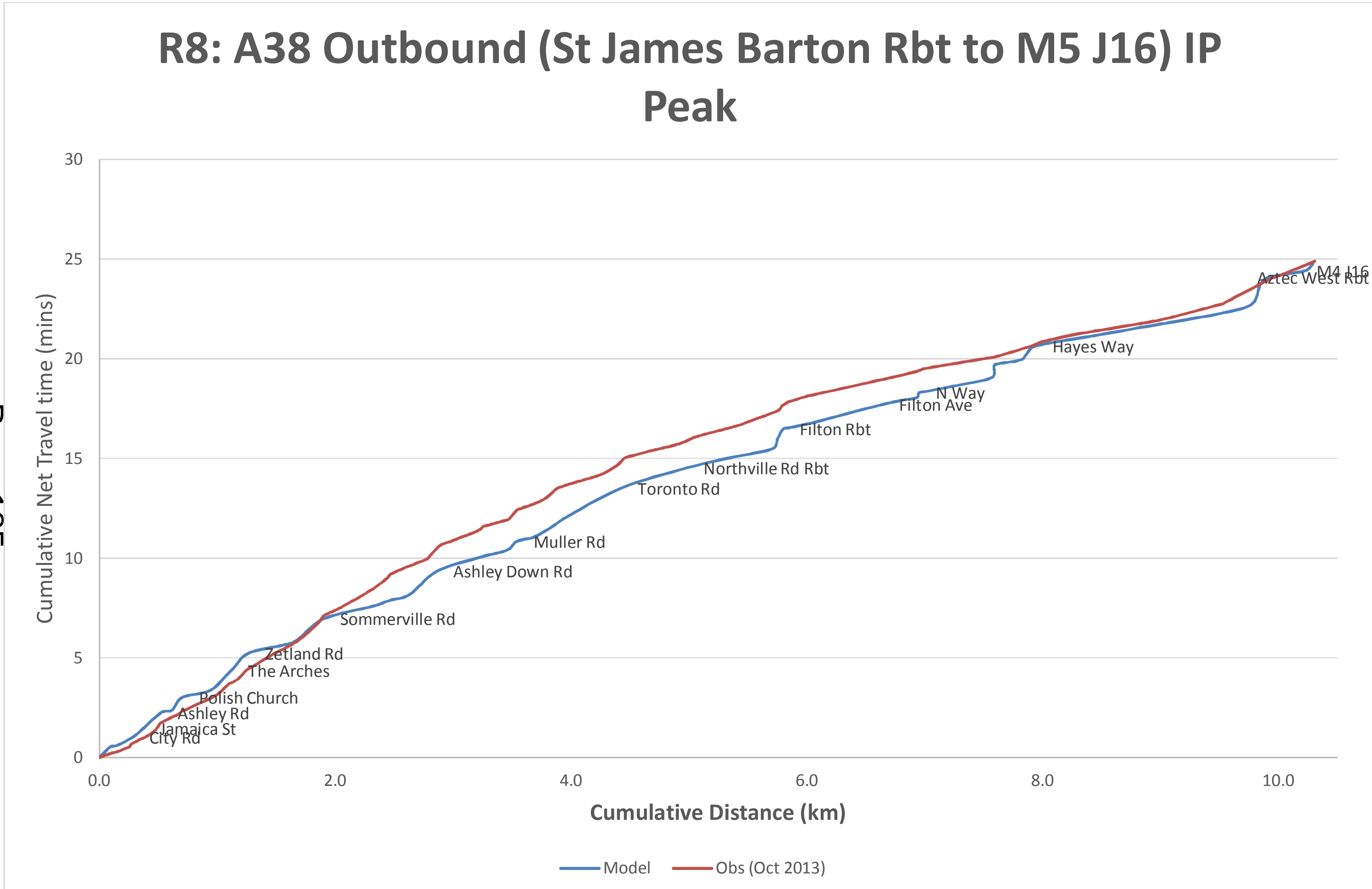

R6: A432 Inbound (A4174 Badminton Rbt to Old Market St) IP Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
Badminton Rbt
A4017 North St Rbt
Staple Hill Rd
Manor Rd
Hockey's Ln
Muller Rd
Robertson Rd
Easton Way
Trinity Rd
Lawfords Gate
Model
Obs (Oct 2013)

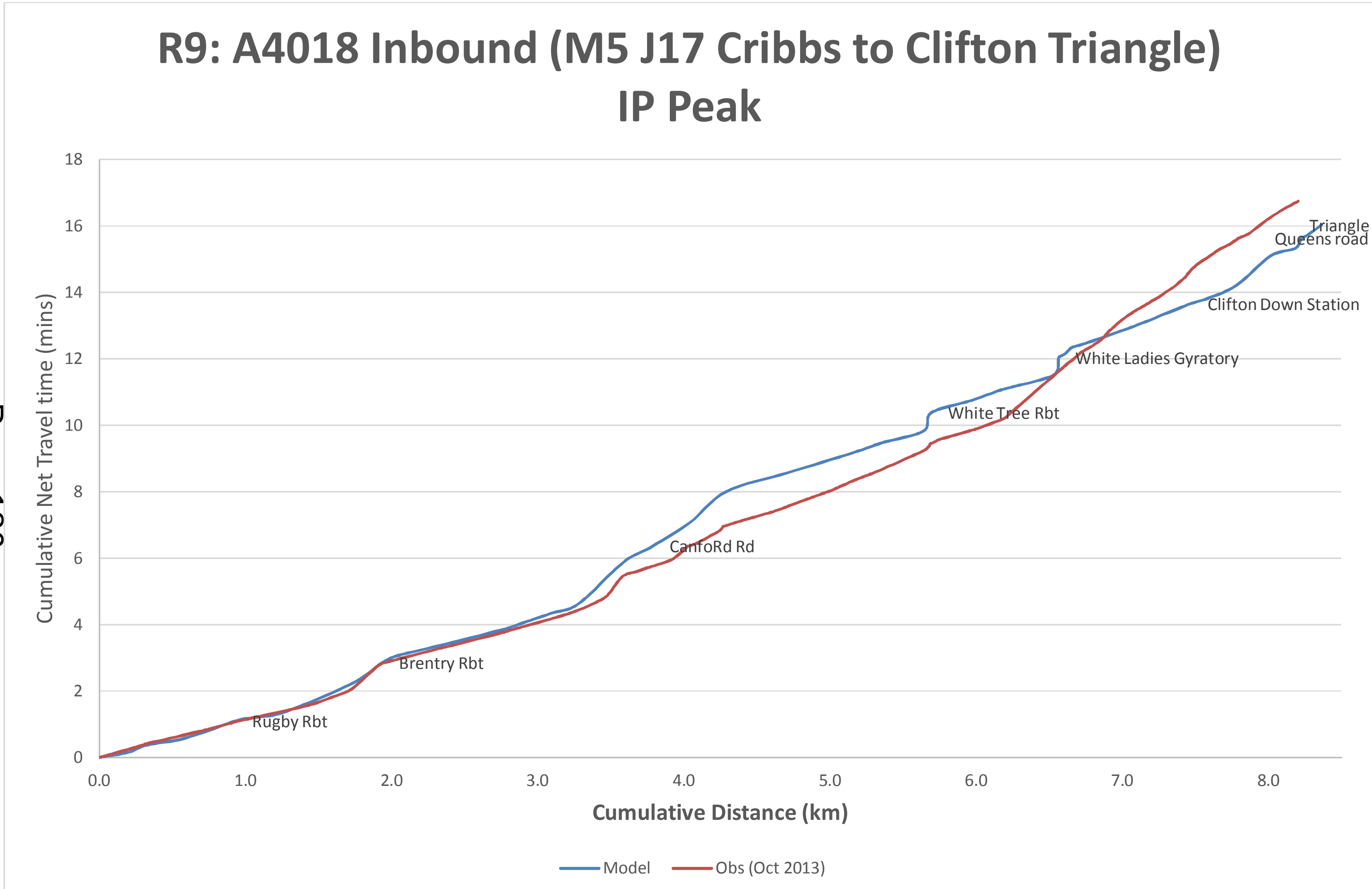

R6: A432 Outbound (West St to A4174 Badminton Rbt) IP Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
30
25
20
15
10
5
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Old Market St
LawfoRds Gate
Easton Way
Robertson Rd
Muller Rd
Hockey's Ln
Manor Rd
Staple Hill Rd
A4017 North St Rbt
Model
Obs (Oct 2013)

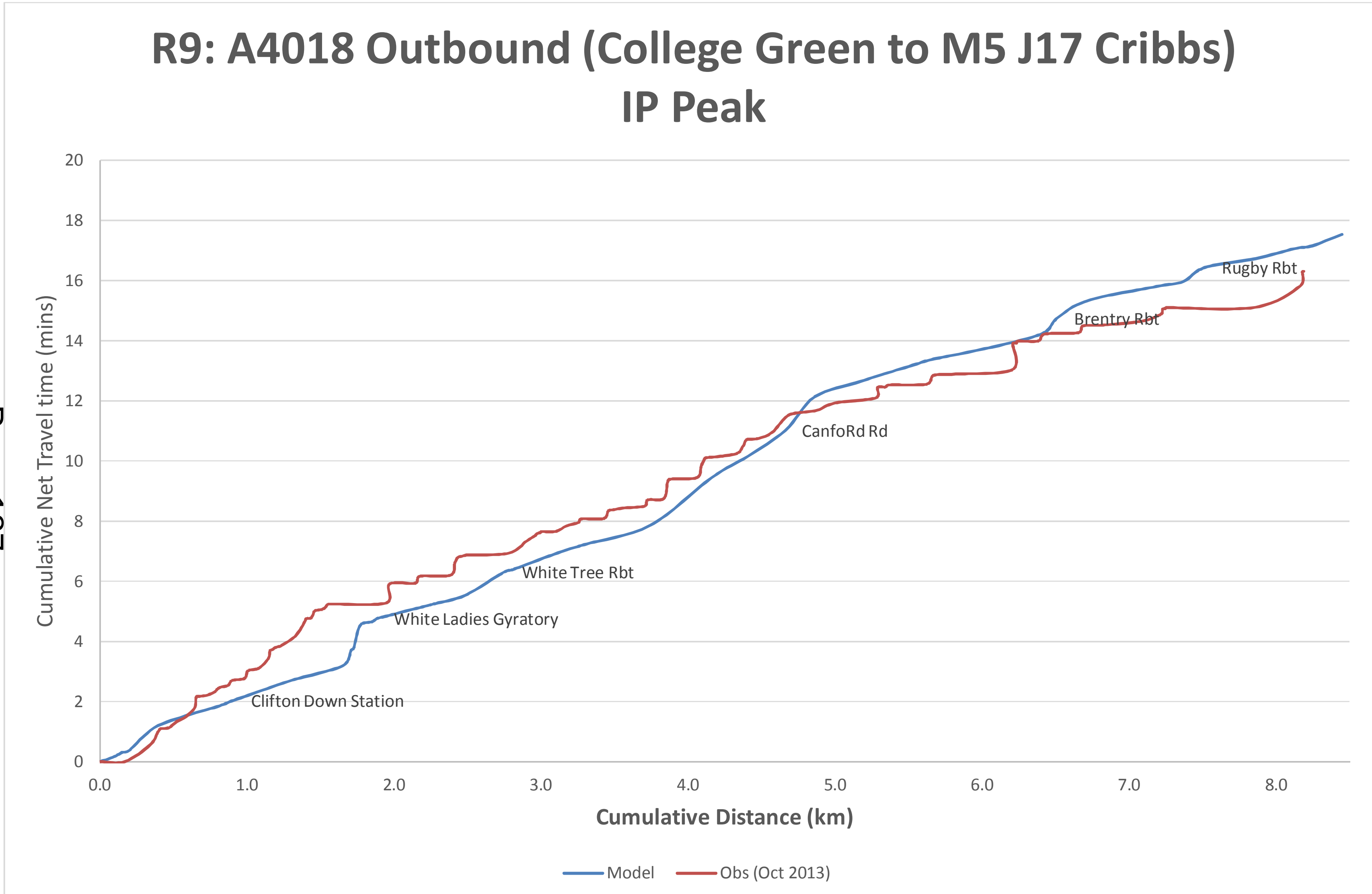

R7: M32 Inbound (M32 J1 to Cabot Circus) IP Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
1
2
3
4
5
6
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
M32 J1
M32 J2
M32 J3
Cabot Circus
Model
Obs (Oct 2013)

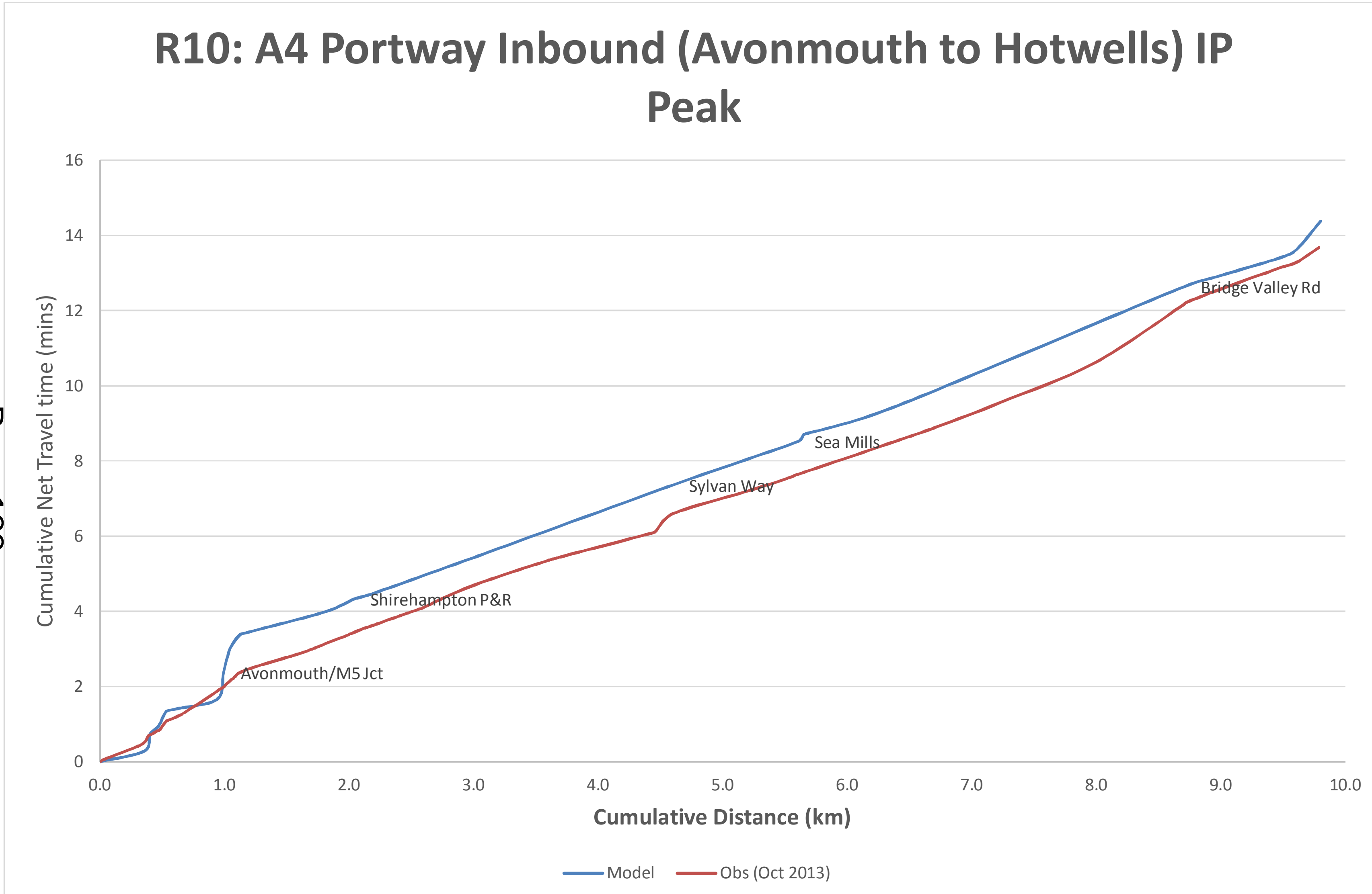

R7: M32 Outbound (Cabot Circus to M32 J1) IP Peak
Cumulative Net Travel time (mins)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
0.0
1.0
2.0
3.0
4.0
5.0
6.0
Cumulative Distance (km)
Cabot Circus
M32 J3
M32 J2
M32 J1
Model
Obs (Oct 2013)


R8: A38 Inbound (M5 J16 to St James Barton Rbt) IP Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
30
0.0
2.0
4.0
6.0
8.0
10.0
M4 J16
Aztec West Rbt
B4057 Exit
Hayes Way
N Way
Filton Ave
Filton Rbt
Filton Rbt
Northville Rd Rbt
Toronto Rd
Muller Rd
Ashley Down Rd
Sommerville Rd
Zetland Rd
The Arches
Polish Church
Ashley Rd
Jamaica St
City Rd
Model
Obs (Oct 2013)

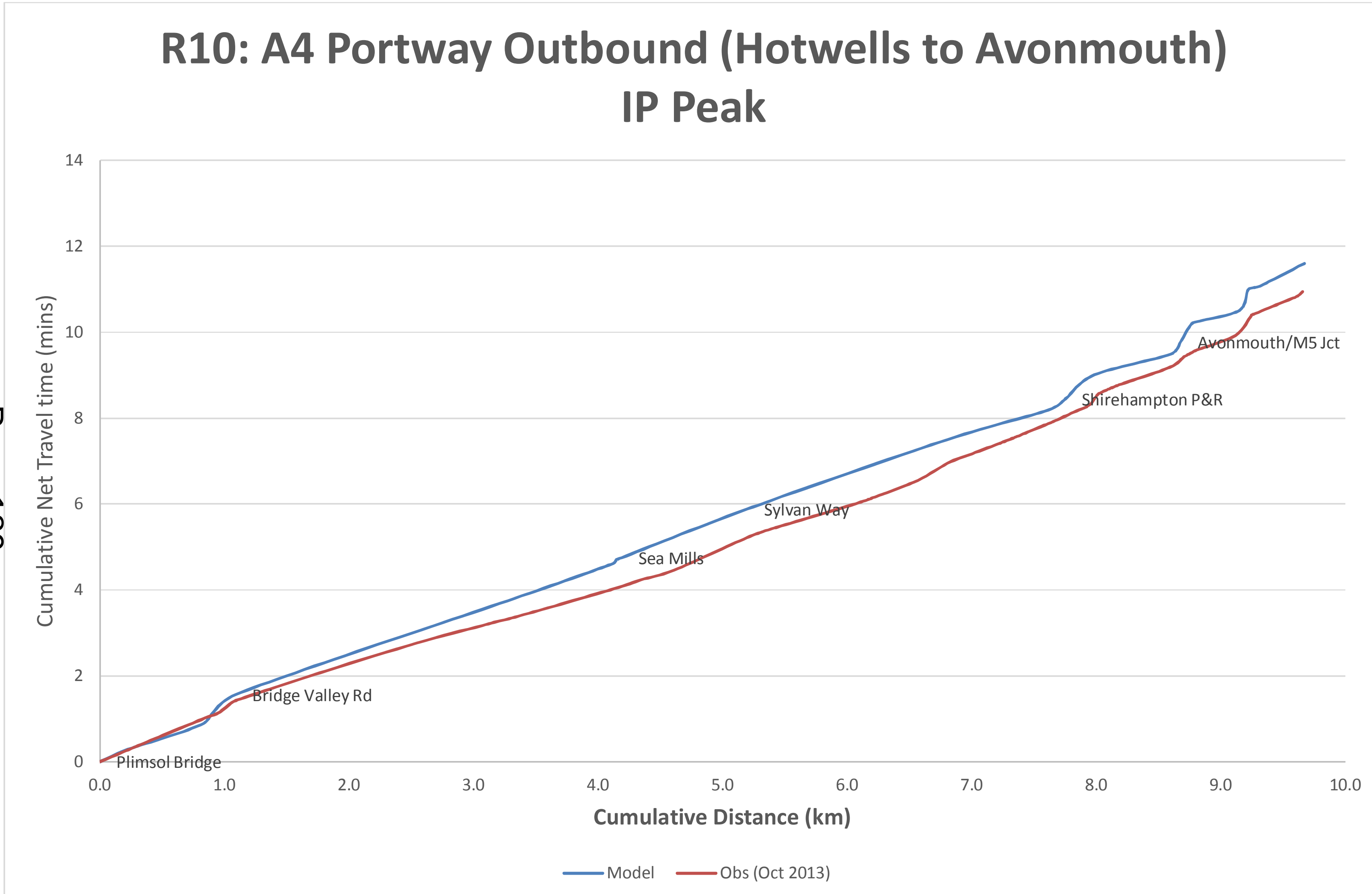

R8: A38 Outbound (St James Barton Rbt to M5 J16) IP Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
30
0.0
2.0
4.0
6.0
8.0
10.0
City Rd
Jamaica St
Ashley Rd
Polish Church
The Arches
Zetland Rd
Sommerville Rd
Ashley Down Rd
Muller Rd
Toronto Rd
Northville Rd Rbt
Filton Rbt
Filton Ave
N Way
Hayes Way
Aztec West Rbt
M4 J16
Model
Obs (Oct 2013)


R9: A4018 Inbound (M5 J17 Cribbs to Clifton Triangle)
IP Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
2
4
6
8
10
12
14
16
18
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Rugby Rbt
Brentry Rbt
CanfoRd Rd
White Tree Rbt
White Ladies Gyratory
Clifton Down Station
Queens road
Triangle
Model
Obs (Oct 2013)

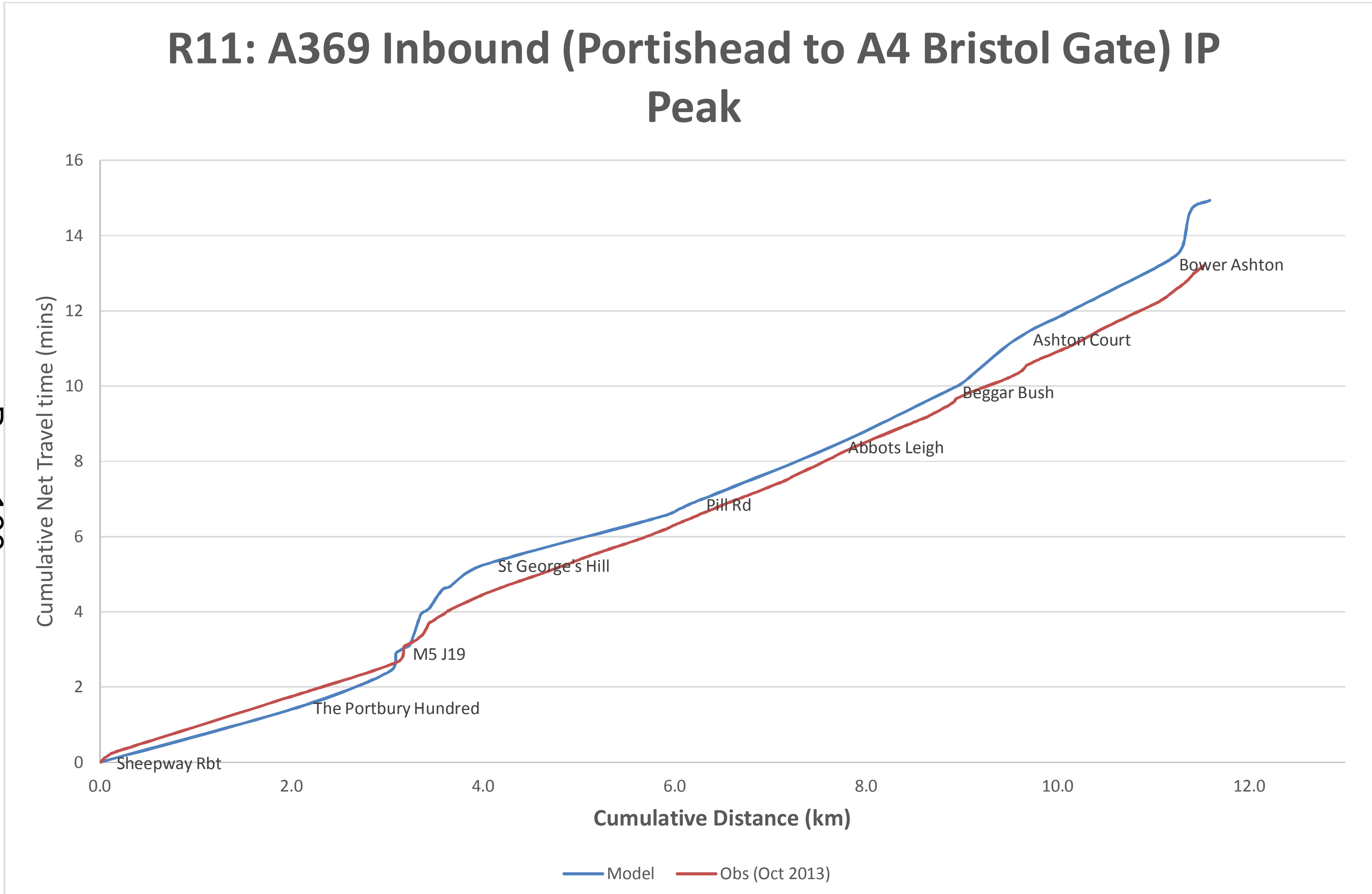

R9: A4018 Outbound (College Green to M5 J17 Cribbs)
IP Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
Clifton Down Station
White Ladies Gyratory
White Tree Rbt
CanfoRd Rd
Brentry Rbt
Rugby Rbt
Model
Obs (Oct 2013)
0
2
4
6
8
10
12
14
16
18
20
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0

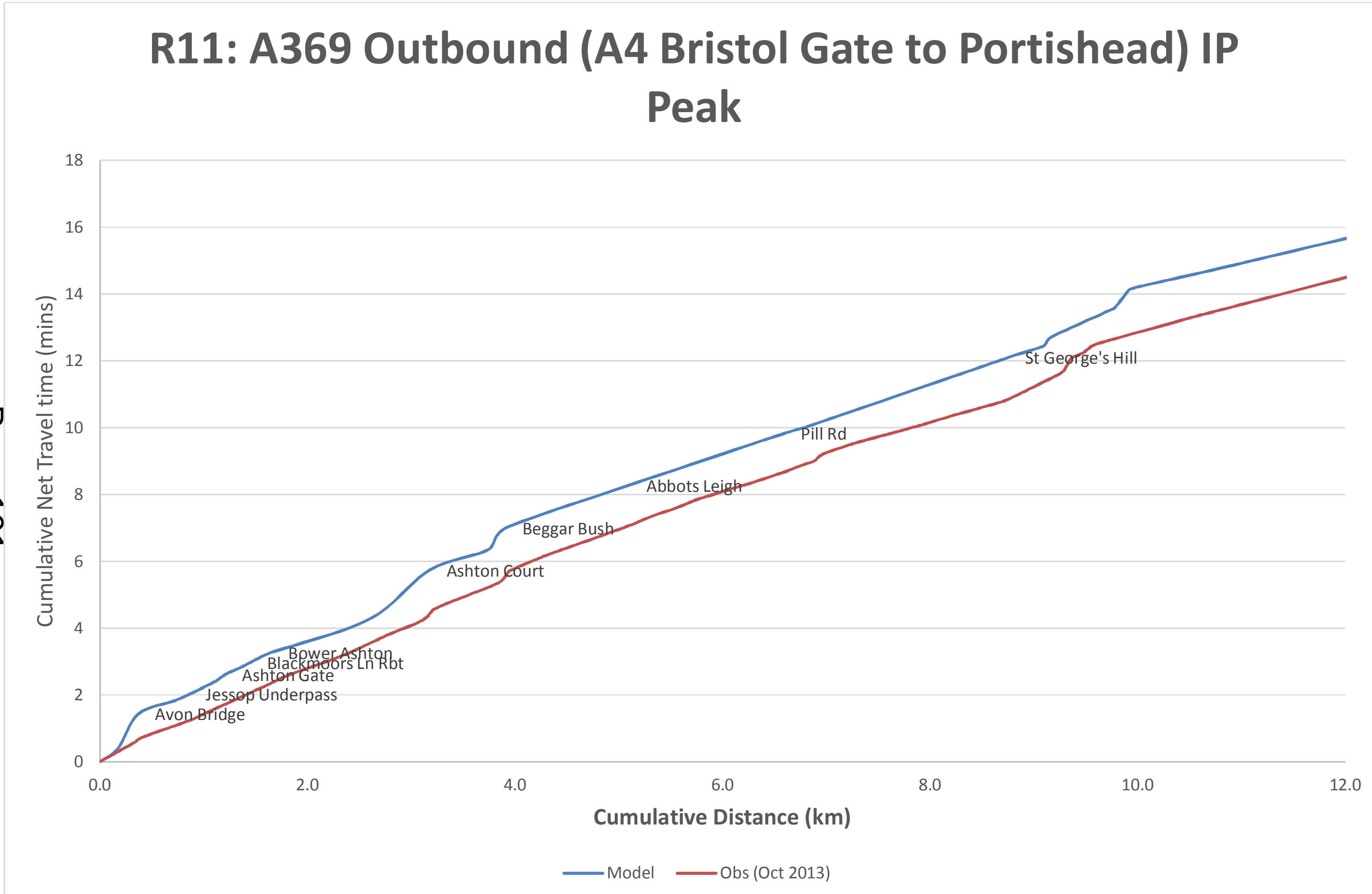


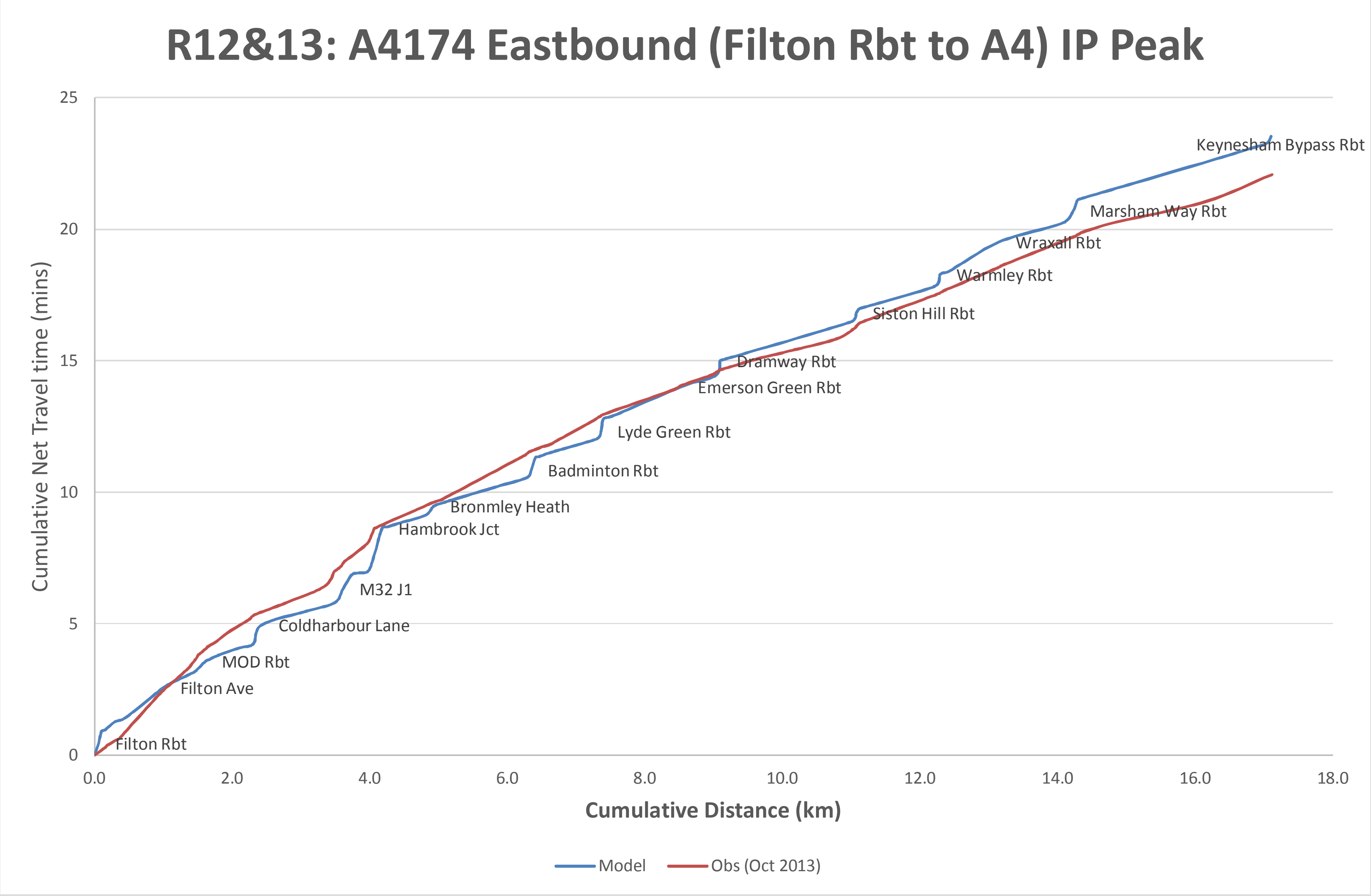
R10: A4 Portway Inbound (Avonmouth to Hotwells) IP Peak
Cumulative Net Travel time (mins)
16
14
12
10
8
6
4
2
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Cumulative Distance (km)
Avonmouth/M5 Jct
Shirehampton P&R
Sylvan Way
Sea Mills
Bridge Valley Rd
Model
Obs (Oct 2013)



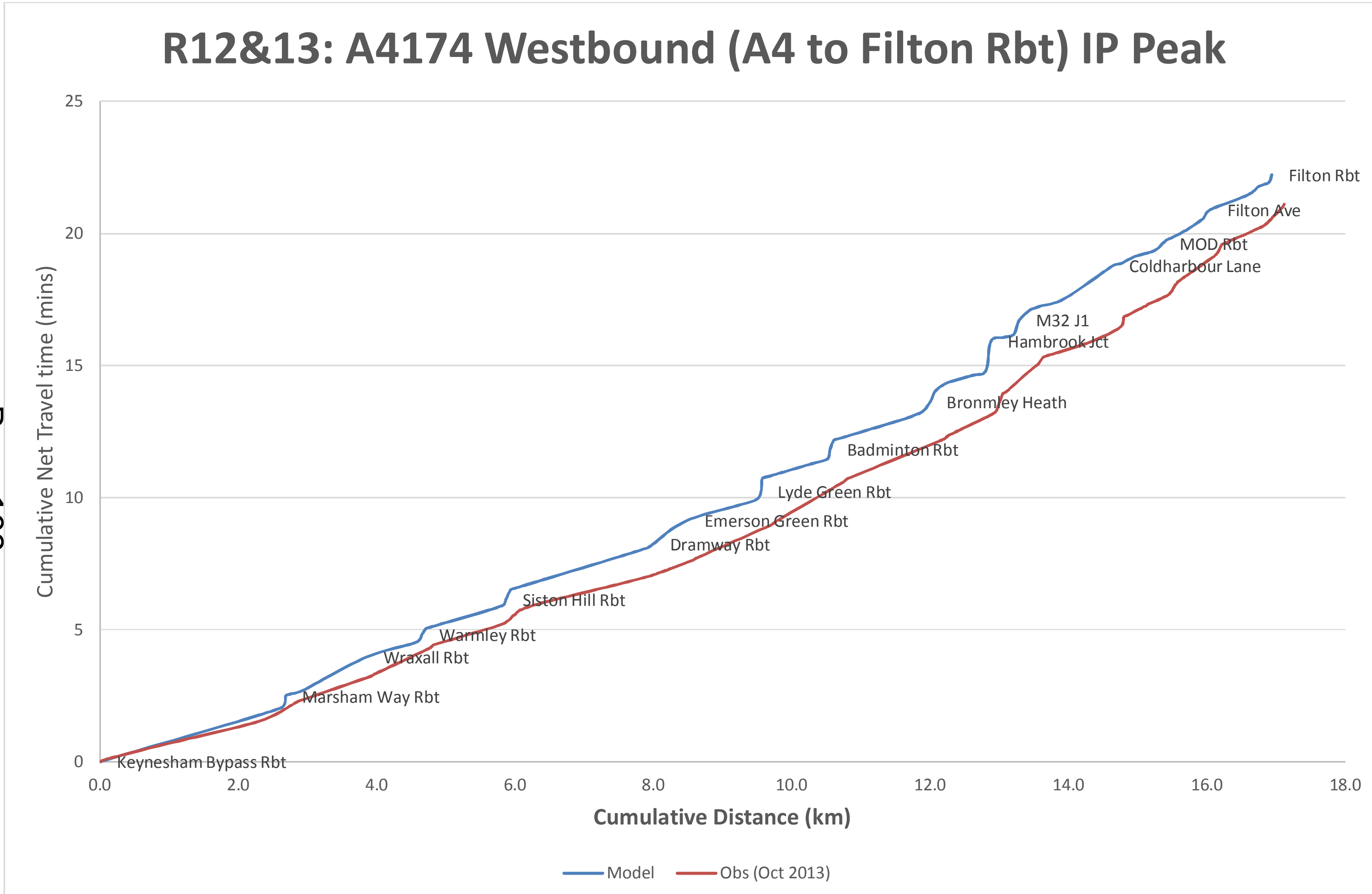
R10: A4 Portway Outbound (Hotwells to Avonmouth)
IP Peak
Cumulative Net Travel time (mins)
14
12
10
8
6
4
2
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Cumulative Distance (km)
Plimsol Bridge
Bridge Valley Rd
Sea Mills
Sylvan Way
Shirehampton P&R
Avonmouth/M5 Jct
Model
Obs (Oct 2013)

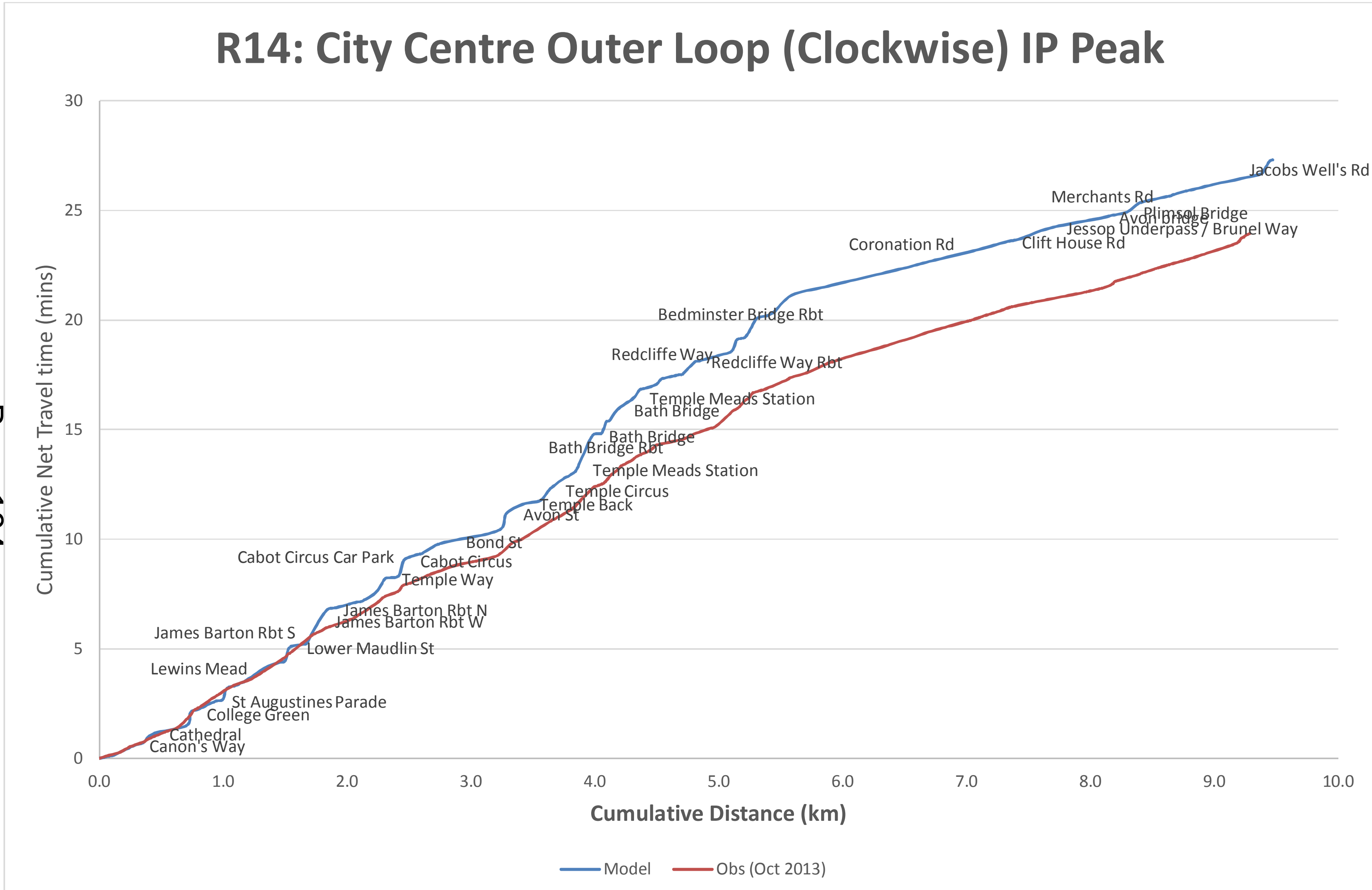

R11: A369 Inbound (Portishead to A4 Bristol Gate) IP Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
2
4
6
8
10
12
14
16
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Sheepway Rbt
The Portbury Hundred
M5 J19
St George's Hill
Pill Rd
Abbots Leigh
Beggar Bush
Ashton Court
Bower Ashton
Model
Obs (Oct 2013)

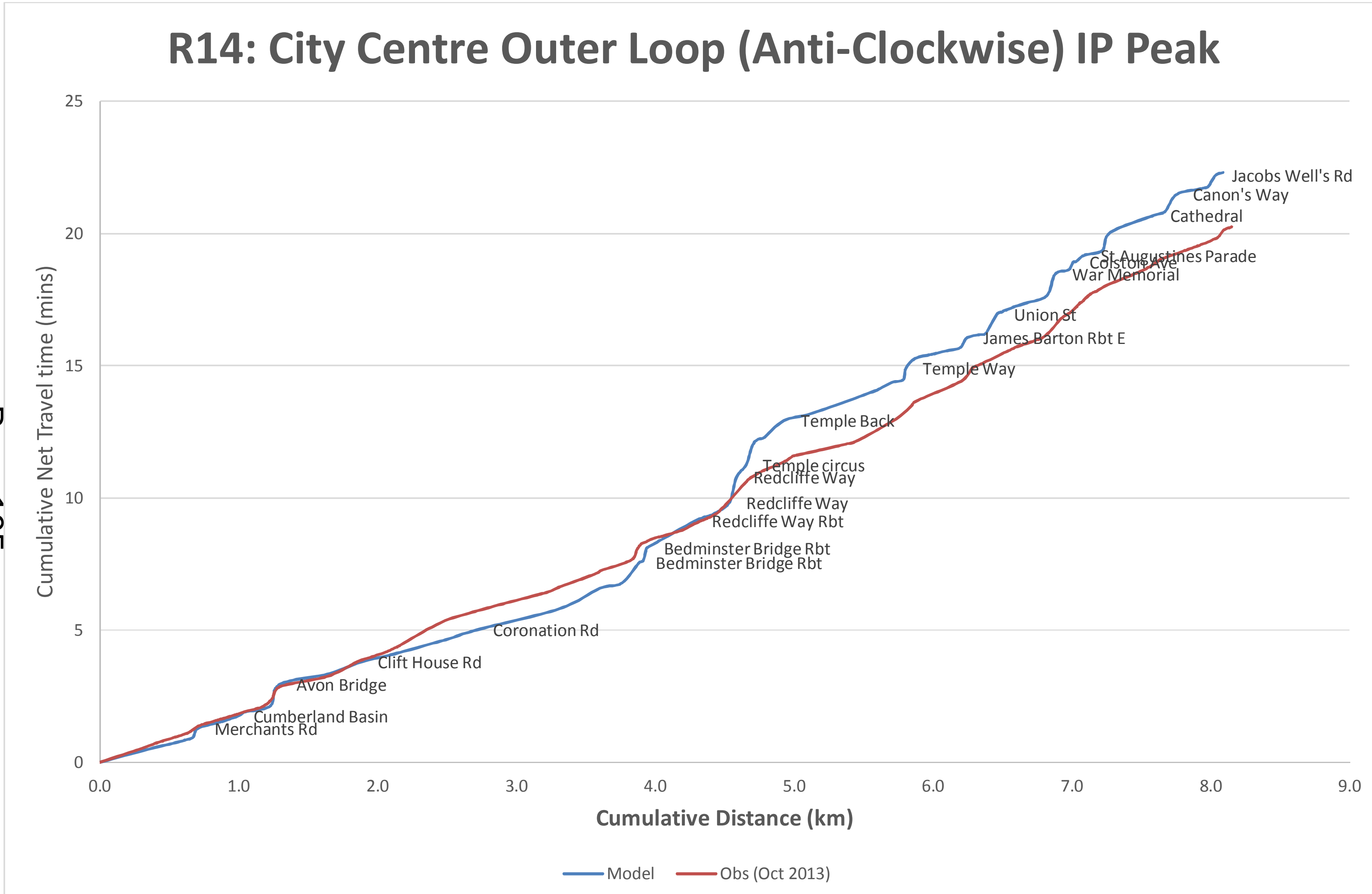

R11: A369 Outbound (A4 Bristol Gate to Portishead) IP Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
2
4
6
8
10
12
14
16
18
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Avon Bridge
Jessop Underpass
Ashton Gate
Blackmoors Ln Rbt
Bower Ashton
Ashton Court
Beggar Bush
Abbots Leigh
Pill Rd
St George's Hill
Model
Obs (Oct 2013)

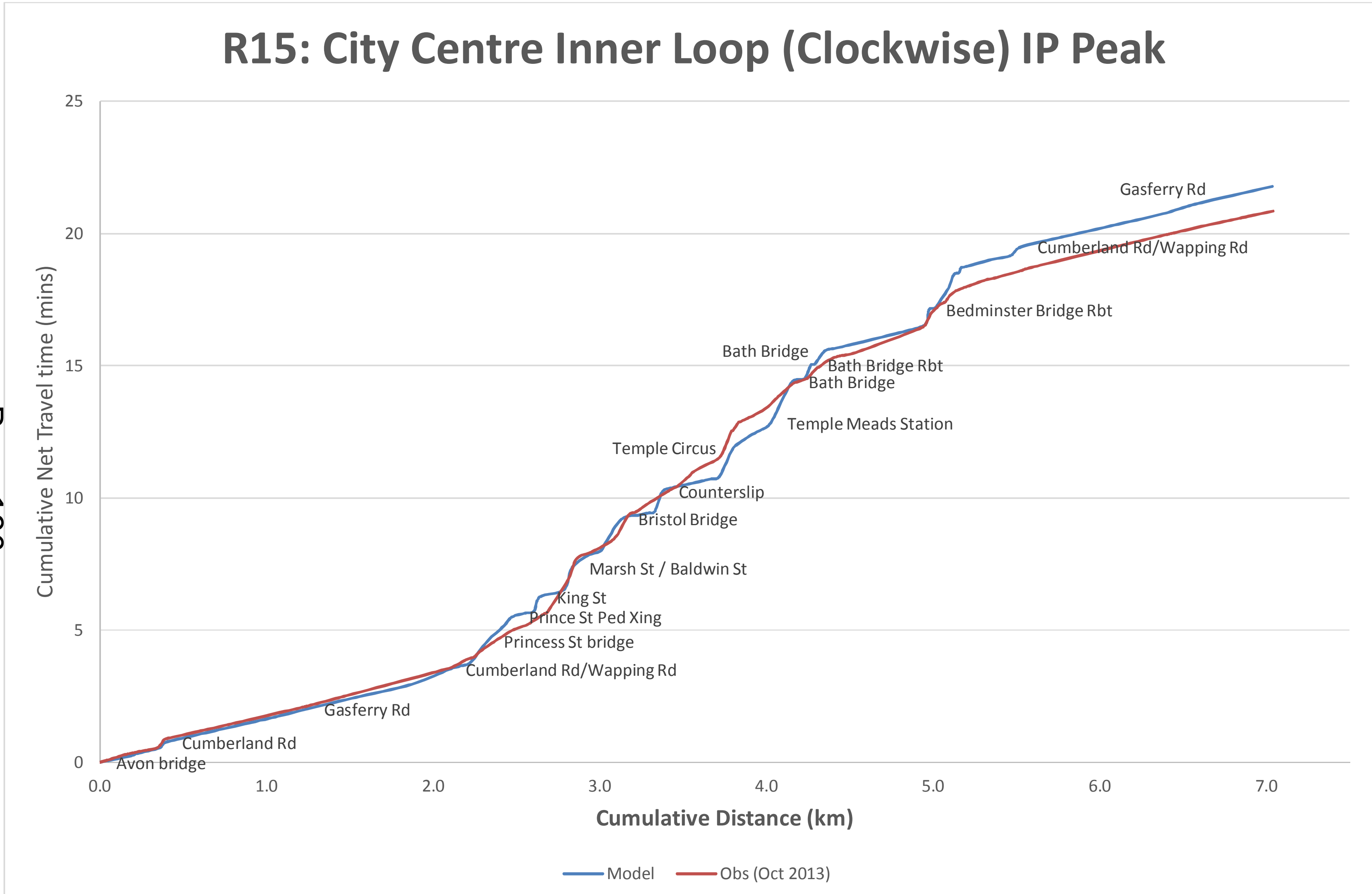


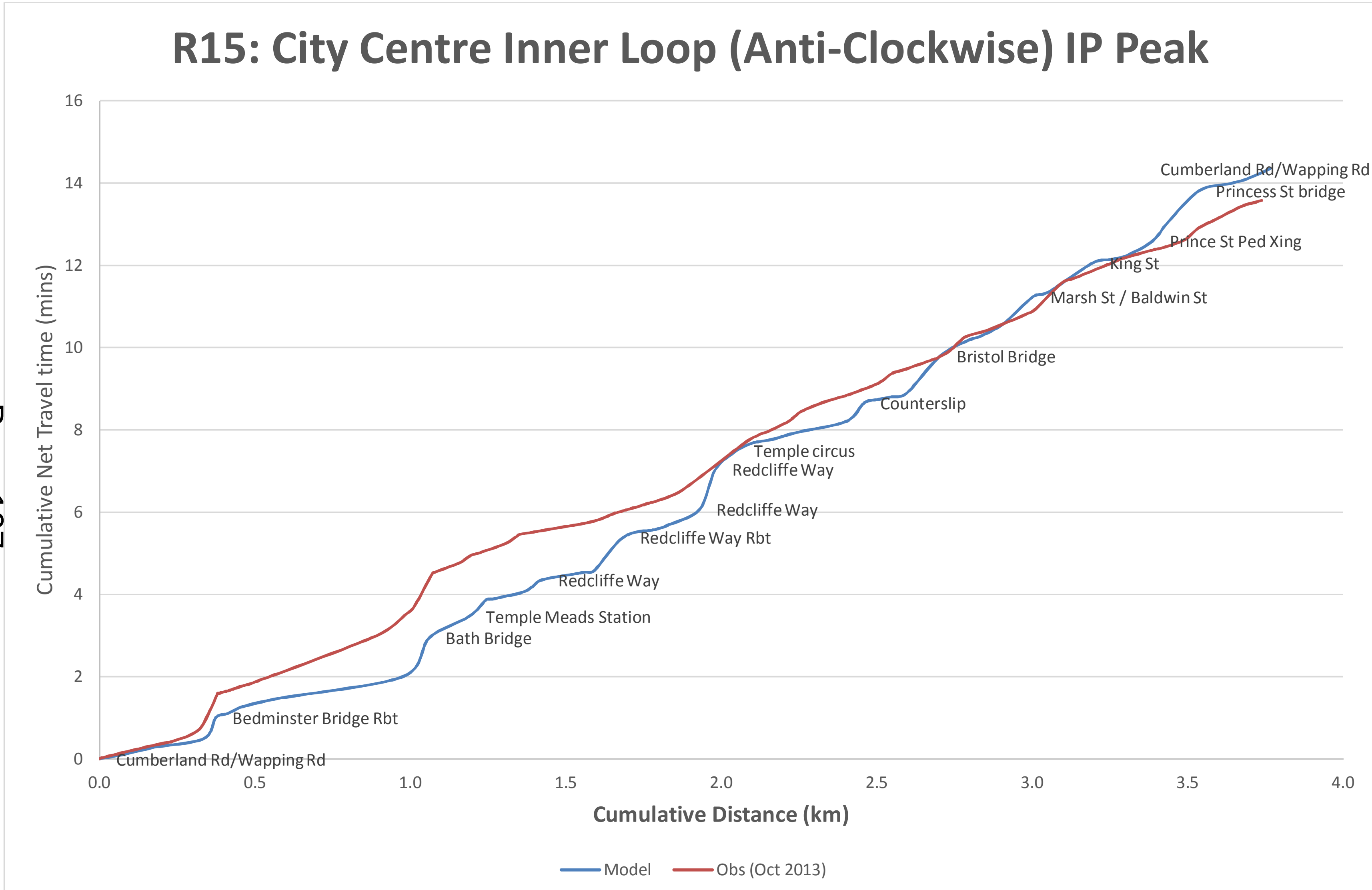
R12&13: A4174 Eastbound (Filton Rbt to A4) IP Peak
Cumulative Net Travel time (mins)
25
20
15
10
5
0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
Cumulative Distance (km)
Keynesham Bypass Rbt
Marsham Way Rbt
Wraxall Rbt
Warmley Rbt
Siston Hill Rbt
Dramway Rbt
Emerson Green Rbt
Lyde Green Rbt
Badminton Rbt
Bronmley Heath
Hambrook Jct
M32 J1
Coldharbour Lane
MOD Rbt
Filton Ave
Filton Rbt
Model
Obs (Oct 2013)

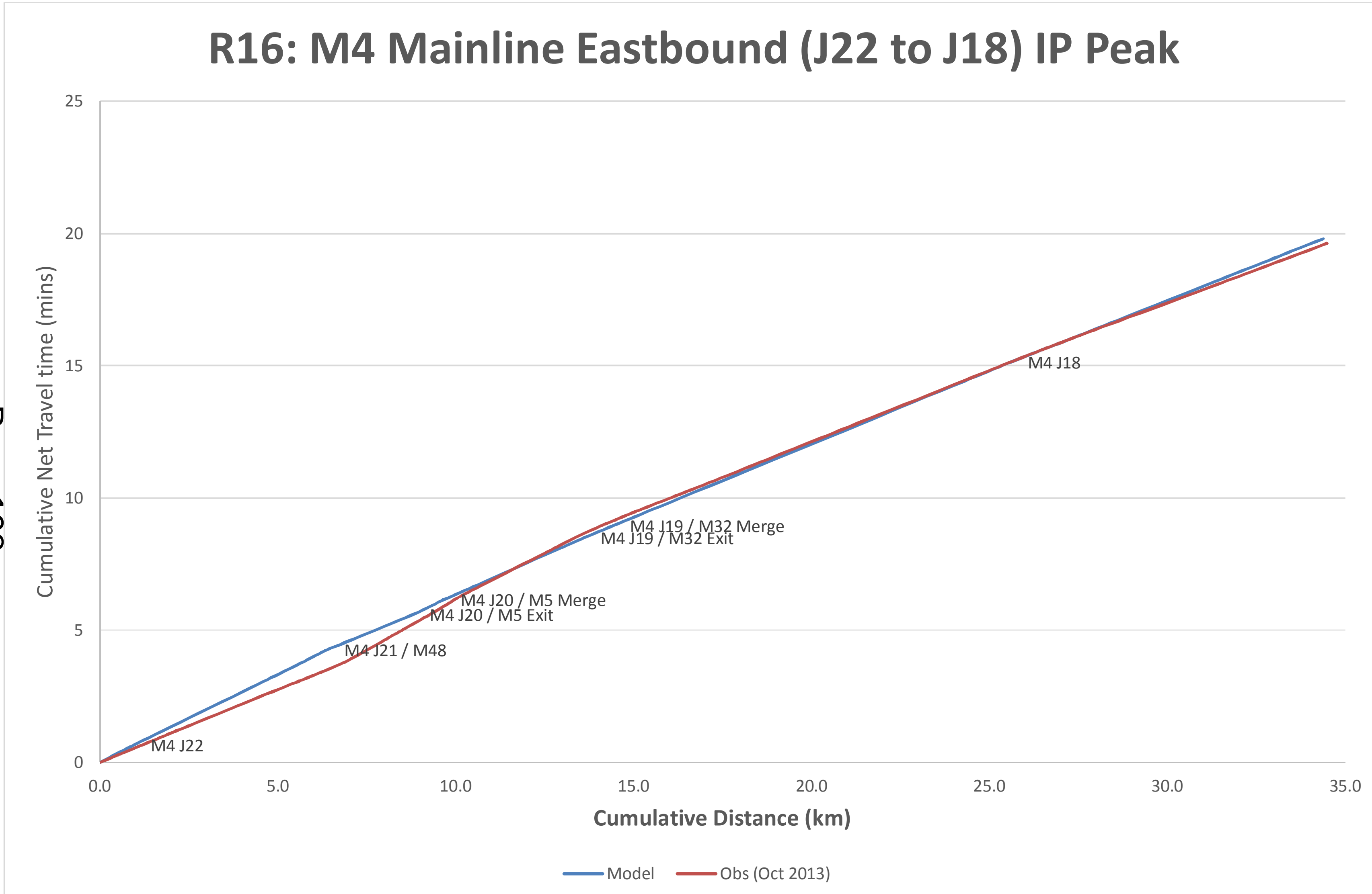

R12&13: A4174 Westbound (A4 to Filton Rbt) IP Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
Keynesham Bypass Rbt
Marsham Way Rbt
Wraxall Rbt
Warmley Rbt
Siston Hill Rbt
Dramway Rbt
Emerson Green Rbt
Lyde Green Rbt
Badminton Rbt
Bronmley Heath
Hambrook Jct
M32 J1
Coldharbour Lane
MOD Rbt
Filton Ave
Filton Rbt
Model
Obs (Oct 2013)

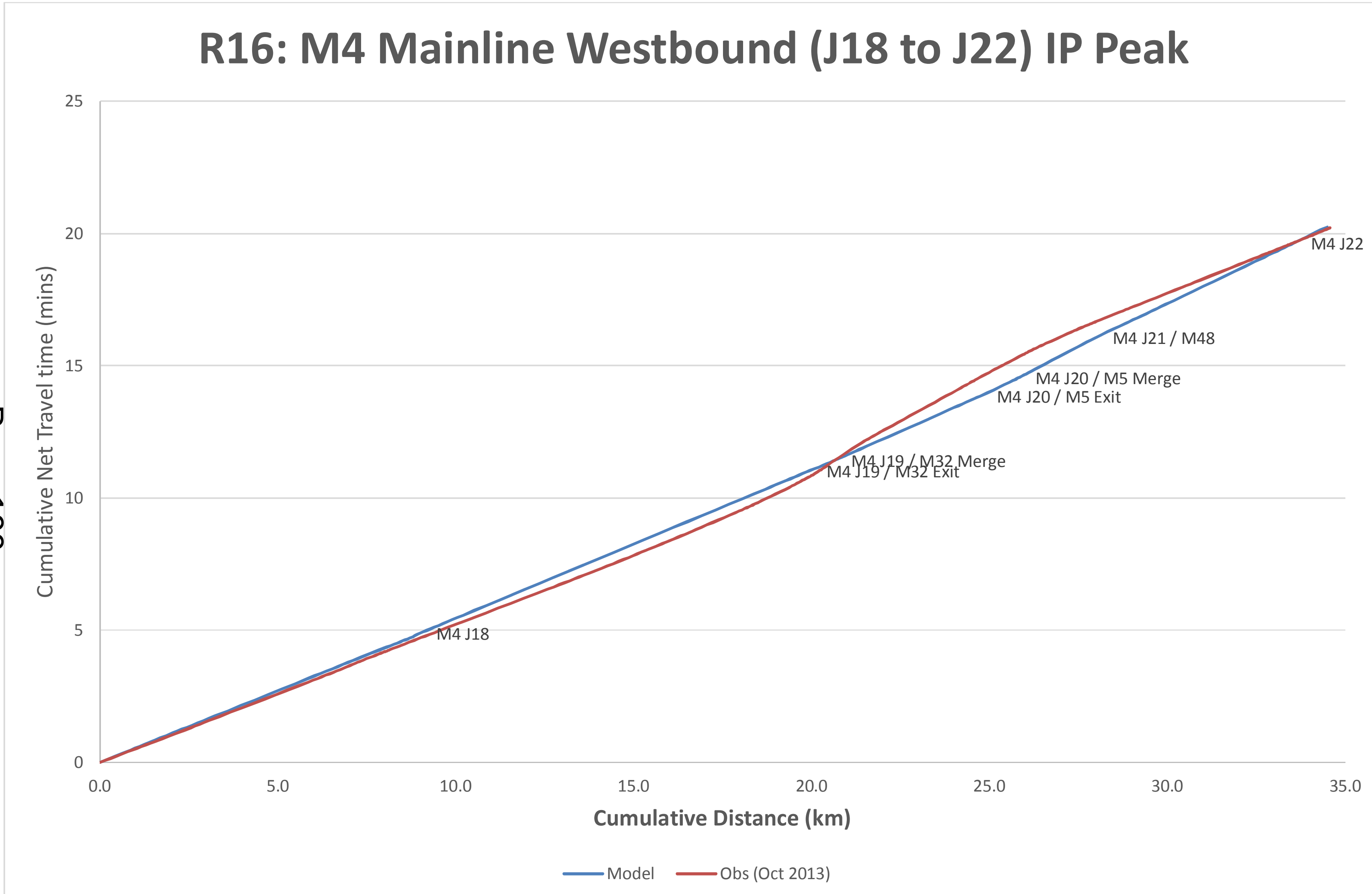

R14: City Centre Outer Loop (Clockwise) IP Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
30
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Jacobs Well's Rd
Merchants Rd
Plimsol Bridge
Avon bridge
Jessop Underpass / Brunel Way
Clift House Rd
Coronation Rd
Bedminster Bridge Rbt
Redcliffe Way
Redcliffe Way Rbt
Temple Meads Station
Bath Bridge
Bath Bridge
Bath Bridge Rbt
Temple Meads Station
Temple Circus
Temple Back
Avon St
Bond St
Cabot Circus Car Park
Cabot Circus
Temple Way
James Barton Rbt N
James Barton Rbt W
James Barton Rbt S
Lower Maudlin St
Lewins Mead
St Augustines Parade
College Green
Cathedral
Canon's Way
Model
Obs (Oct 2013)

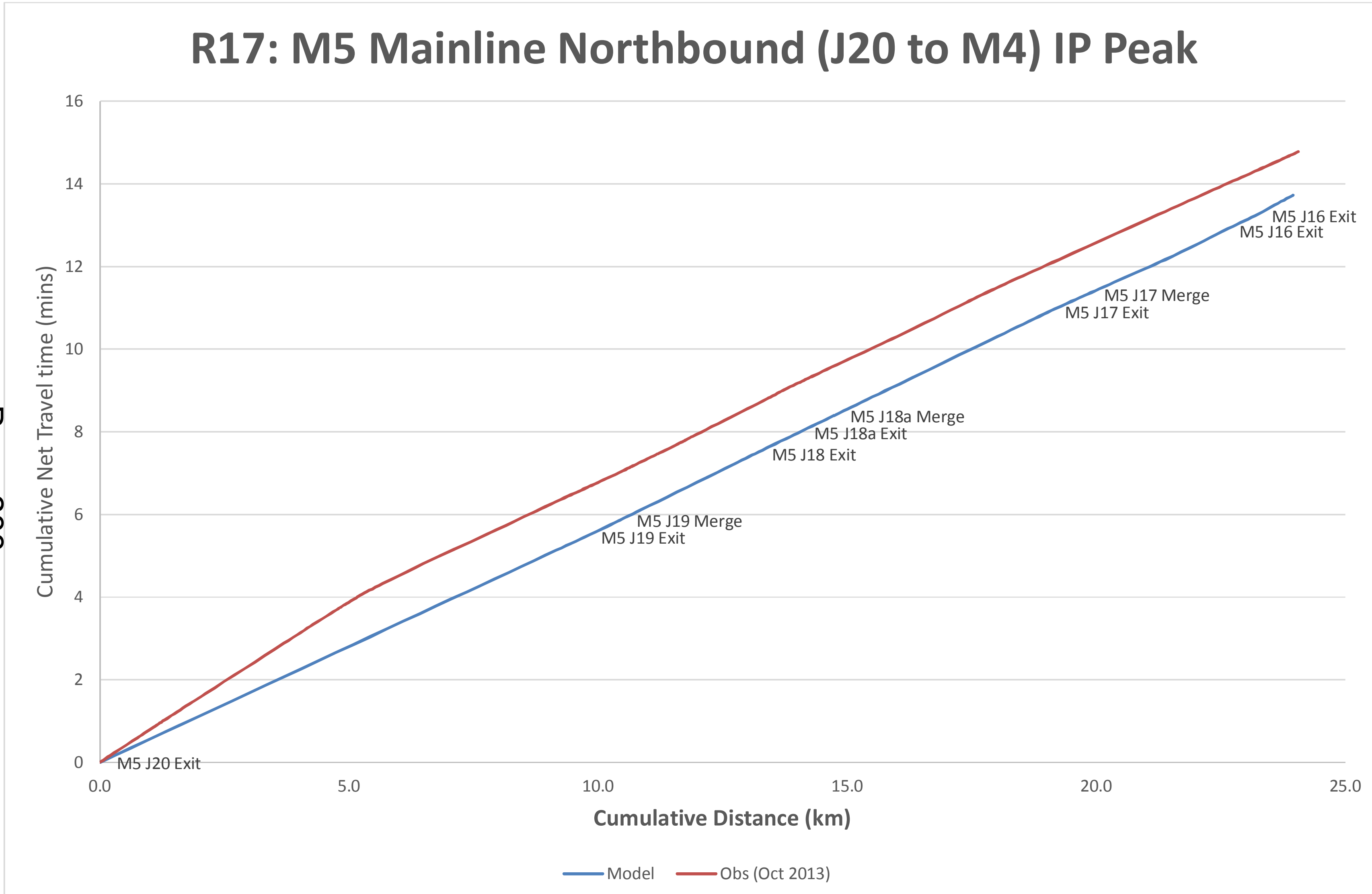

R14: City Centre Outer Loop (Anti-Clockwise) IP Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Jacobs Well's Rd
Canon's Way
Cathedral
St Augustines Parade
Colston Ave
War Memorial
Union St
James Barton Rbt E
Temple Way
Temple Back
Temple circus
Redcliffe Way
Redcliffe Way
Redcliffe Way Rbt
Bedminster Bridge Rbt
Bedminster Bridge Rbt
Coronation Rd
Clift House Rd
Avon Bridge
Cumberland Basin
Merchants Rd
Model
Obs (Oct 2013)

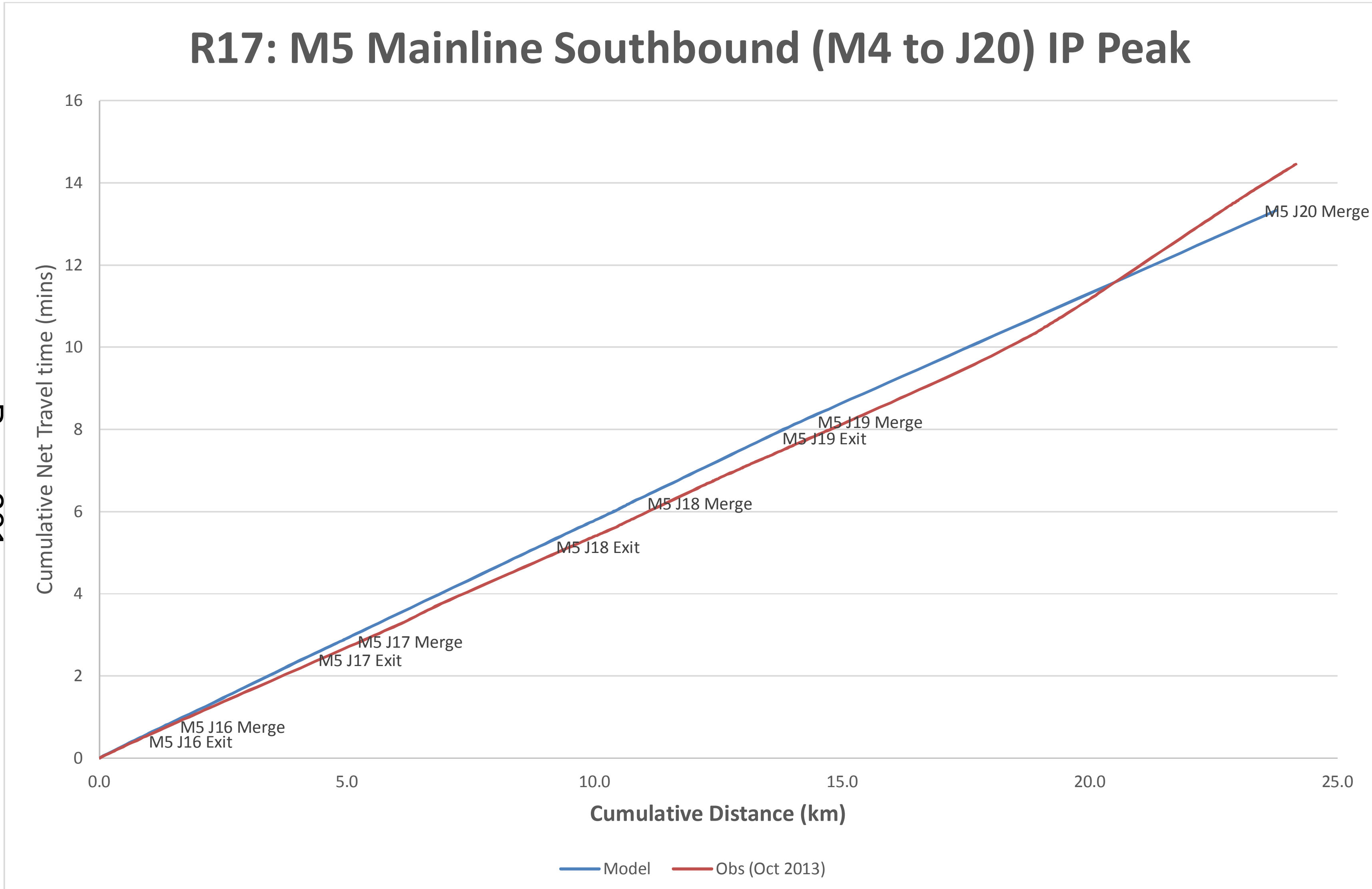

R15: City Centre Inner Loop (Clockwise) IP Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
Model
Obs (Oct 2013)
Avon bridge
Cumberland Rd
Gasferry Rd
Cumberland Rd/Wapping Rd
Princess St bridge
Prince St Ped Xing
King St
Marsh St / Baldwin St
Bristol Bridge
Counterslip
Temple Circus
Temple Meads Station
Bath Bridge
Bath Bridge Rbt
Bath Bridge
Bedminster Bridge Rbt
Cumberland Rd/Wapping Rd
Gasferry Rd


R15: City Centre Inner Loop (Anti-Clockwise) IP Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
Cumberland Rd/Wapping Rd
Bedminster Bridge Rbt
Bath Bridge
Temple Meads Station
Redcliffe Way
Redcliffe Way Rbt
Redcliffe Way
Redcliffe Way
Temple circus
Counterslip
Bristol Bridge
Marsh St / Baldwin St
King St
Prince St Ped Xing
Princess St bridge
Cumberland Rd/Wapping Rd
Model
Obs (Oct 2013)

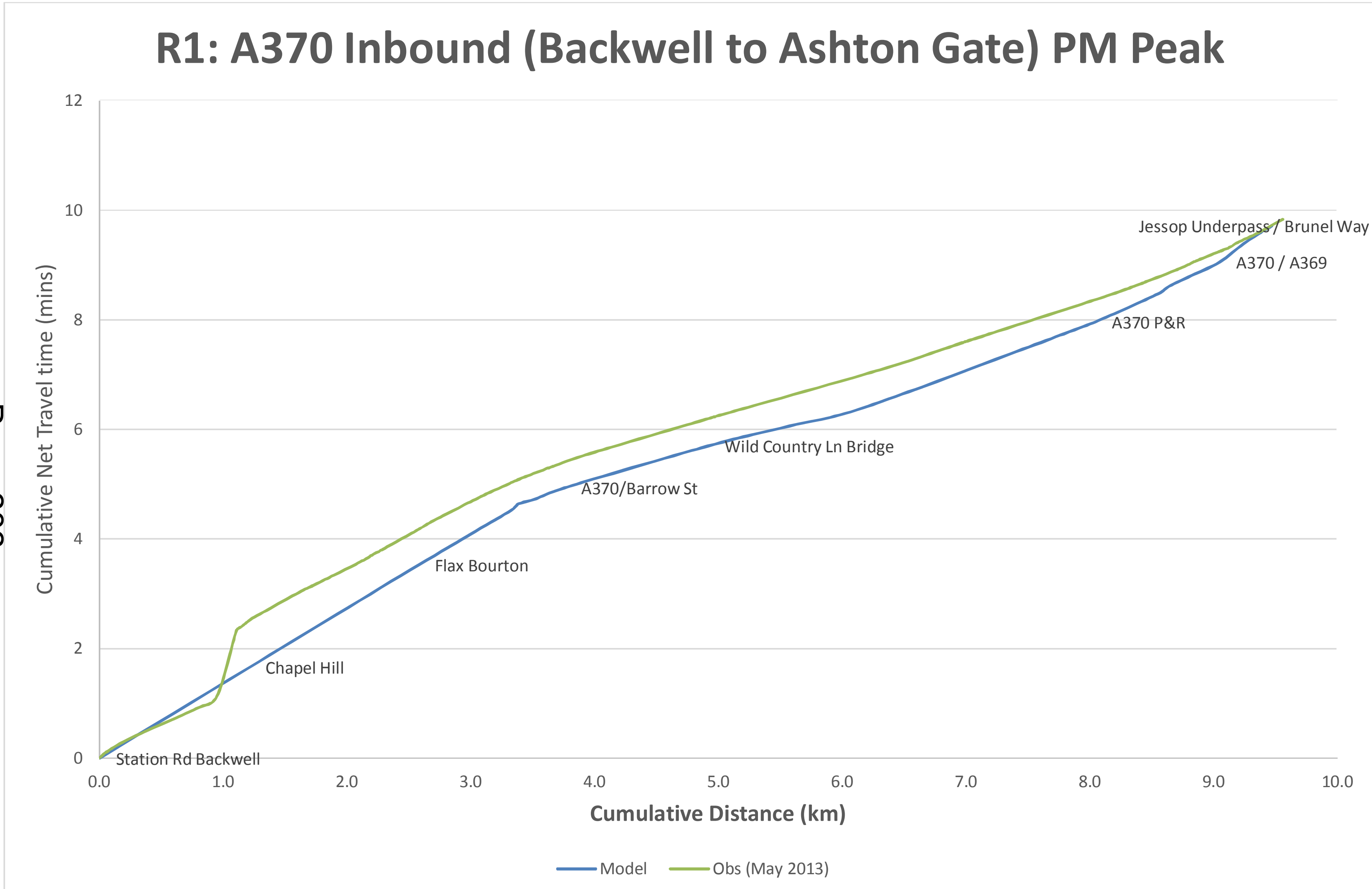

R16: M4 Mainline Eastbound (J22 to J18) IP Peak
Cumulative Net Travel time (mins)
25
20
15
10
5
0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Cumulative Distance (km)
M4 J22
M4 J21 / M48
M4 J20 / M5 Merge
M4 J20 / M5 Exit
M4 J19 / M32 Merge
M4 J19 / M32 Exit
M4 J18
Model
Obs (Oct 2013)

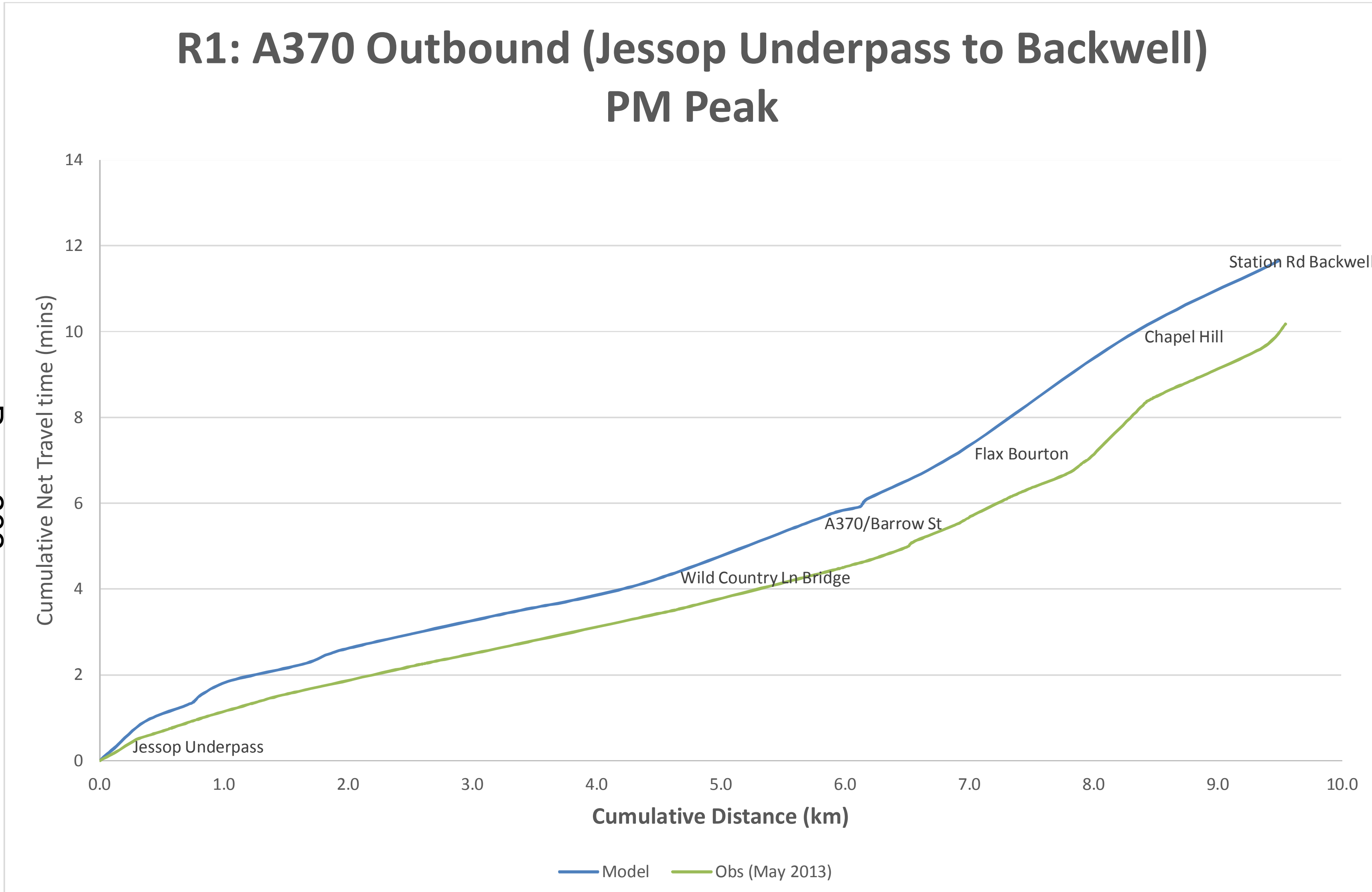

R16: M4 Mainline Westbound (J18 to J22) IP Peak
Cumulative Net Travel time (mins)
25
20
15
10
5
0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Cumulative Distance (km)
M4 J18
M4 J19 / M32 Merge
M4 J19 / M32 Exit
M4 J20 / M5 Merge
M4 J20 / M5 Exit
M4 J21 / M48
M4 J22
Model
Obs (Oct 2013)

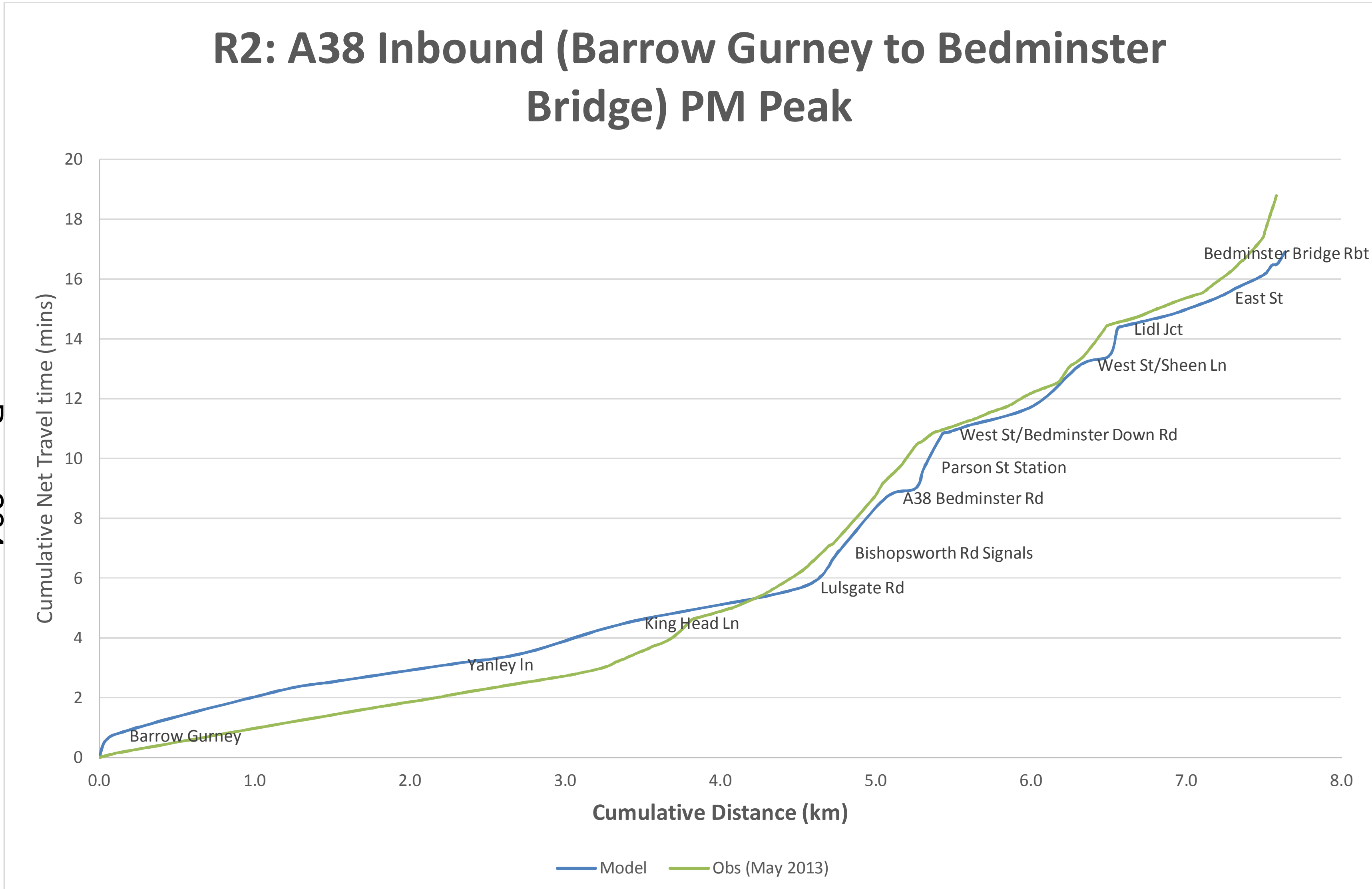

R17: M5 Mainline Northbound (J20 to M4) IP Peak
Cumulative Net Travel time (mins)
0
2
4
6
8
10
12
14
16
0.0
5.0
10.0
15.0
20.0
25.0
Cumulative Distance (km)
M5 J20 Exit
M5 J19 Merge
M5 J19 Exit
M5 J18a Merge
M5 J18a Exit
M5 J18 Exit
M5 J17 Merge
M5 J17 Exit
M5 J16 Exit
M5 J16 Exit
Model
Obs (Oct 2013)

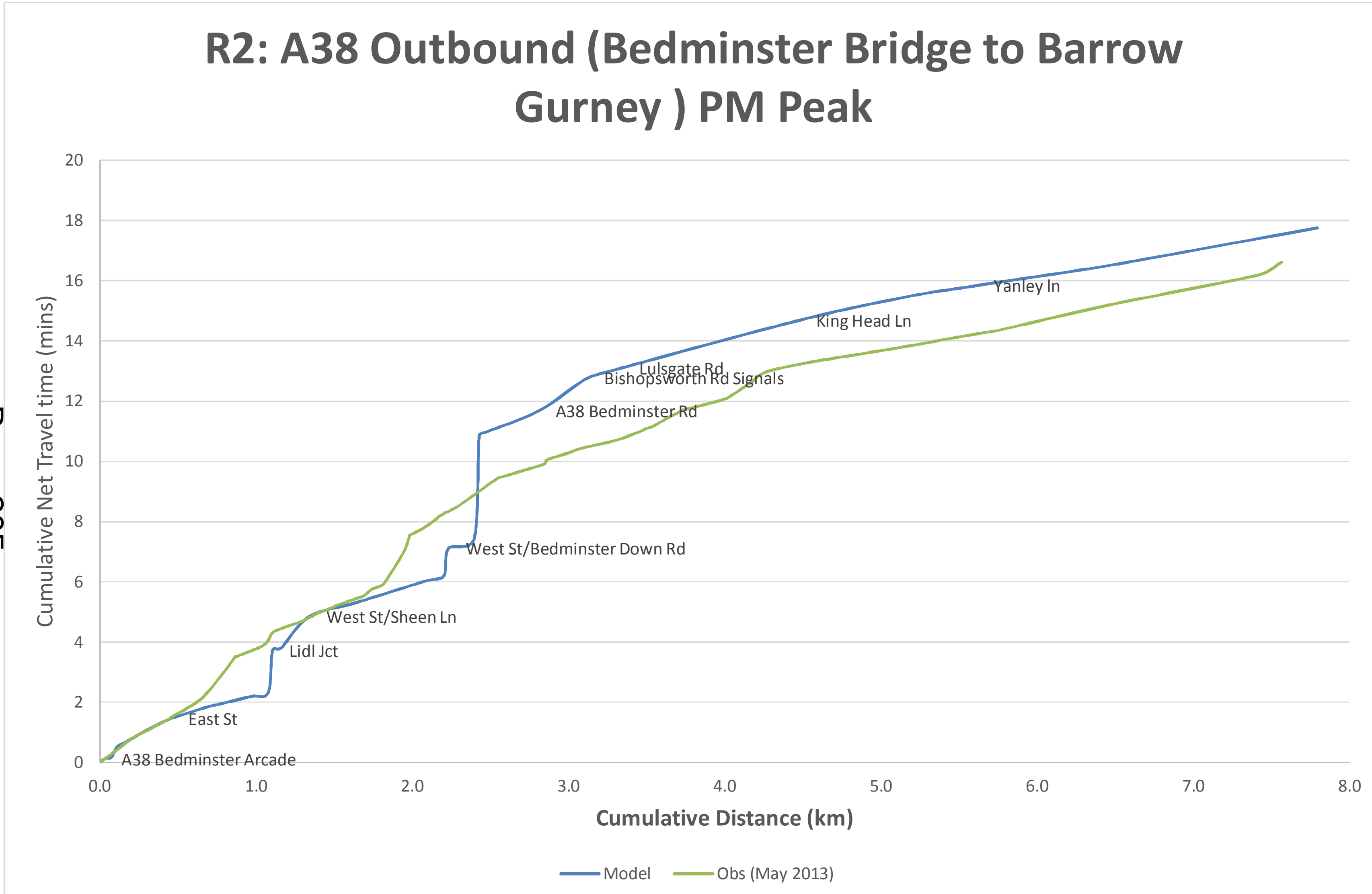


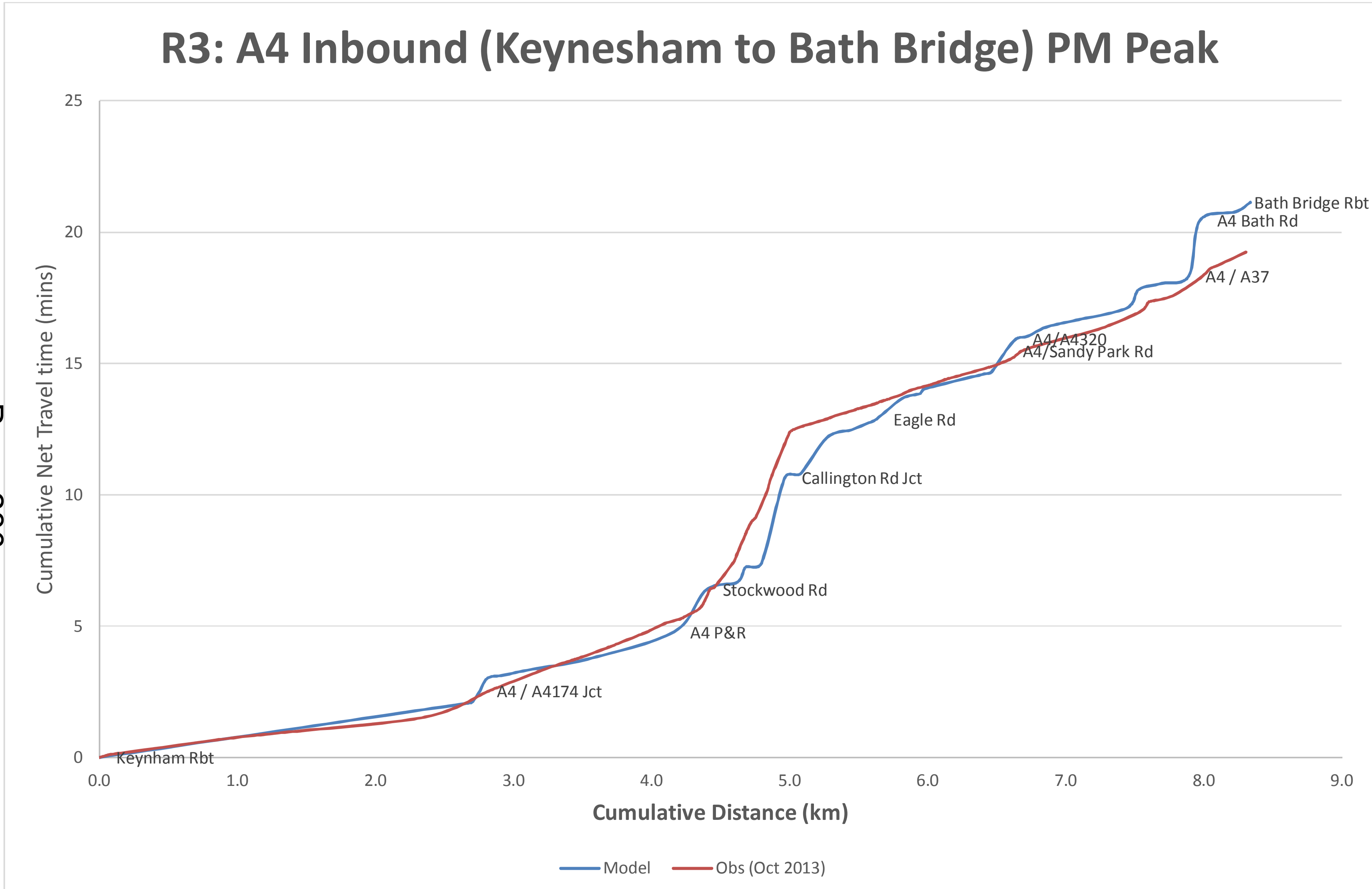
R17: M5 Mainline Southbound (M4 to J20) IP Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
2
4
6
8
10
12
14
16
0.0
5.0
10.0
15.0
20.0
25.0
M5 J16 Merge
M5 J16 Exit
M5 J17 Merge
M5 J17 Exit
M5 J18 Merge
M5 J18 Exit
M5 J19 Merge
M5 J19 Exit
M5 J20 Merge
Model
Obs (Oct 2013)


R1: A370 Inbound (Backwell to Ashton Gate) PM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
2
4
6
8
10
12
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Station Rd Backwell
Chapel Hill
Flax Bourton
A370/Barrow St
Wild Country Ln Bridge
A370 P&R
A370 / A369
Jessop Underpass / Brunel Way
Model
Obs (May 2013)

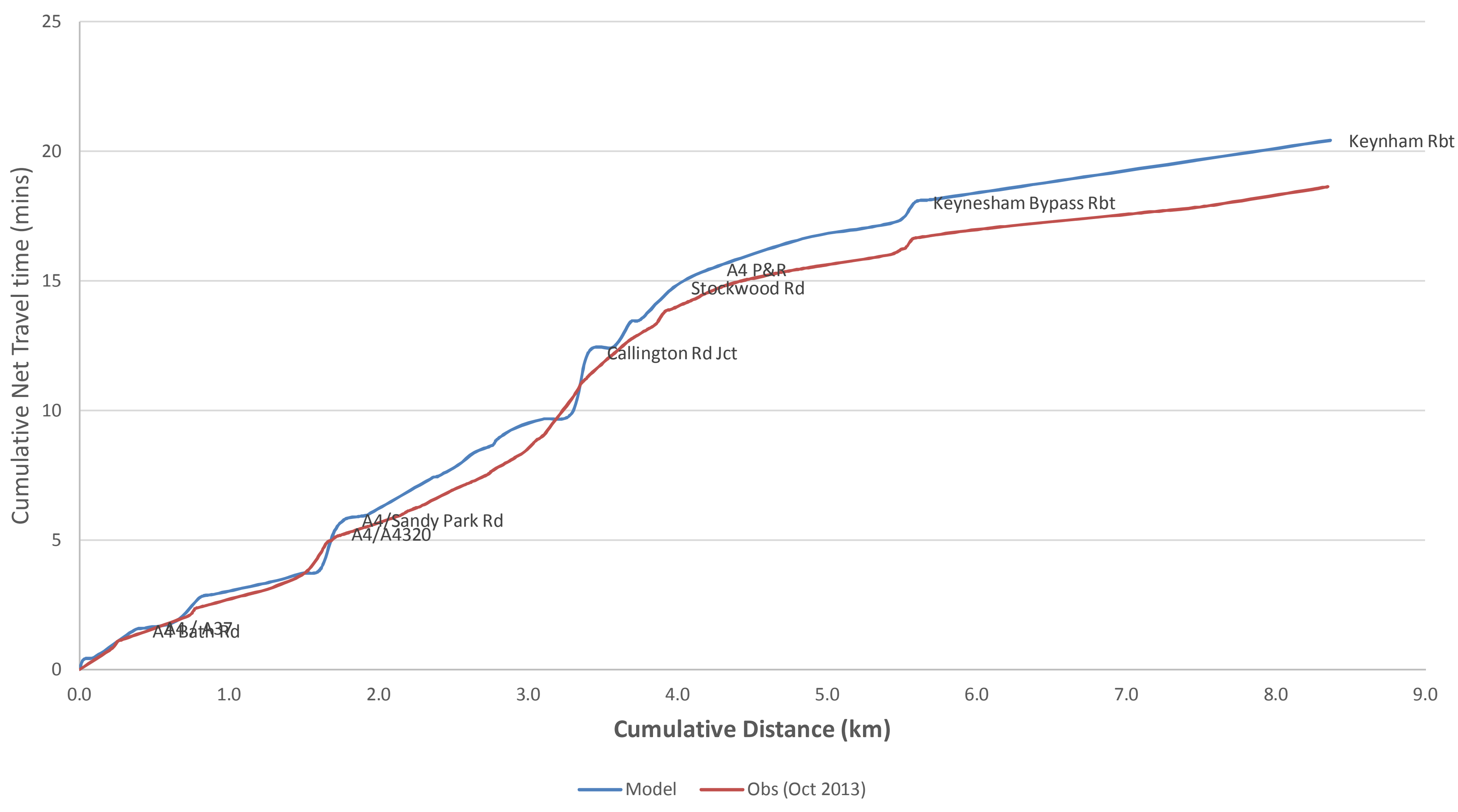

R1: A370 Outbound (Jessop Underpass to Backwell)
PM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
2
4
6
8
10
12
14
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Jessop Underpass
Wild Country Ln Bridge
A370/Barrow St
Flax Bourton
Chapel Hill
Station Rd Backwell
Model
Obs (May 2013)

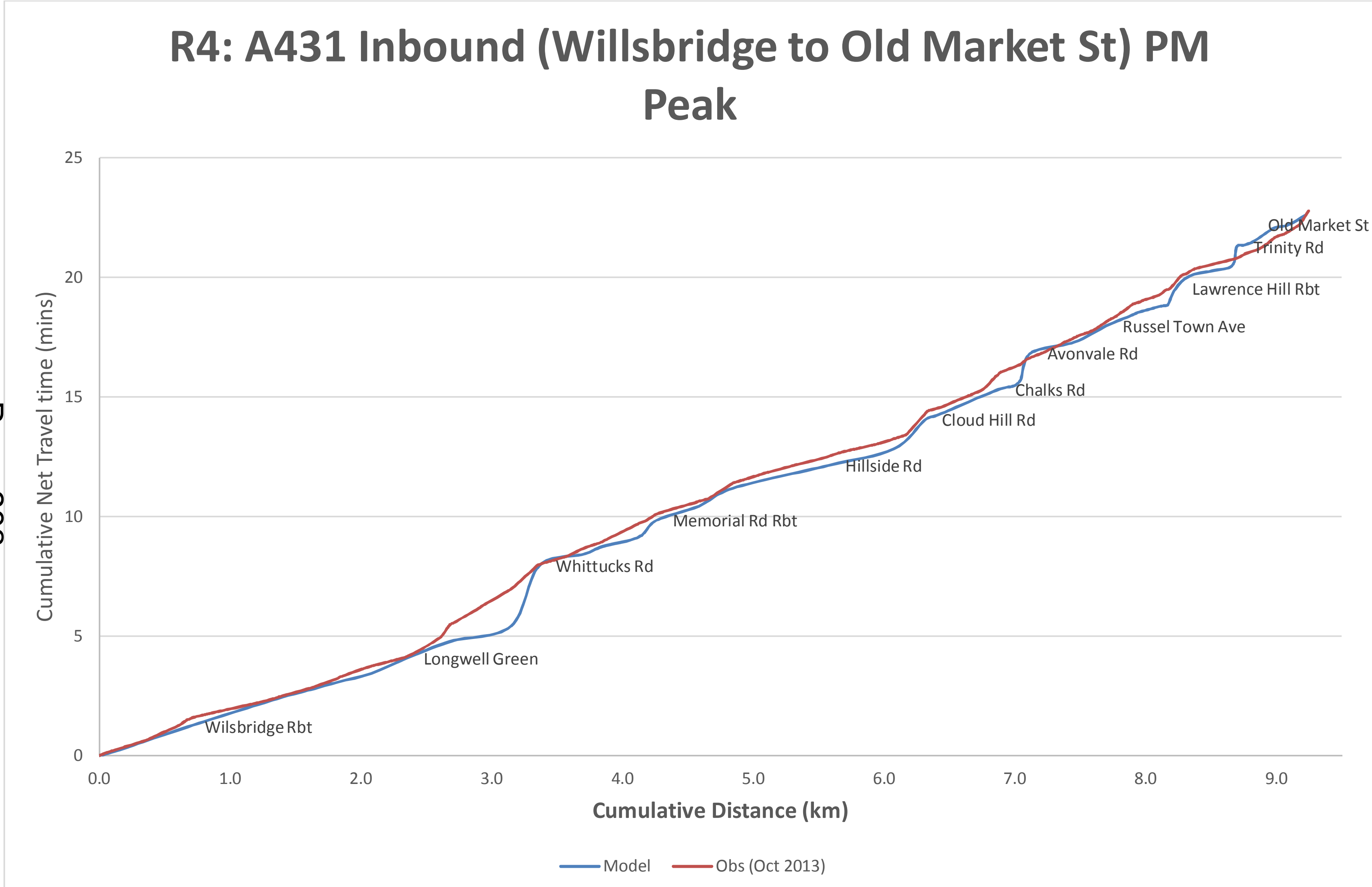

R2: A38 Inbound (Barrow Gurney to Bedminster Bridge) PM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
2
4
6
8
10
12
14
16
18
20
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Barrow Gurney
Yanley ln
King Head Ln
Lulsgate Rd
Bishopsworth Rd Signals
A38 Bedminster Rd
Parson St Station
West St/Bedminster Down Rd
West St/Sheen Ln
Lidl Jct
East St
Bedminster Bridge Rbt
Model
Obs (May 2013)

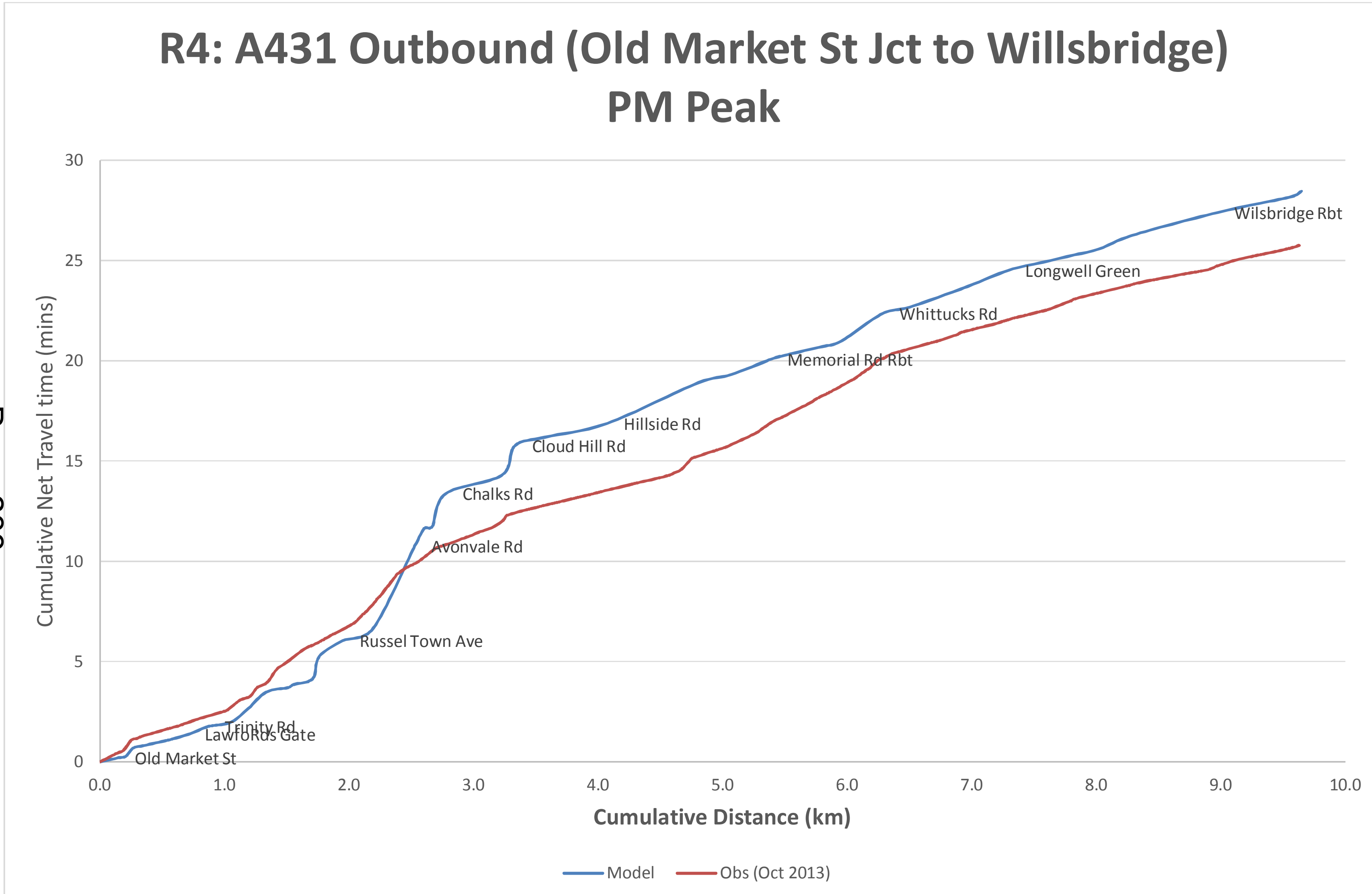

R2: A38 Outbound (Bedminster Bridge to Barrow Gurney) PM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
2
4
6
8
10
12
14
16
18
20
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
A38 Bedminster Arcade
East St
Lidl Jct
West St/Sheen Ln
West St/Bedminster Down Rd
A38 Bedminster Rd
Bishopsworth Rd Signals
Lulsgate Rd
King Head Ln
Yanley ln
Model
Obs (May 2013)

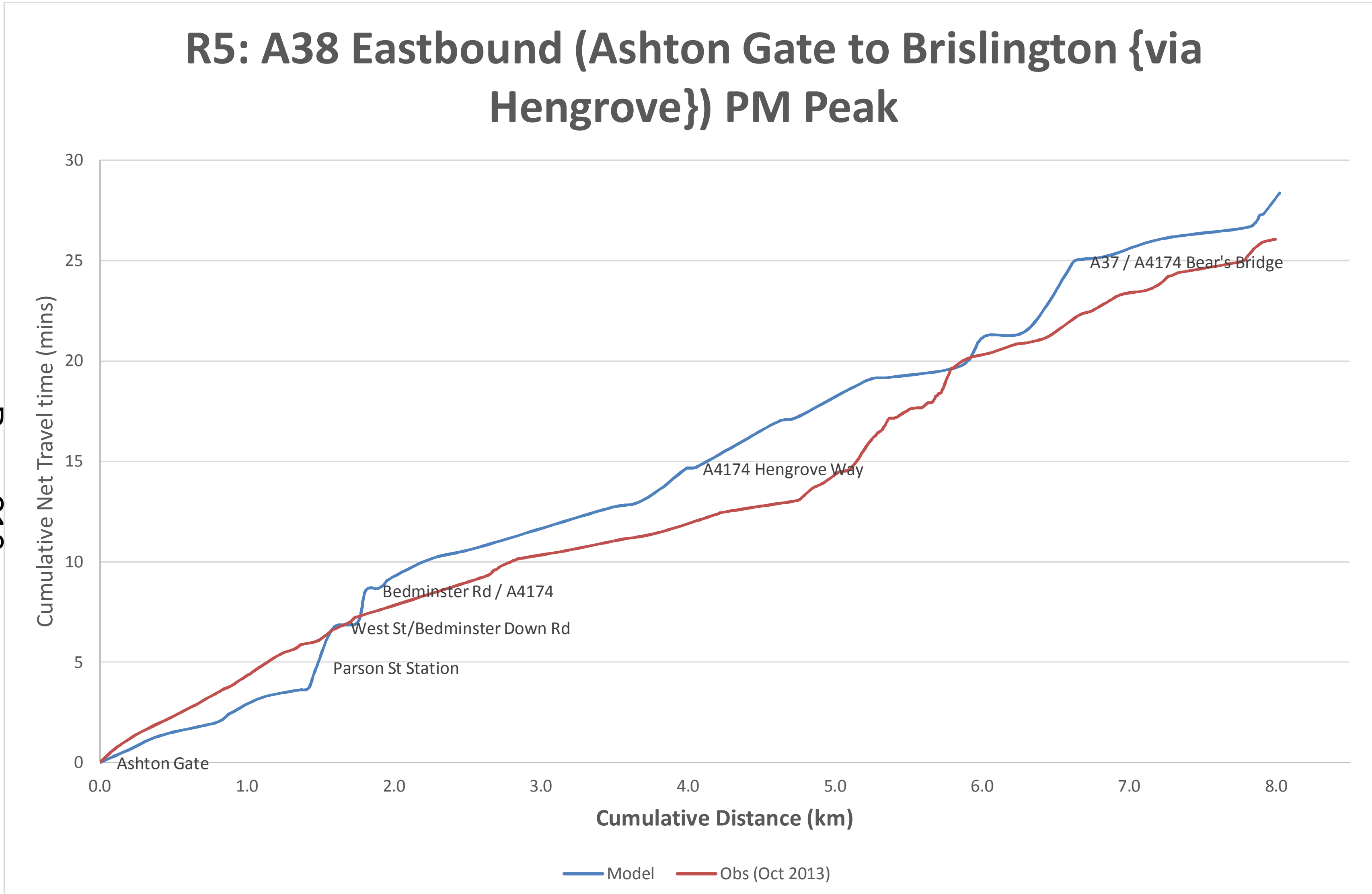

R3: A4 Inbound (Keynesham to Bath Bridge) PM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Keynham Rbt
A4 / A4174 Jct
A4 P&R
Stockwood Rd
Callington Rd Jct
Eagle Rd
A4/A4320
A4/Sandy Park Rd
A4 / A37
A4 Bath Rd
Bath Bridge Rbt
Model
Obs (Oct 2013)

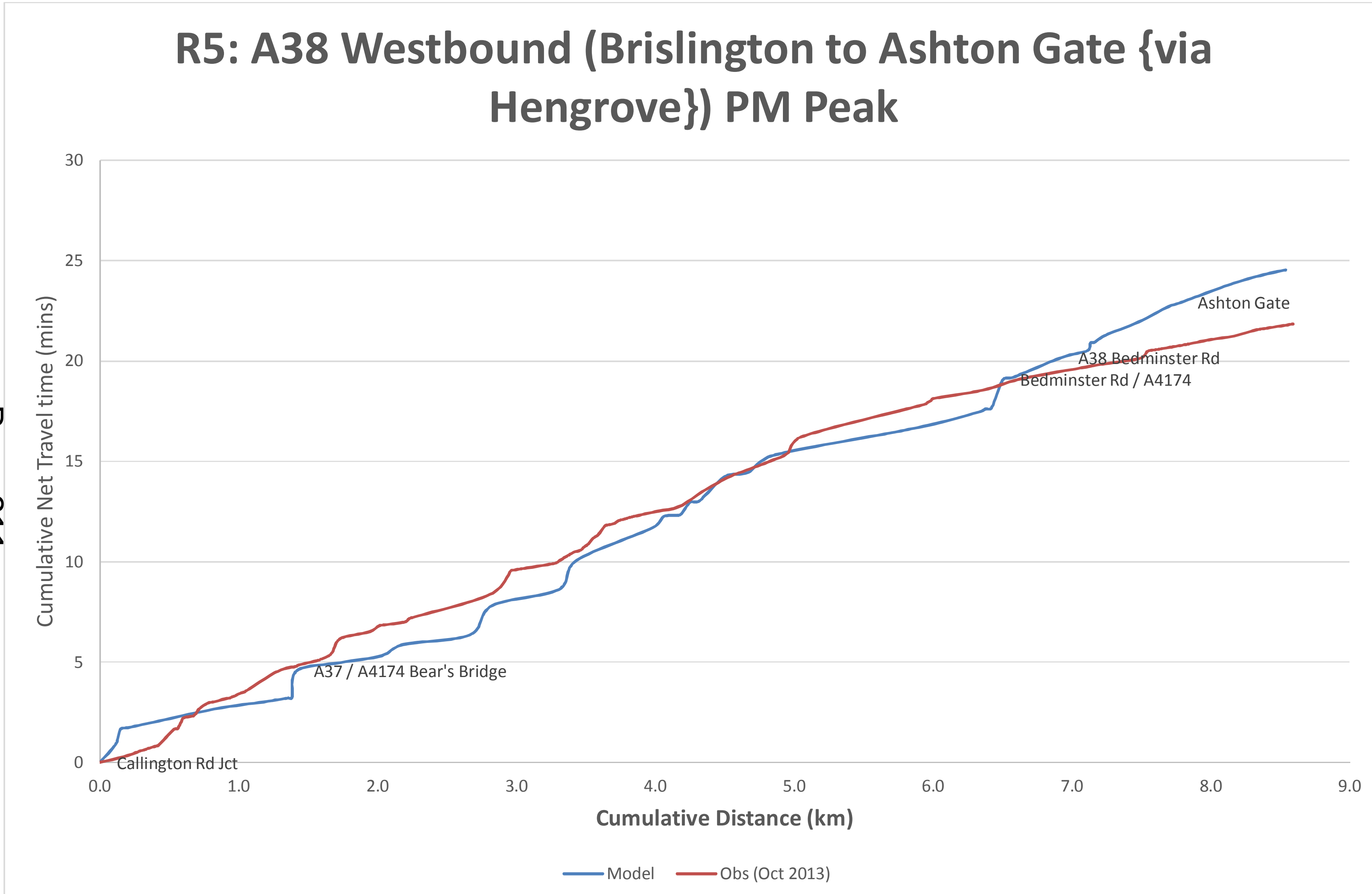
R3: A4 Outbound (Bath Bridge to Keynesham) PM Peak



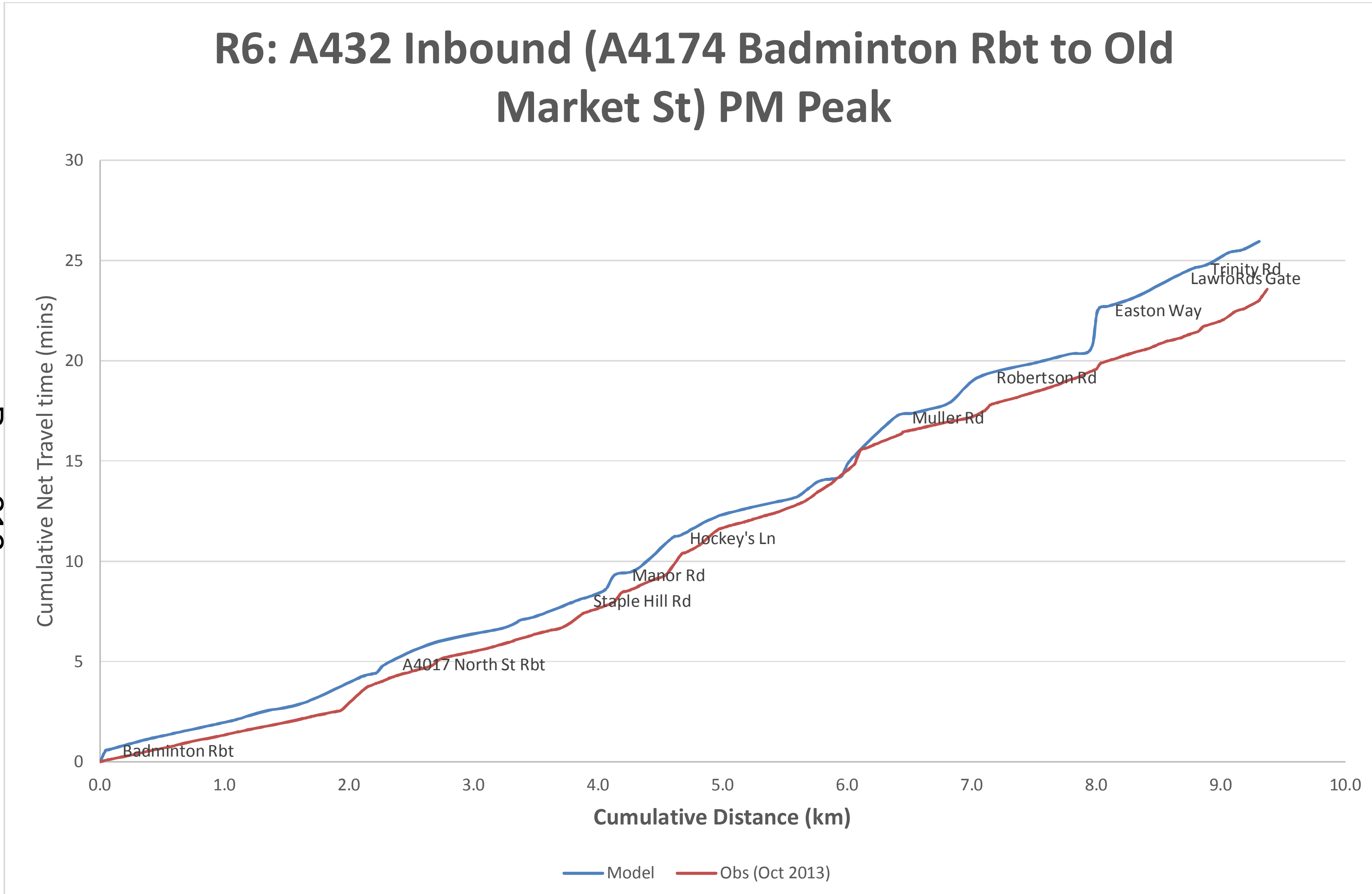

R4: A431 Inbound (Willsbridge to Old Market St) PM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
25
20
15
10
5
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Wilsbridge Rbt
Longwell Green
Whittucks Rd
Memorial Rd Rbt
Hillside Rd
Cloud Hill Rd
Chalks Rd
Avonvale Rd
Russel Town Ave
Lawrence Hill Rbt
Trinity Rd
Old Market St
Model
Obs (Oct 2013)

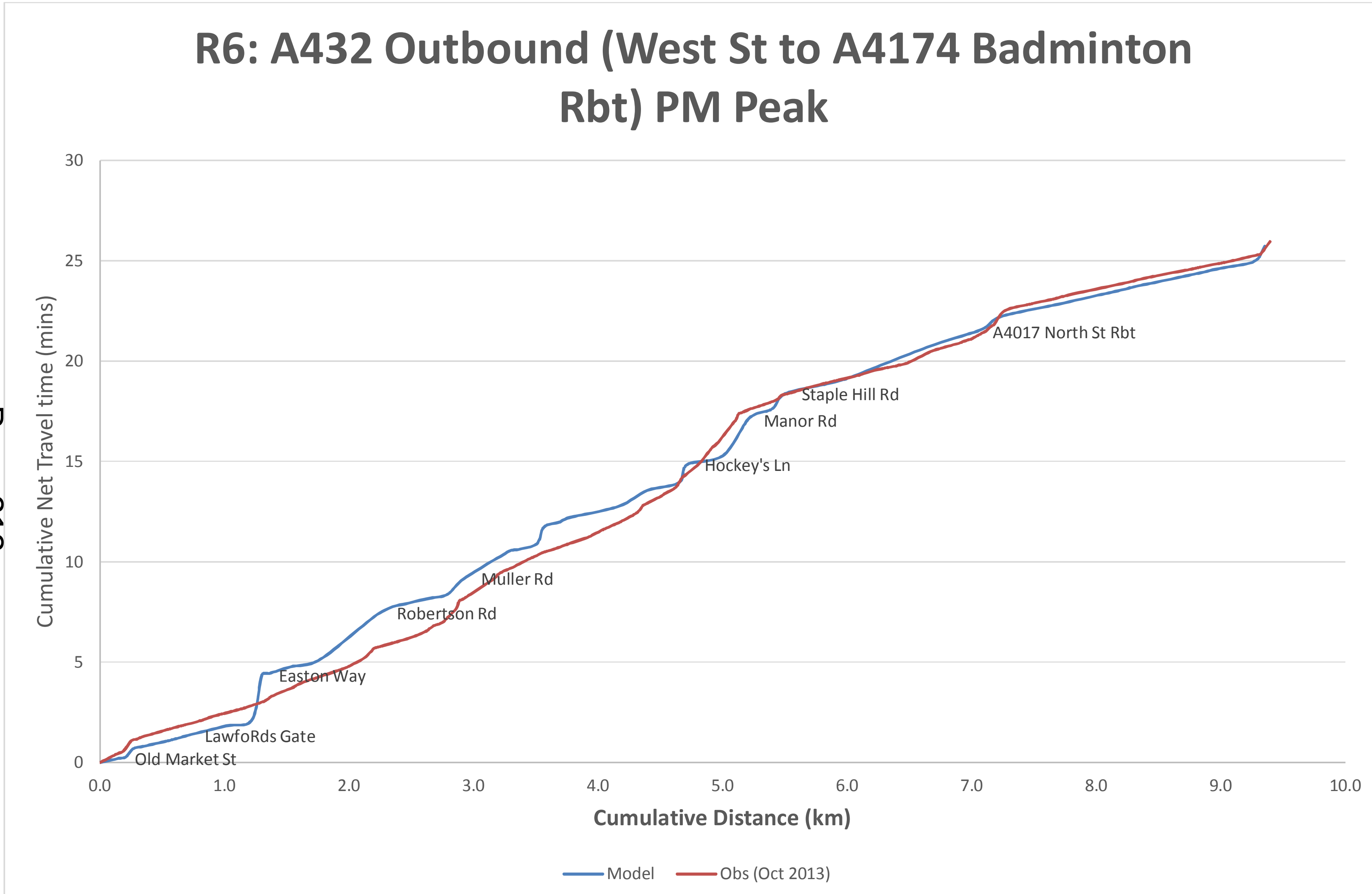

R4: A431 Outbound (Old Market St Jct to Willsbridge)
PM Peak
Cumulative Net Travel time (mins)
30
25
20
15
10
5
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Cumulative Distance (km)
Old Market St
Lawfords Gate
Trinity Rd
Russel Town Ave
Avonvale Rd
Chalks Rd
Cloud Hill Rd
Hillside Rd
Memorial Rd Rbt
Whittucks Rd
Longwell Green
Wilsbridge Rbt
Model
Obs (Oct 2013)

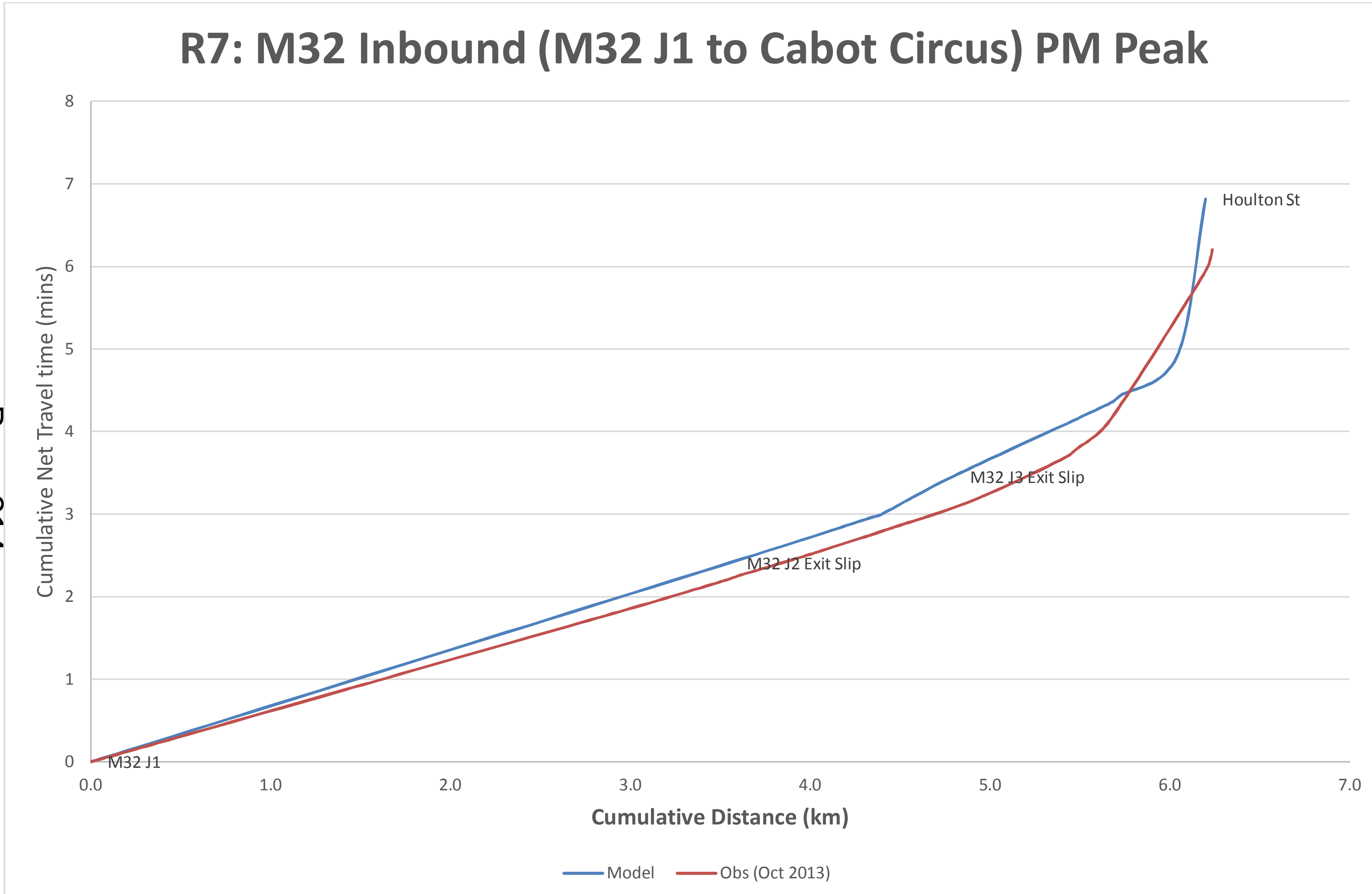

R5: A38 Eastbound (Ashton Gate to Brislington {via Hengrove}) PM Peak
Cumulative Net Travel time (mins)
30
25
20
15
10
5
0
Ashton Gate
Parson St Station
West St/Bedminster Down Rd
Bedminster Rd / A4174
A4174 Hengrove Way
A37 / A4174 Bear's Bridge
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Cumulative Distance (km)
Model
Obs (Oct 2013)

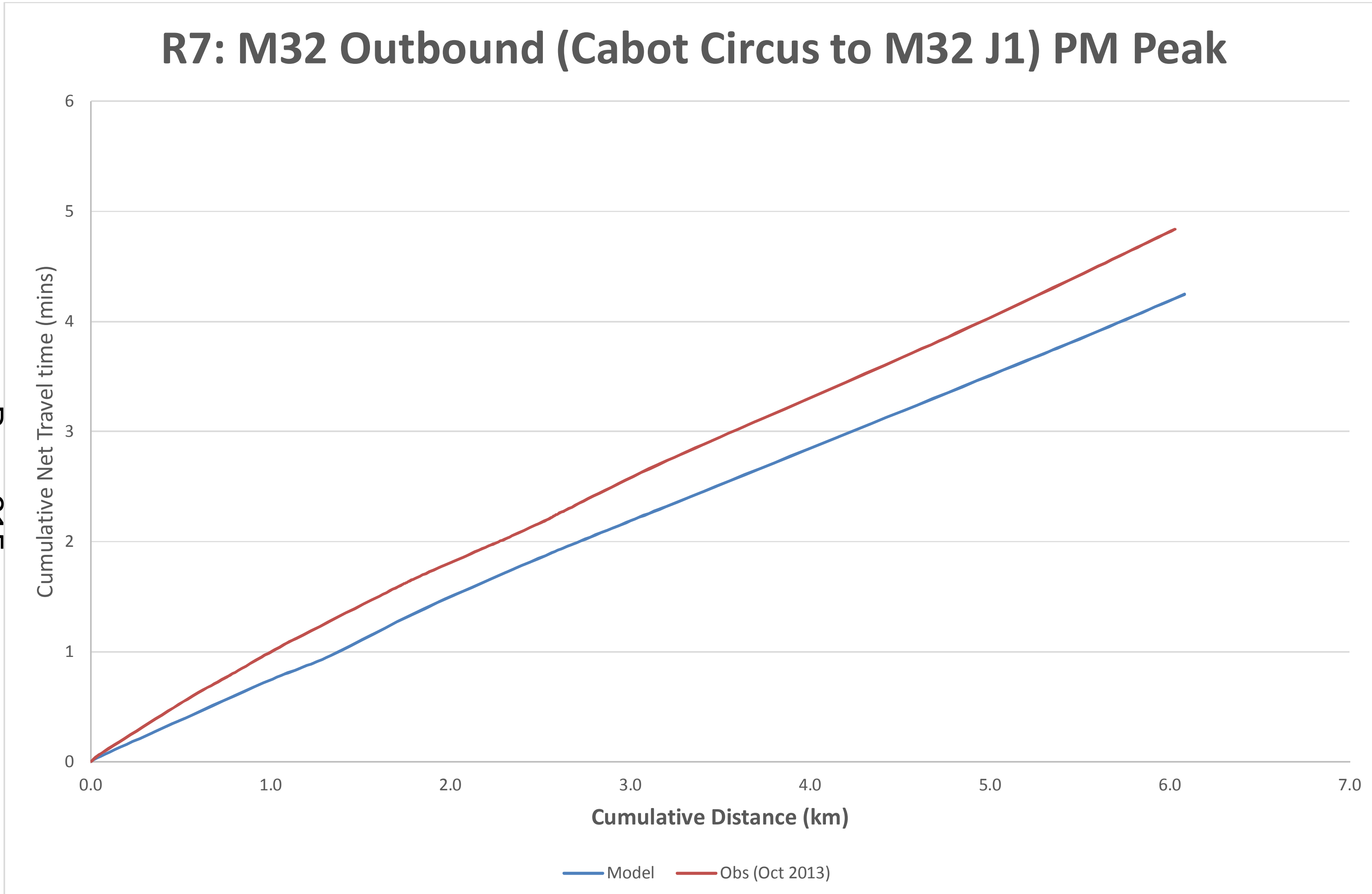


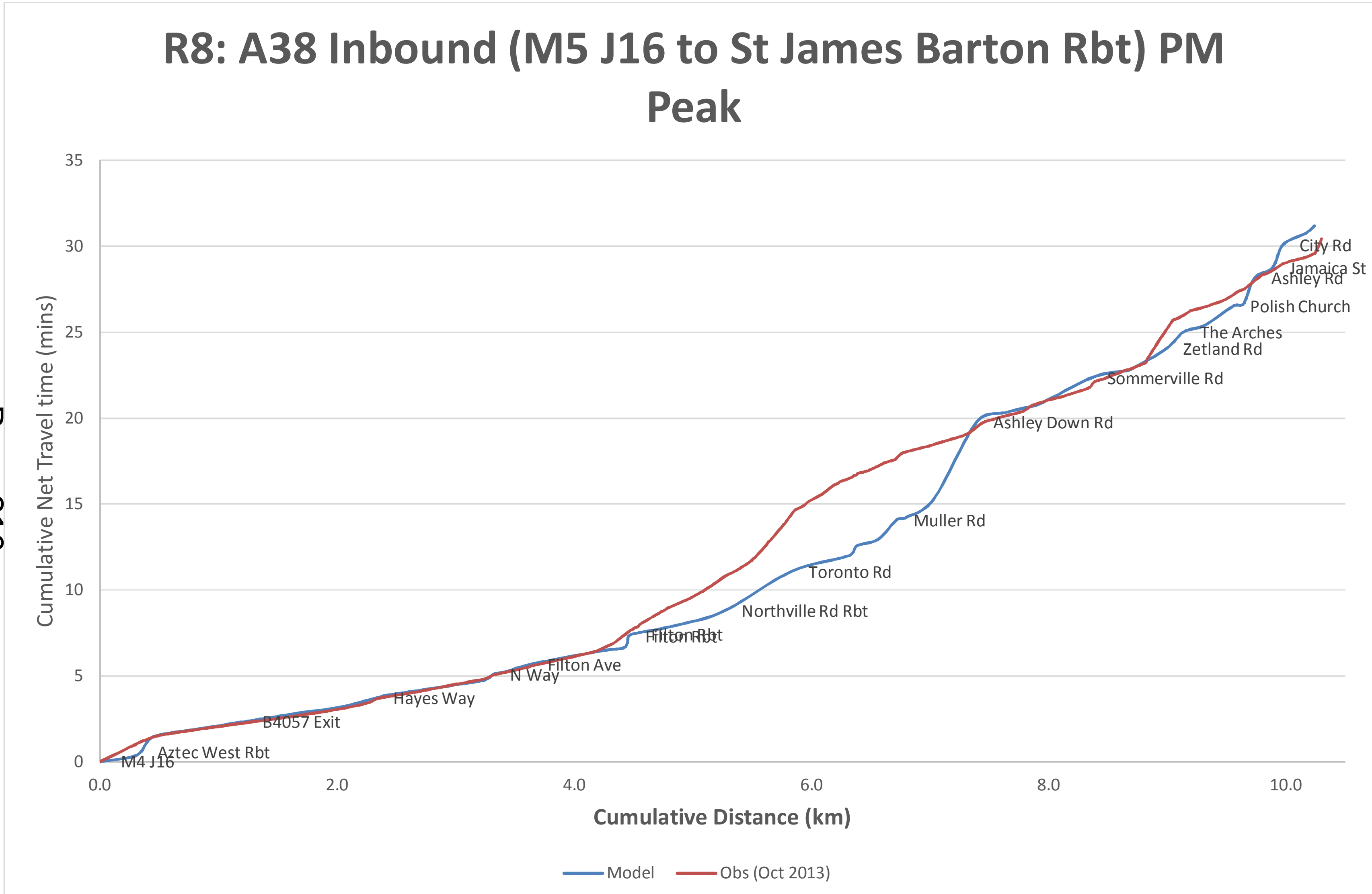
R5: A38 Westbound (Brislington to Ashton Gate {via Hengrove}) PM Peak
Cumulative Net Travel time (mins)
30
25
20
15
10
5
0
Cumulative Distance (km)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Callington Rd Jct
A37 / A4174 Bear's Bridge
Bedminster Rd / A4174
A38 Bedminster Rd
Ashton Gate
Model
Obs (Oct 2013)

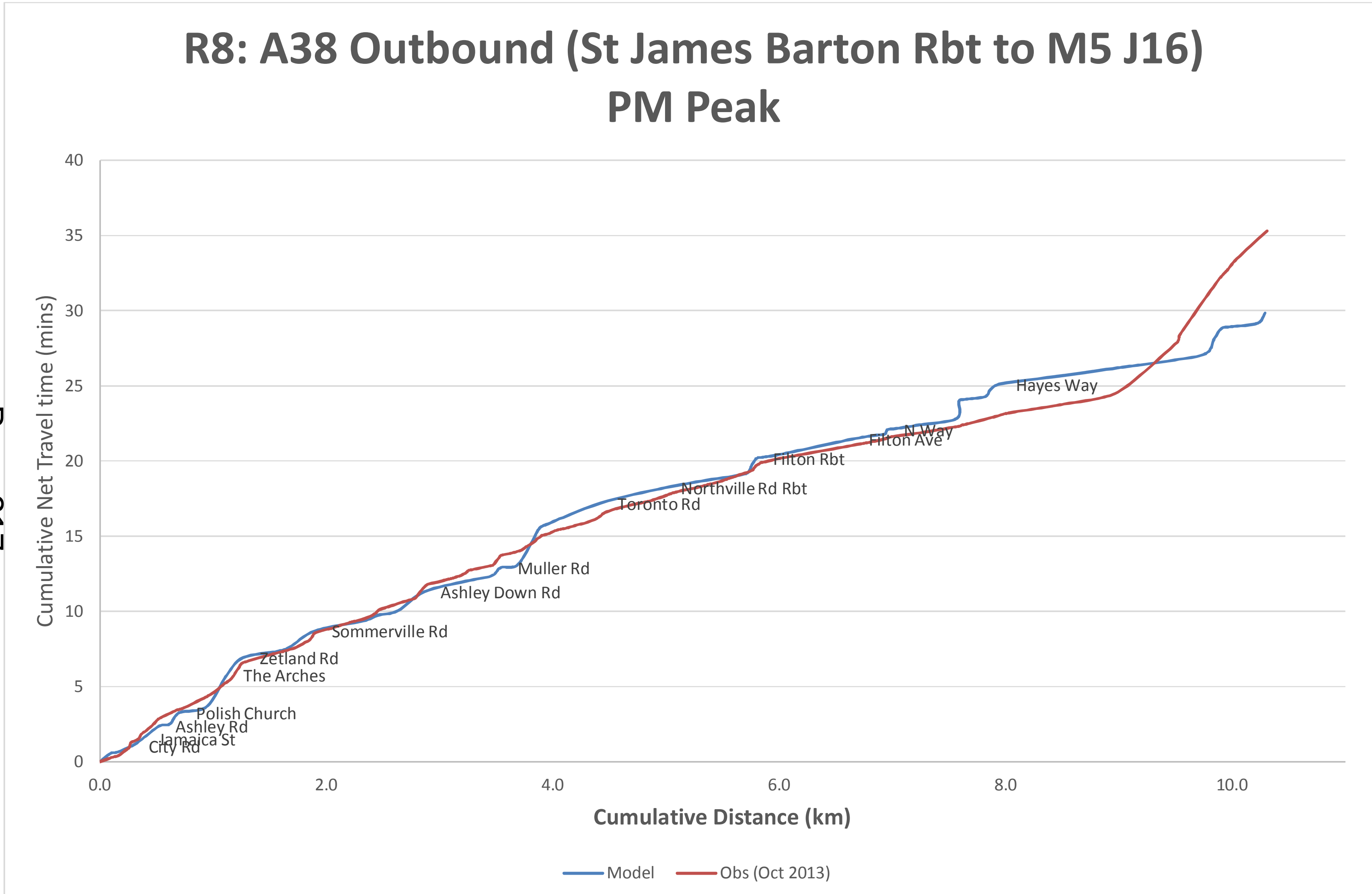

R6: A432 Inbound (A4174 Badminton Rbt to Old Market St) PM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
30
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Badminton Rbt
A4017 North St Rbt
Staple Hill Rd
Manor Rd
Hockey's Ln
Muller Rd
Robertson Rd
Easton Way
Trinity Rd
Lawfords Gate
Model
Obs (Oct 2013)

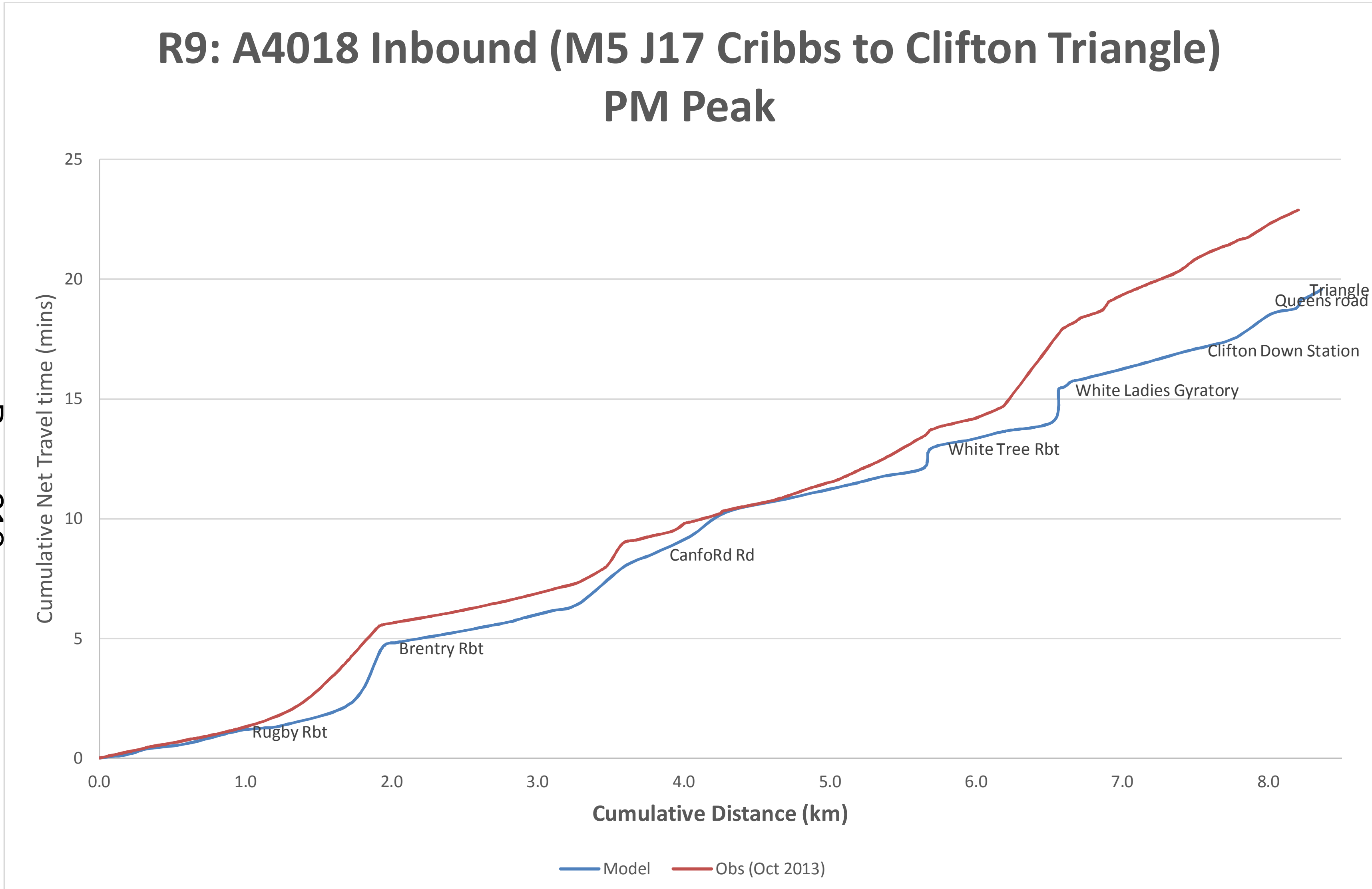

R6: A432 Outbound (West St to A4174 Badminton Rbt) PM Peak
Cumulative Net Travel time (mins)
30
25
20
15
10
5
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Cumulative Distance (km)
Old Market St
LawfoRds Gate
Easton Way
Robertson Rd
Muller Rd
Hockey's Ln
Manor Rd
Staple Hill Rd
A4017 North St Rbt
Model
Obs (Oct 2013)

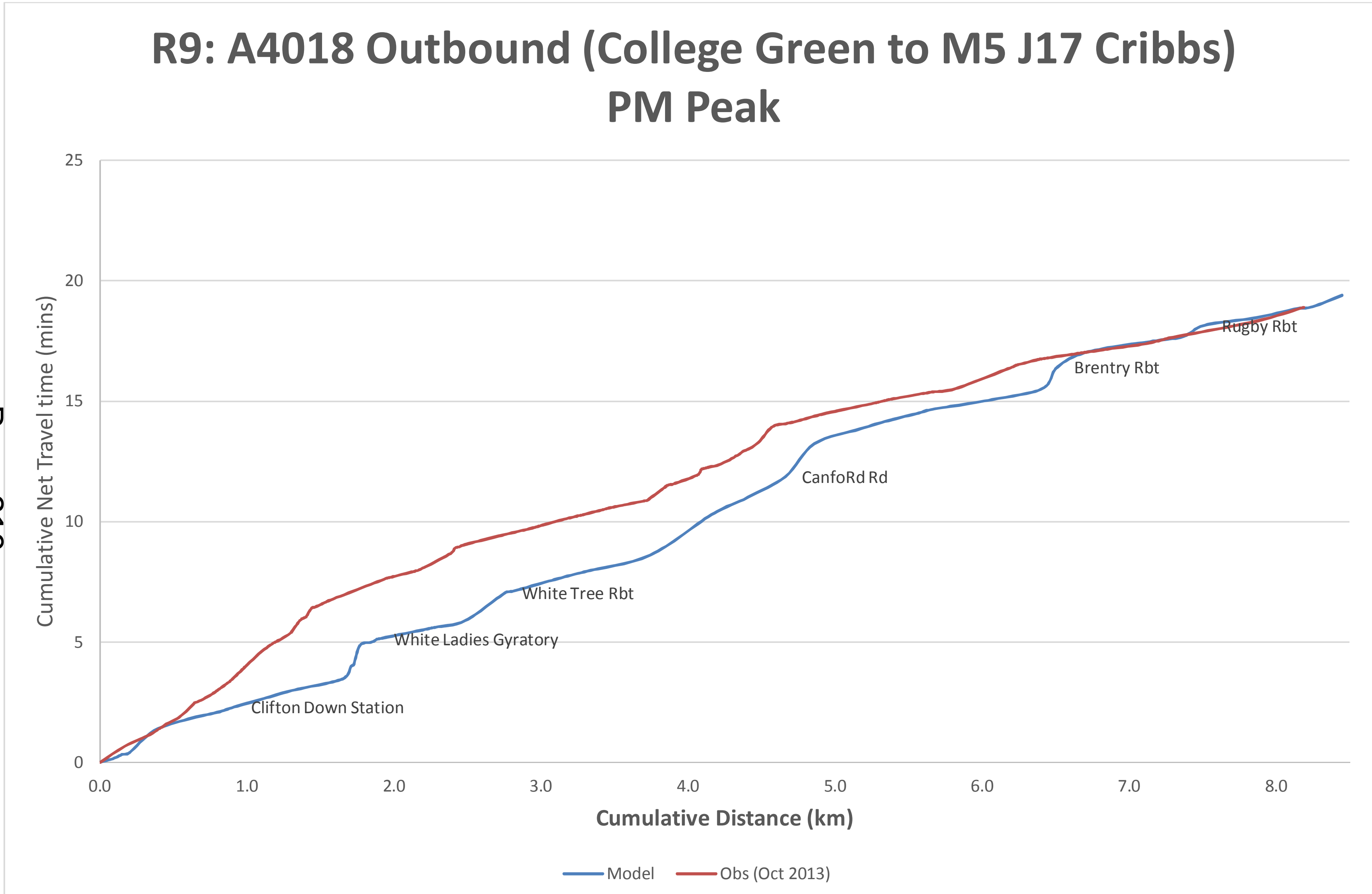

R7: M32 Inbound (M32 J1 to Cabot Circus) PM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
1
2
3
4
5
6
7
8
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
M32 J1
M32 J2 Exit Slip
M32 J3 Exit Slip
Houlton St
Model
Obs (Oct 2013)

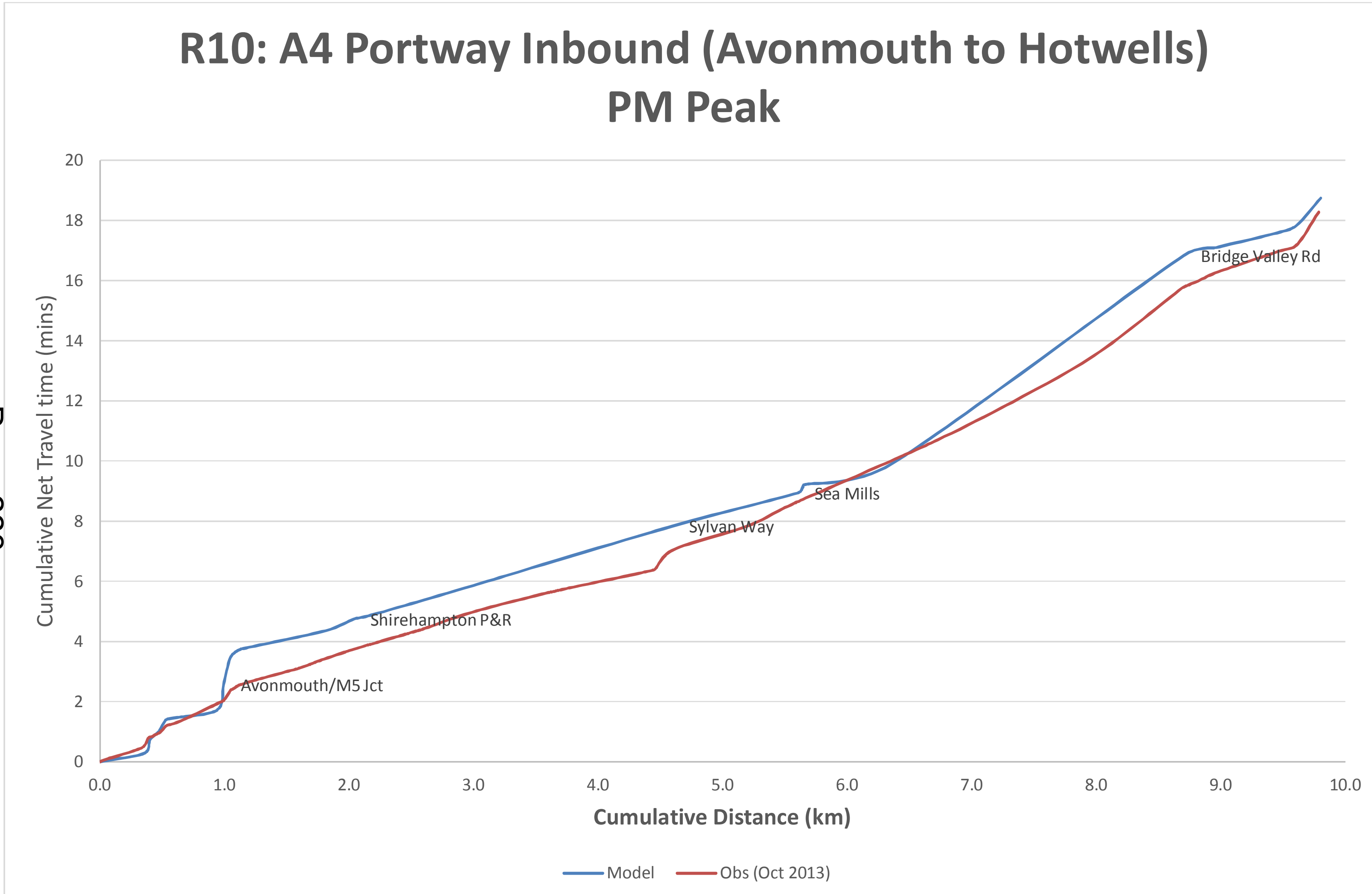

R7: M32 Outbound (Cabot Circus to M32 J1) PM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
1
2
3
4
5
6
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Model
Obs (Oct 2013)

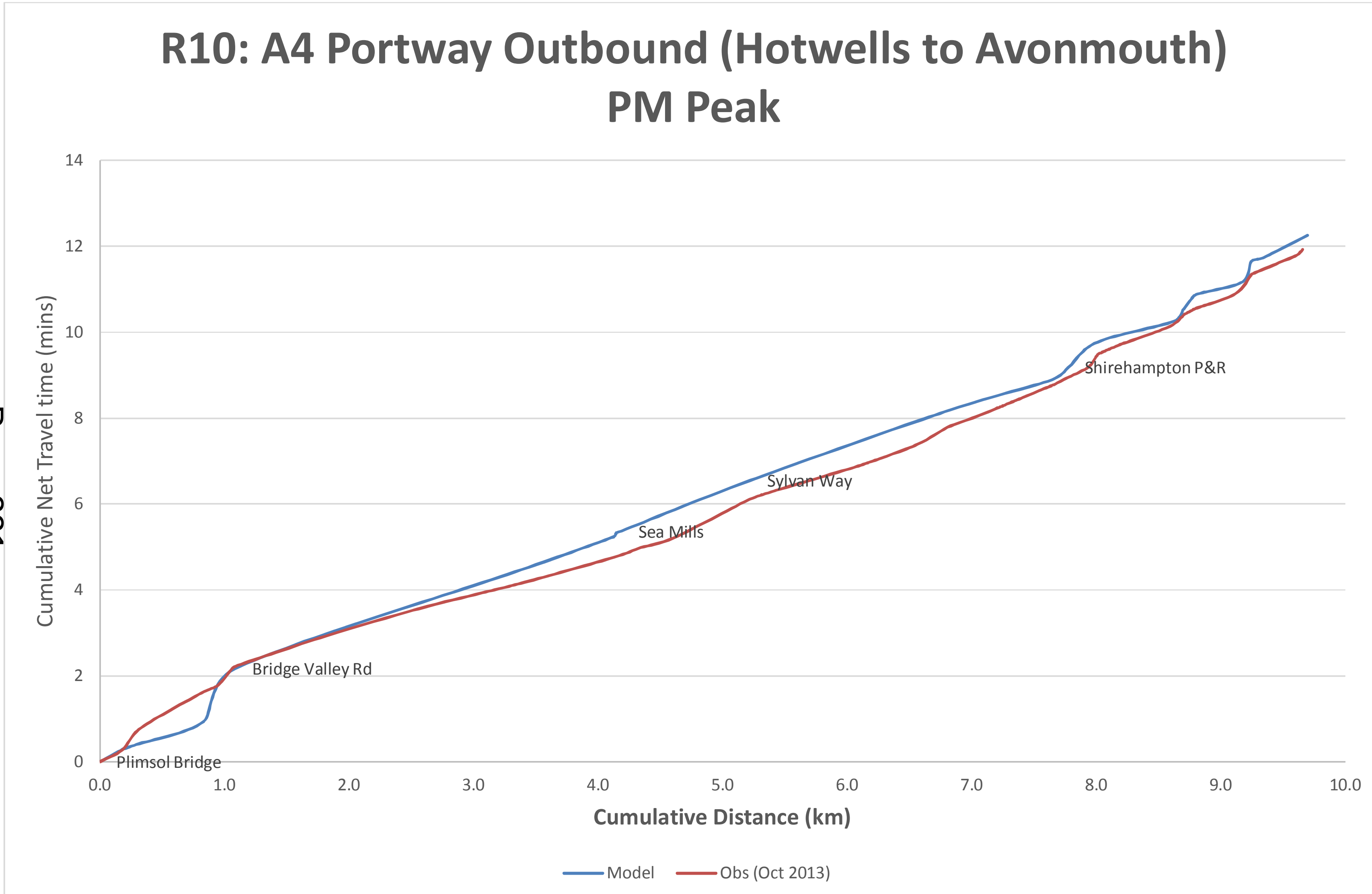

R8: A38 Inbound (M5 J16 to St James Barton Rbt) PM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
30
35
0.0
2.0
4.0
6.0
8.0
10.0
M4 J16
Aztec West Rbt
B4057 Exit
Hayes Way
N Way
Filton Ave
Filton Rbt
Northville Rd Rbt
Toronto Rd
Muller Rd
Ashley Down Rd
Sommerville Rd
Zetland Rd
The Arches
Polish Church
Ashley Rd
Jamaica St
City Rd
Model
Obs (Oct 2013)

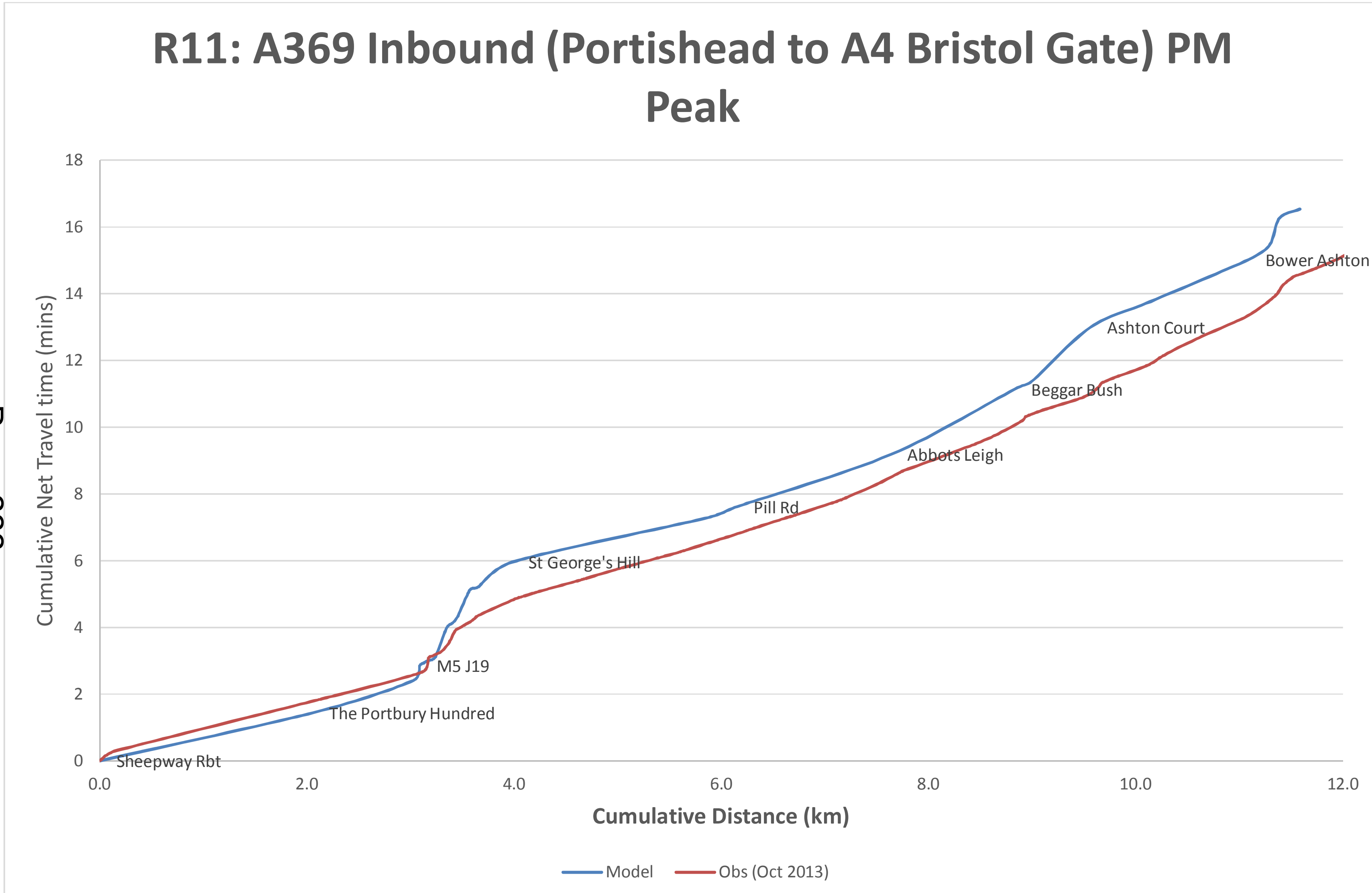

R8: A38 Outbound (St James Barton Rbt to M5 J16)
PM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
30
35
40
0.0
2.0
4.0
6.0
8.0
10.0
City Rd
Jamaica St
Ashley Rd
Polish Church
The Arches
Zetland Rd
Sommerville Rd
Ashley Down Rd
Muller Rd
Toronto Rd
Northville Rd Rbt
Filton Rbt
Filton Ave
N Way
Hayes Way
Model
Obs (Oct 2013)

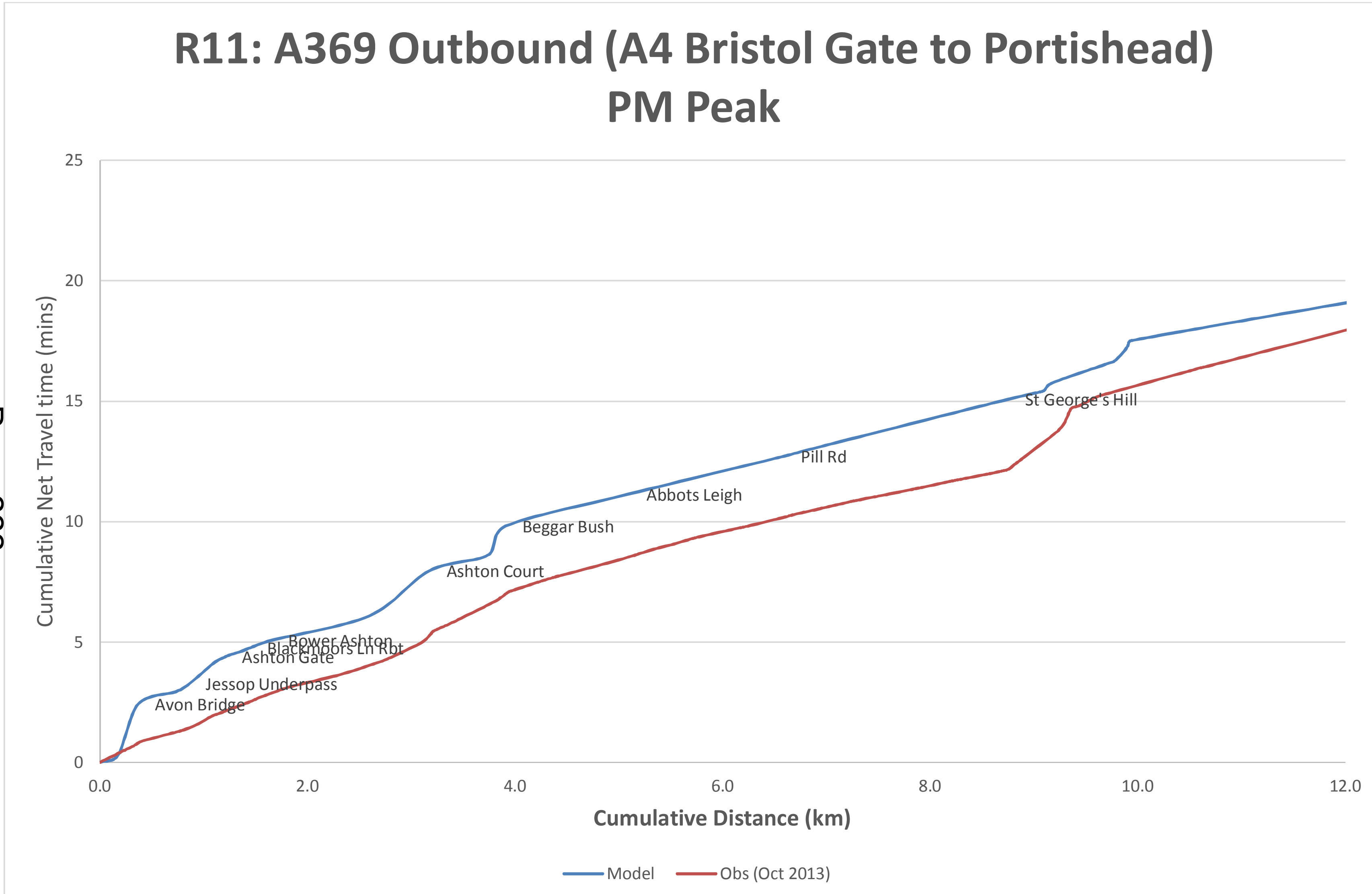

R9: A4018 Inbound (M5 J17 Cribbs to Clifton Triangle)
PM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Rugby Rbt
Brentry Rbt
CanfoRd Rd
White Tree Rbt
White Ladies Gyratory
Clifton Down Station
Queens road
Triangle
Model
Obs (Oct 2013)


R9: A4018 Outbound (College Green to M5 J17 Cribbs)
PM Peak
Cumulative Net Travel time (mins)
25
20
15
10
5
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Cumulative Distance (km)
Clifton Down Station
White Ladies Gyratory
White Tree Rbt
CanfoRd Rd
Brentry Rbt
Rugby Rbt
Model
Obs (Oct 2013)

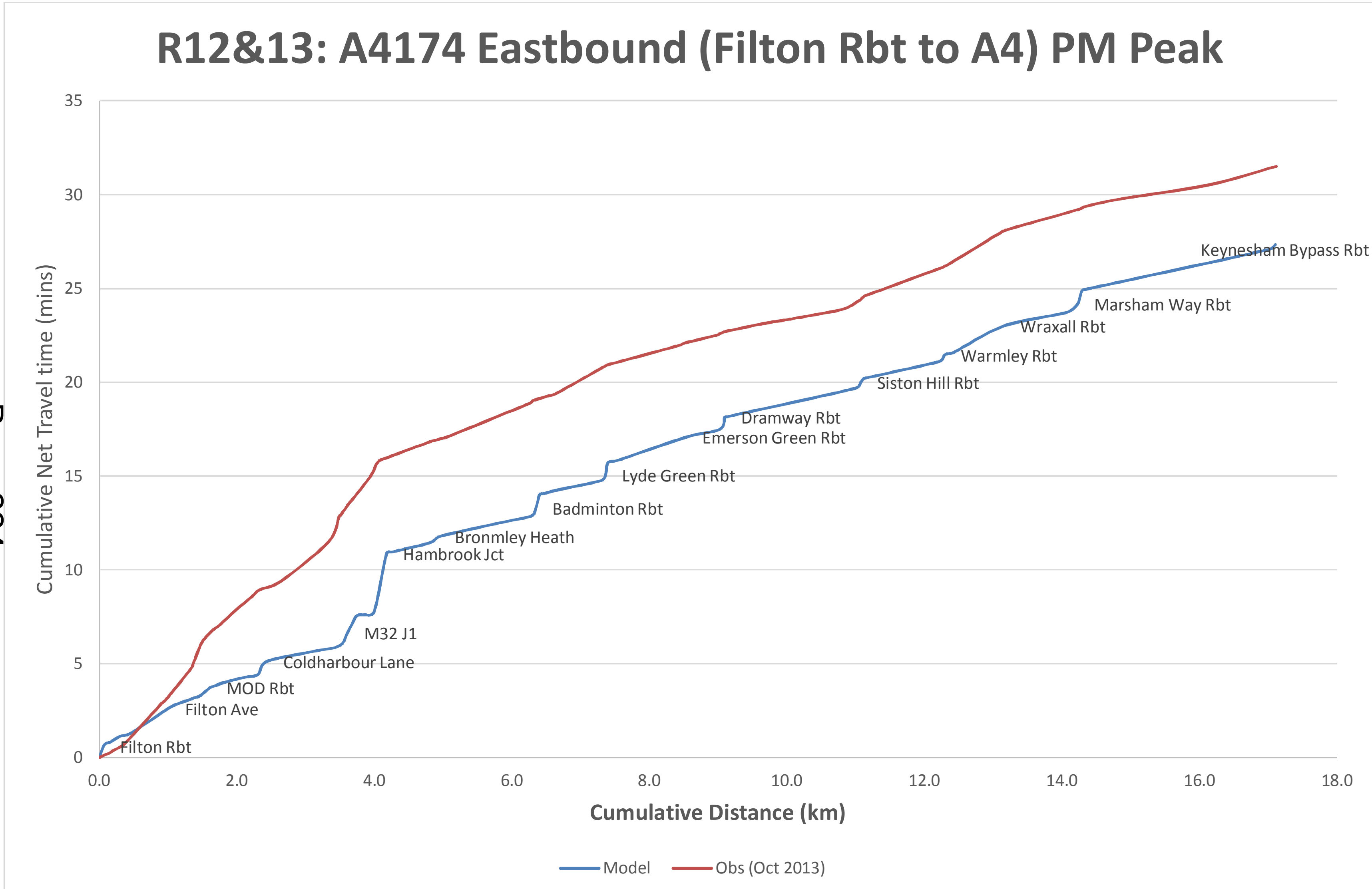

R10: A4 Portway Inbound (Avonmouth to Hotwells)
PM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
2
4
6
8
10
12
14
16
18
20
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Avonmouth/M5 Jct
Shirehampton P&R
Sylvan Way
Sea Mills
Bridge Valley Rd
Model
Obs (Oct 2013)

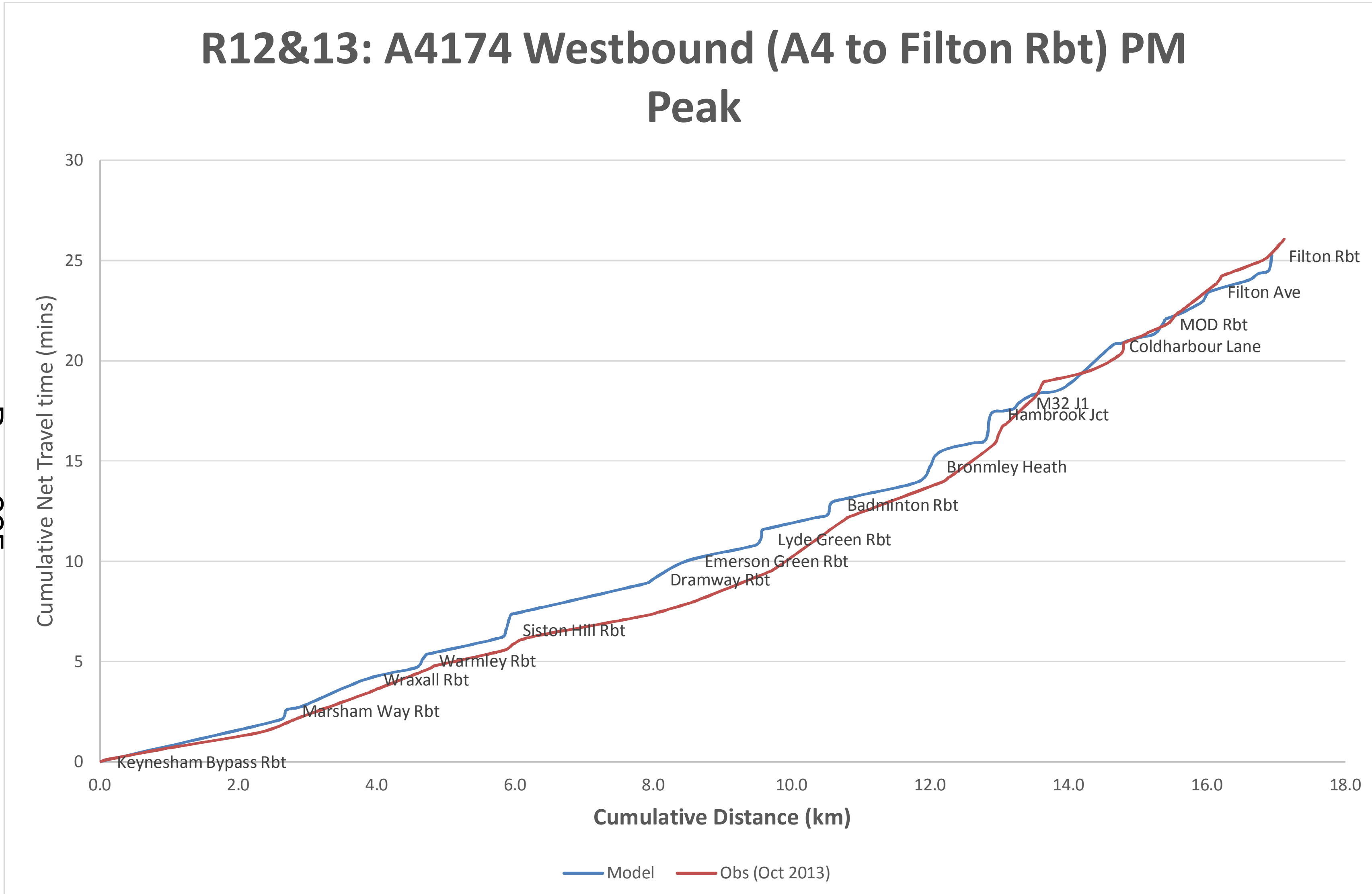

R10: A4 Portway Outbound (Hotwells to Avonmouth)
PM Peak
Cumulative Net Travel time (mins)
0
2
4
6
8
10
12
14
Cumulative Distance (km)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Plimsol Bridge
Bridge Valley Rd
Sea Mills
Sylvan Way
Shirehampton P&R
Model
Obs (Oct 2013)

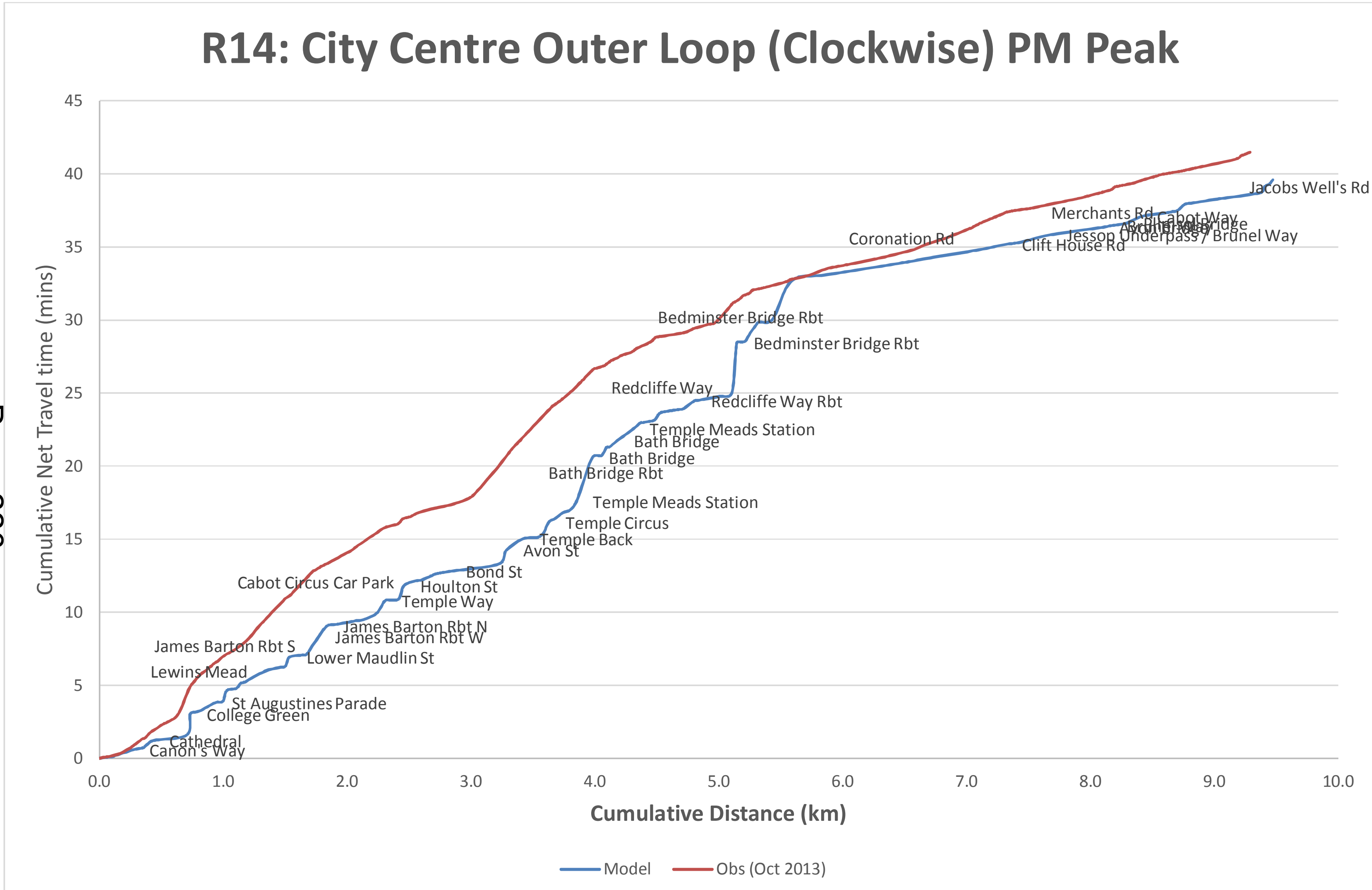

R11: A369 Inbound (Portishead to A4 Bristol Gate) PM Peak
Cumulative Net Travel time (mins)
0
2
4
6
8
10
12
14
16
18
Cumulative Distance (km)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Sheepway Rbt
The Portbury Hundred
M5 J19
St George's Hill
Pill Rd
Abbots Leigh
Beggar Bush
Ashton Court
Bower Ashton
Model
Obs (Oct 2013)



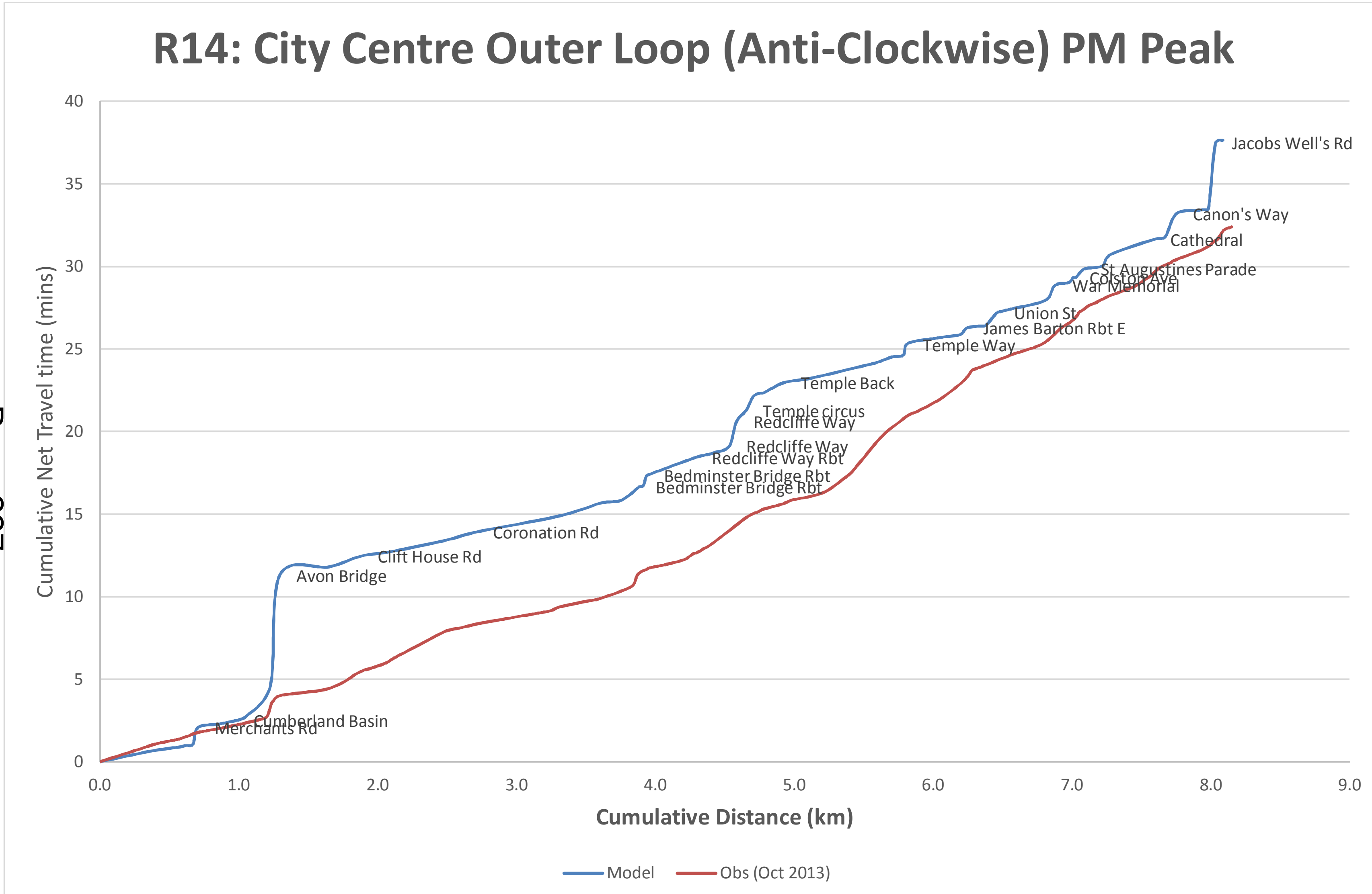
R11: A369 Outbound (A4 Bristol Gate to Portishead)
PM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Avon Bridge
Jessop Underpass
Ashton Gate
Blackmoors Ln Rbt
Bower Ashton
Ashton Court
Beggar Bush
Abbots Leigh
Pill Rd
St George's Hill
Model
Obs (Oct 2013)

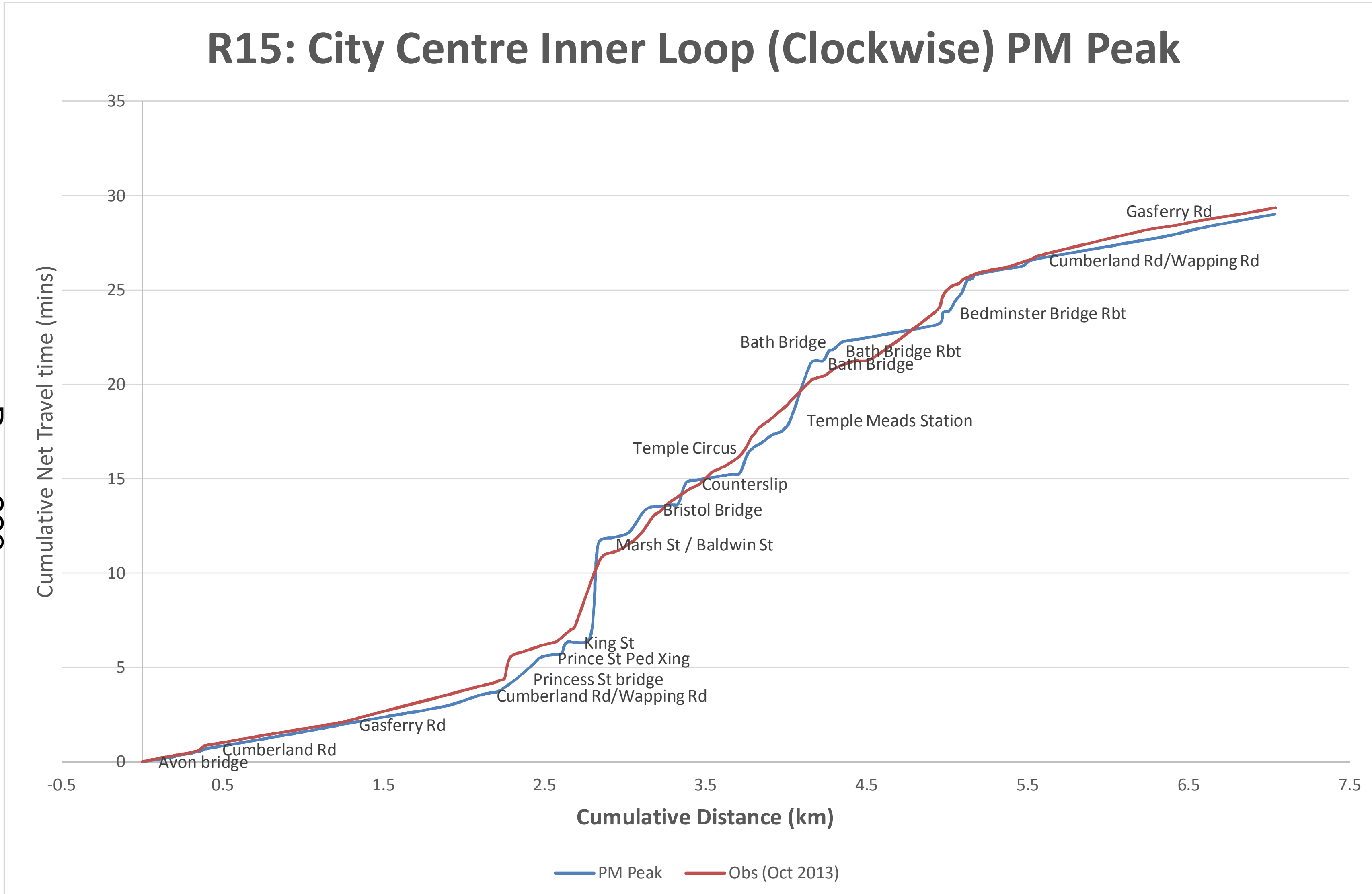

R12&13: A4174 Eastbound (Filton Rbt to A4) PM Peak
Cumulative Net Travel time (mins)
35
30
25
20
15
10
5
0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
Cumulative Distance (km)
Filton Rbt
Filton Ave
MOD Rbt
Coldharbour Lane
M32 J1
Hambrook Jct
Bronmley Heath
Badminton Rbt
Lyde Green Rbt
Emerson Green Rbt
Dramway Rbt
Siston Hill Rbt
Warmley Rbt
Wraxall Rbt
Marsham Way Rbt
Keynesham Bypass Rbt
Model
Obs (Oct 2013)

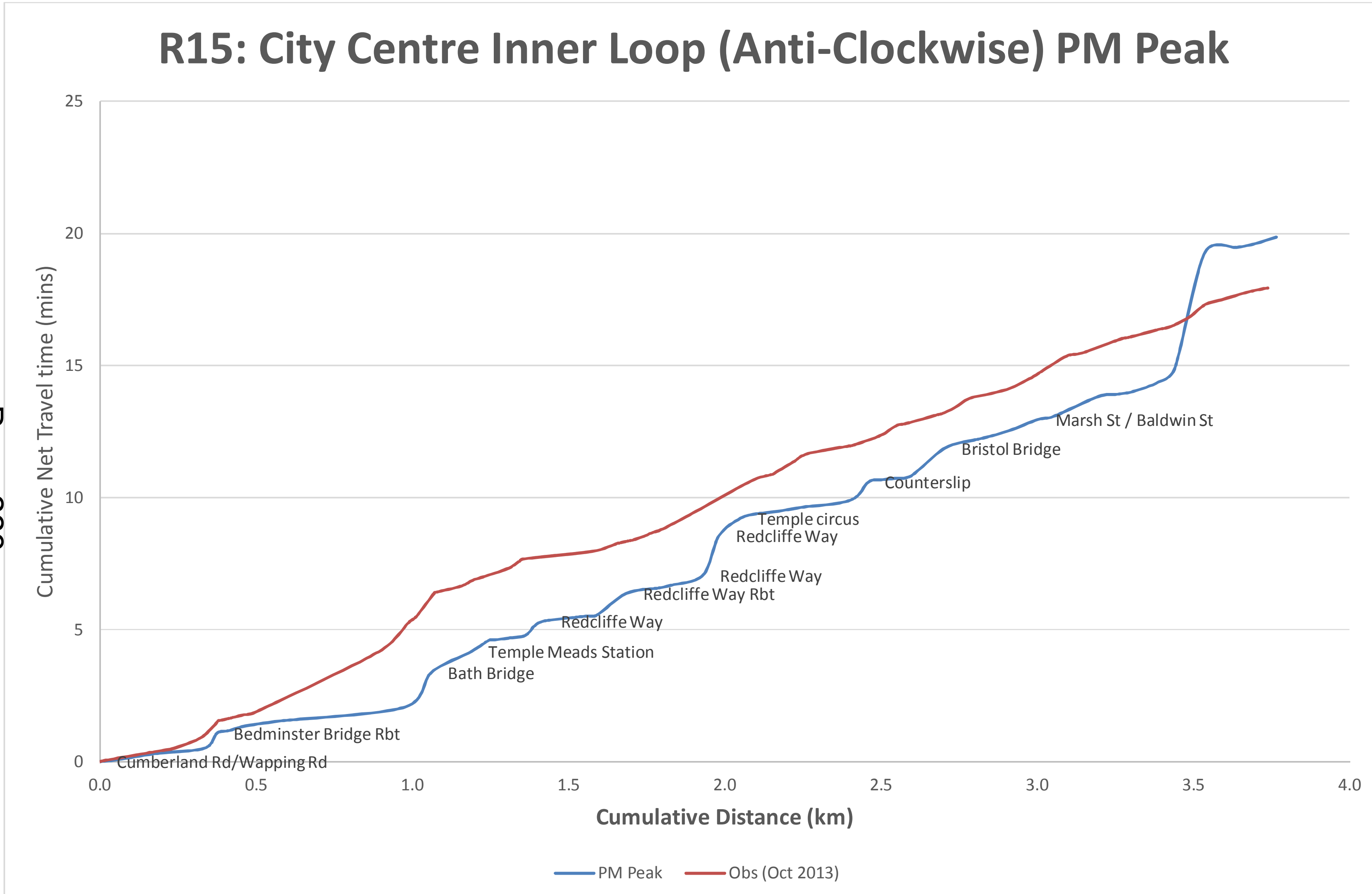

R12&13: A4174 Westbound (A4 to Filton Rbt) PM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
30
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
Keynesham Bypass Rbt
Marsham Way Rbt
Wraxall Rbt
Warmley Rbt
Siston Hill Rbt
Dramway Rbt
Emerson Green Rbt
Lyde Green Rbt
Badminton Rbt
Bronmley Heath
Hambrook Jct
M32 J1
Coldharbour Lane
MOD Rbt
Filton Ave
Filton Rbt
Model
Obs (Oct 2013)

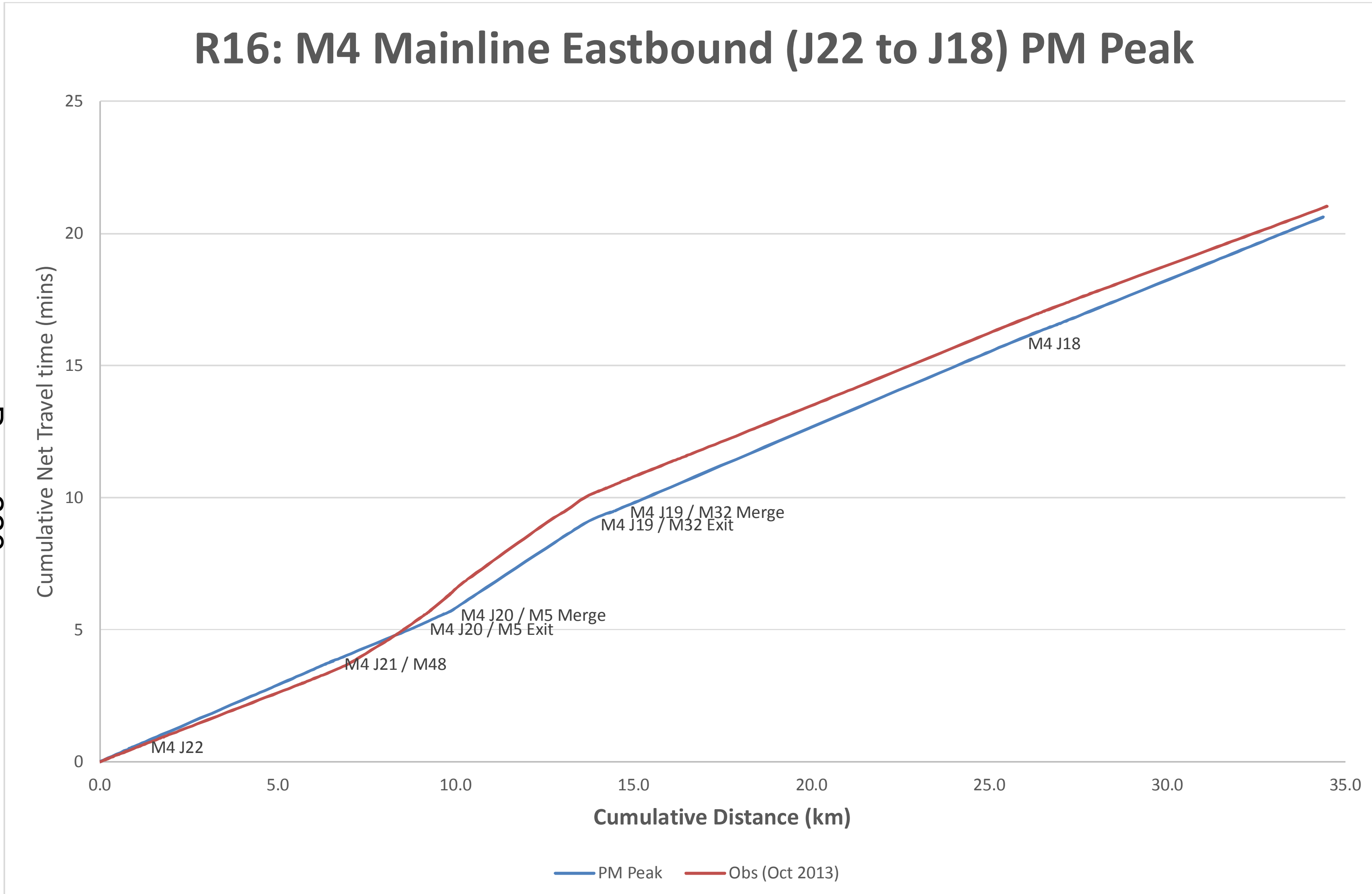


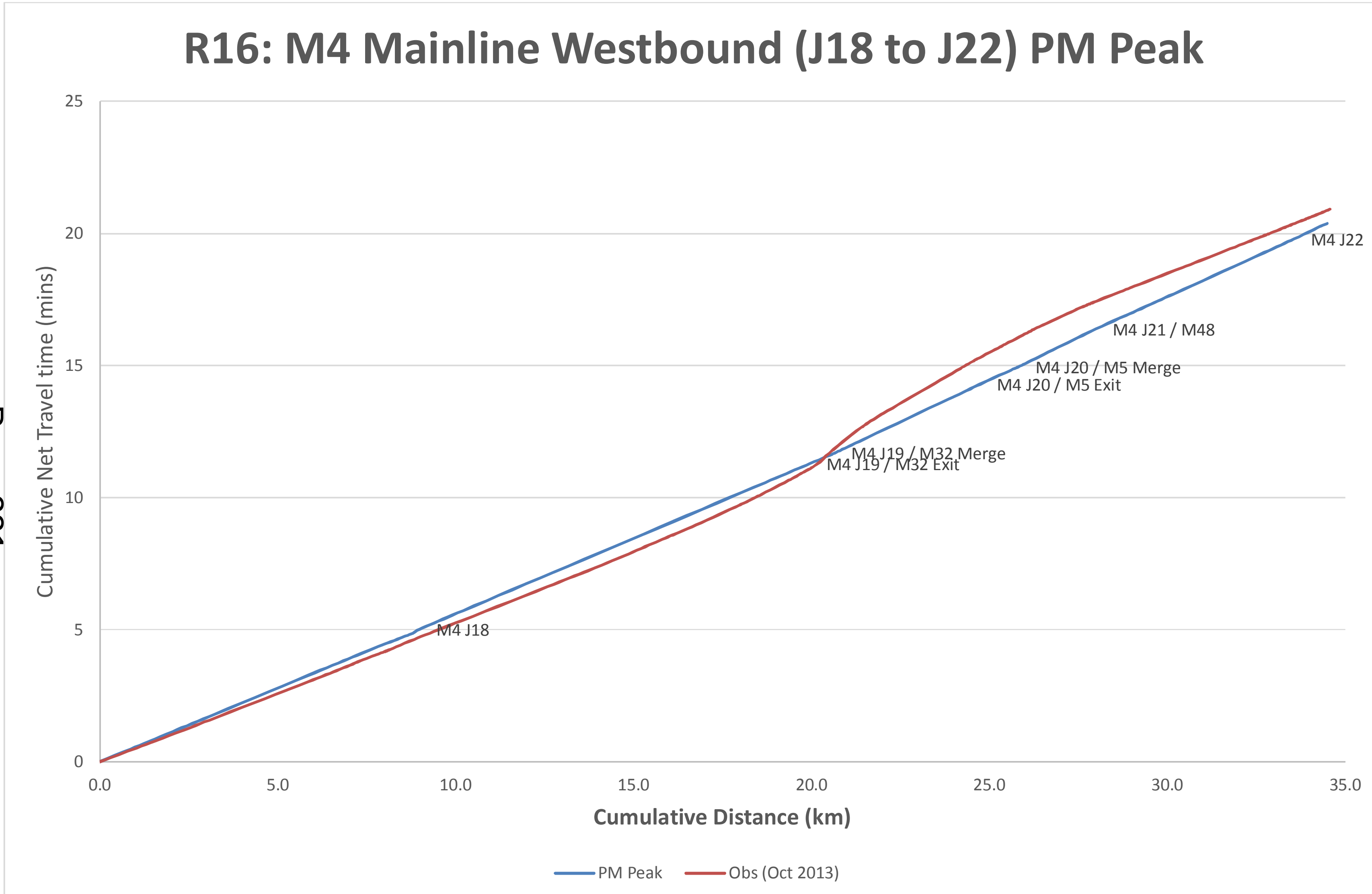
R14: City Centre Outer Loop (Clockwise) PM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
30
35
40
45
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Jacobs Well's Rd
Merchants Rd
Cabot Way
Jessop Underpass / Brunel Way
Clift House Rd
Coronation Rd
Bedminster Bridge Rbt
Bedminster Bridge Rbt
Redcliffe Way
Redcliffe Way Rbt
Temple Meads Station
Bath Bridge
Bath Bridge
Bath Bridge Rbt
Temple Meads Station
Temple Circus
Temple Back
Avon St
Bond St
Houlton St
Temple Way
Cabot Circus Car Park
James Barton Rbt N
James Barton Rbt W
James Barton Rbt S
Lower Maudlin St
Lewins Mead
St Augustines Parade
College Green
Cathedral
Canon's Way
Model
Obs (Oct 2013)

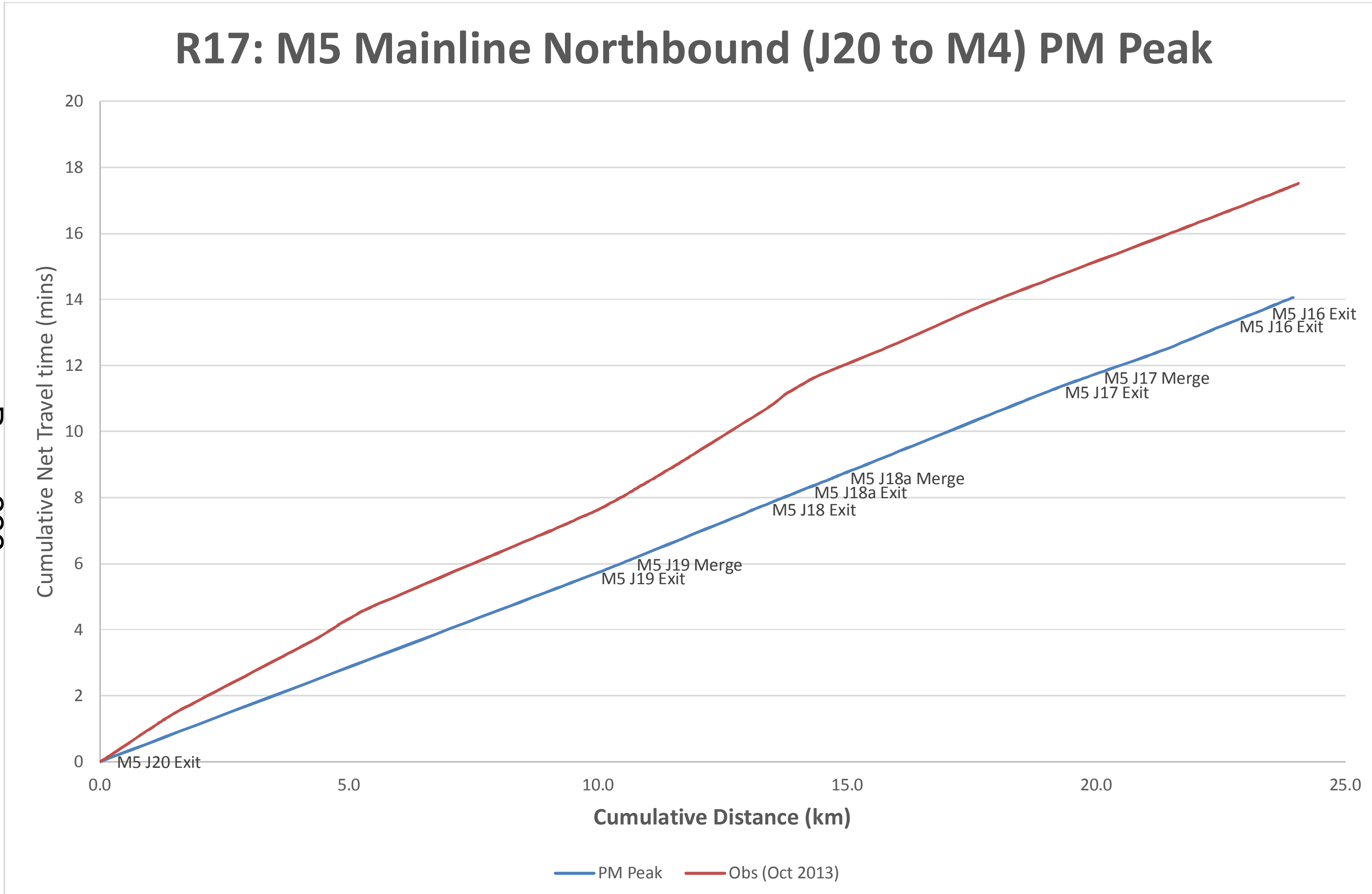

R14: City Centre Outer Loop (Anti-Clockwise) PM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
30
35
40
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Jacobs Well's Rd
Canon's Way
Cathedral
St Augustines Parade
Colston Ave
War Memorial
Union St
James Barton Rbt E
Temple Way
Temple Back
Temple circus
Redcliffe Way
Redcliffe Way
Redcliffe Way Rbt
Bedminster Bridge Rbt
Bedminster Bridge Rbt
Coronation Rd
Clift House Rd
Avon Bridge
Cumberland Basin
Merchants Rd
Model
Obs (Oct 2013)

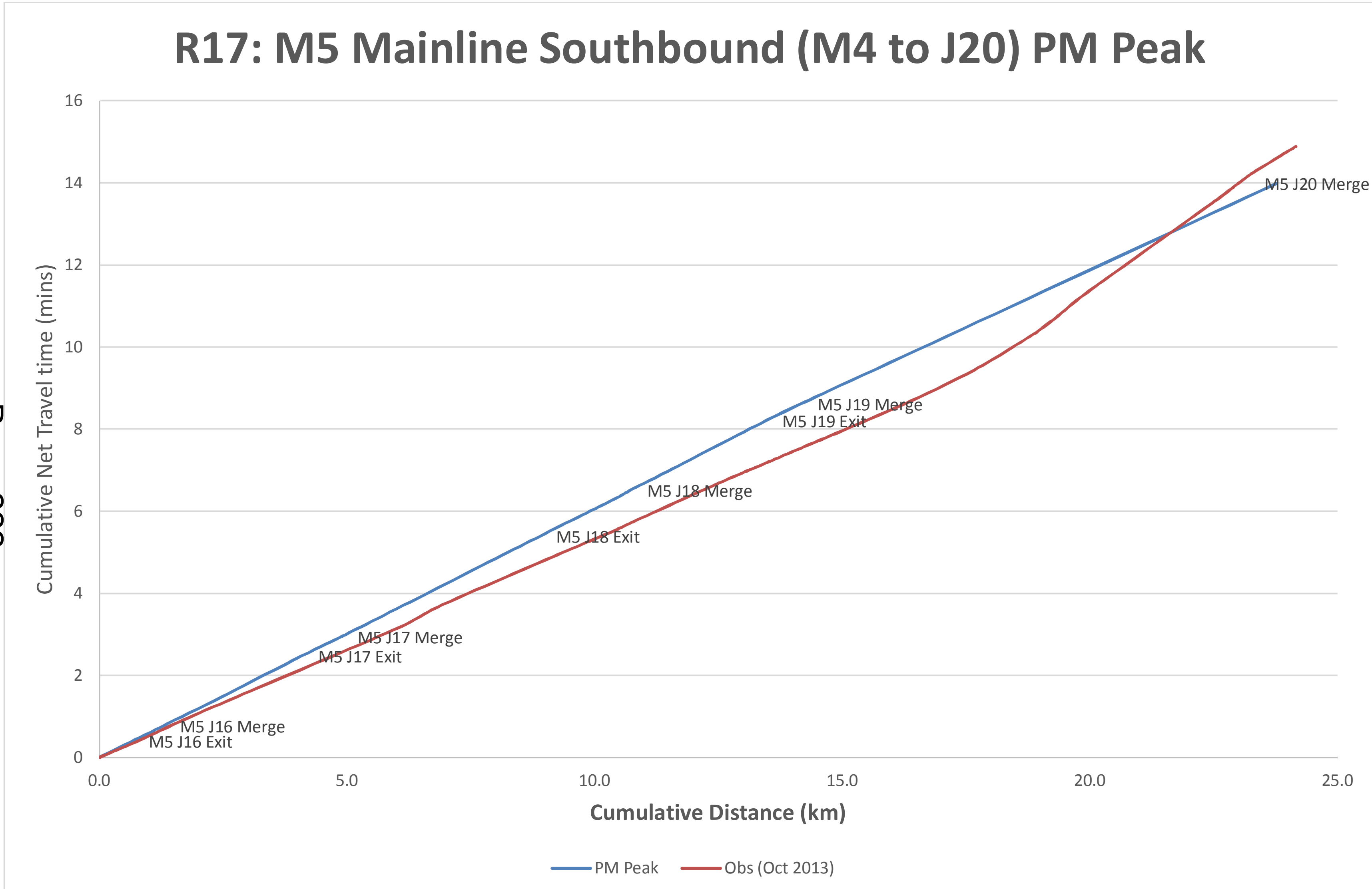

R15: City Centre Inner Loop (Clockwise) PM Peak
Cumulative Net Travel time (mins)
35
30
25
20
15
10
5
0
-0.5
0.5
1.5
2.5
3.5
4.5
5.5
6.5
7.5
Cumulative Distance (km)
Gasferry Rd
Cumberland Rd/Wapping Rd
Bedminster Bridge Rbt
Bath Bridge
Bath Bridge Rbt
Bath Bridge
Temple Meads Station
Temple Circus
Counterslip
Bristol Bridge
Marsh St / Baldwin St
King St
Prince St Ped Xing
Princess St bridge
Cumberland Rd/Wapping Rd
Gasferry Rd
Cumberland Rd
Avon bridge
PM Peak
Obs (Oct 2013)


R15: City Centre Inner Loop (Anti-Clockwise) PM Peak
Cumulative Net Travel time (mins)
25
20
15
10
5
0
Cumberland Rd/Wapping Rd
Bedminster Bridge Rbt
Bath Bridge
Temple Meads Station
Redcliffe Way
Redcliffe Way Rbt
Redcliffe Way
Redcliffe Way
Temple circus
Counterslip
Bristol Bridge
Marsh St / Baldwin St
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Cumulative Distance (km)
PM Peak
Obs (Oct 2013)


R16: M4 Mainline Eastbound (J22 to J18) PM Peak
Cumulative Net Travel time (mins)
0
5
10
15
20
25
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Cumulative Distance (km)
M4 J22
M4 J21 / M48
M4 J20 / M5 Merge
M4 J20 / M5 Exit
M4 J19 / M32 Merge
M4 J19 / M32 Exit
M4 J18
PM Peak
Obs (Oct 2013)


R16: M4 Mainline Westbound (J18 to J22) PM Peak
Cumulative Net Travel time (mins)
Cumulative Distance (km)
0
5
10
15
20
25
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
M4 J18
M4 J19 / M32 Merge
M4 J19 / M32 Exit
M4 J20 / M5 Merge
M4 J20 / M5 Exit
M4 J21 / M48
M4 J22
PM Peak
Obs (Oct 2013)


R17: M5 Mainline Northbound (J20 to M4) PM Peak
Cumulative Net Travel time (mins)
20
18
16
14
12
10
8
6
4
2
0
0.0
5.0
10.0
15.0
20.0
25.0
Cumulative Distance (km)
M5 J20 Exit
M5 J19 Merge
M5 J19 Exit
M5 J18a Merge
M5 J18a Exit
M5 J18 Exit
M5 J17 Merge
M5 J17 Exit
M5 J16 Exit
M5 J16 Exit
PM Peak
Obs (Oct 2013)


R17: M5 Mainline Southbound (M4 to J20) PM Peak
16
14
12
10
8
6
4
2
0
Cumulative Net Travel time (mins)
0.0
5.0
10.0
15.0
20.0
25.0
Cumulative Distance (km)
M5 J16 Exit
M5 J16 Merge
M5 J17 Exit
M5 J17 Merge
M5 J18 Exit
M5 J18 Merge
M5 J19 Exit
M5 J19 Merge
M5 J20 Merge
PM Peak
Obs (Oct 2013)

Appendix G: Model Convergence Graphs

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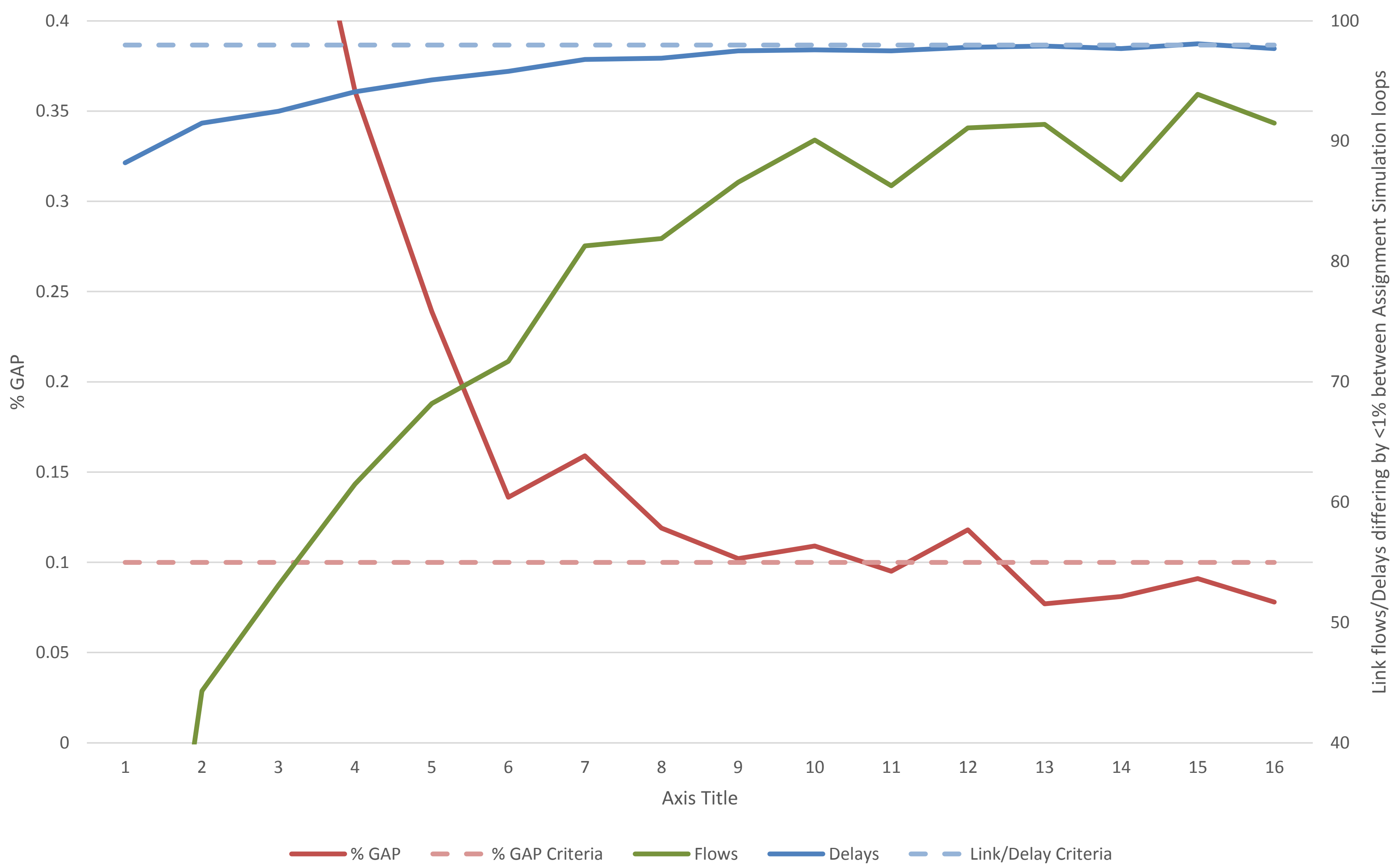
Figure G1 - AM Peak: % GAP and Link Flows



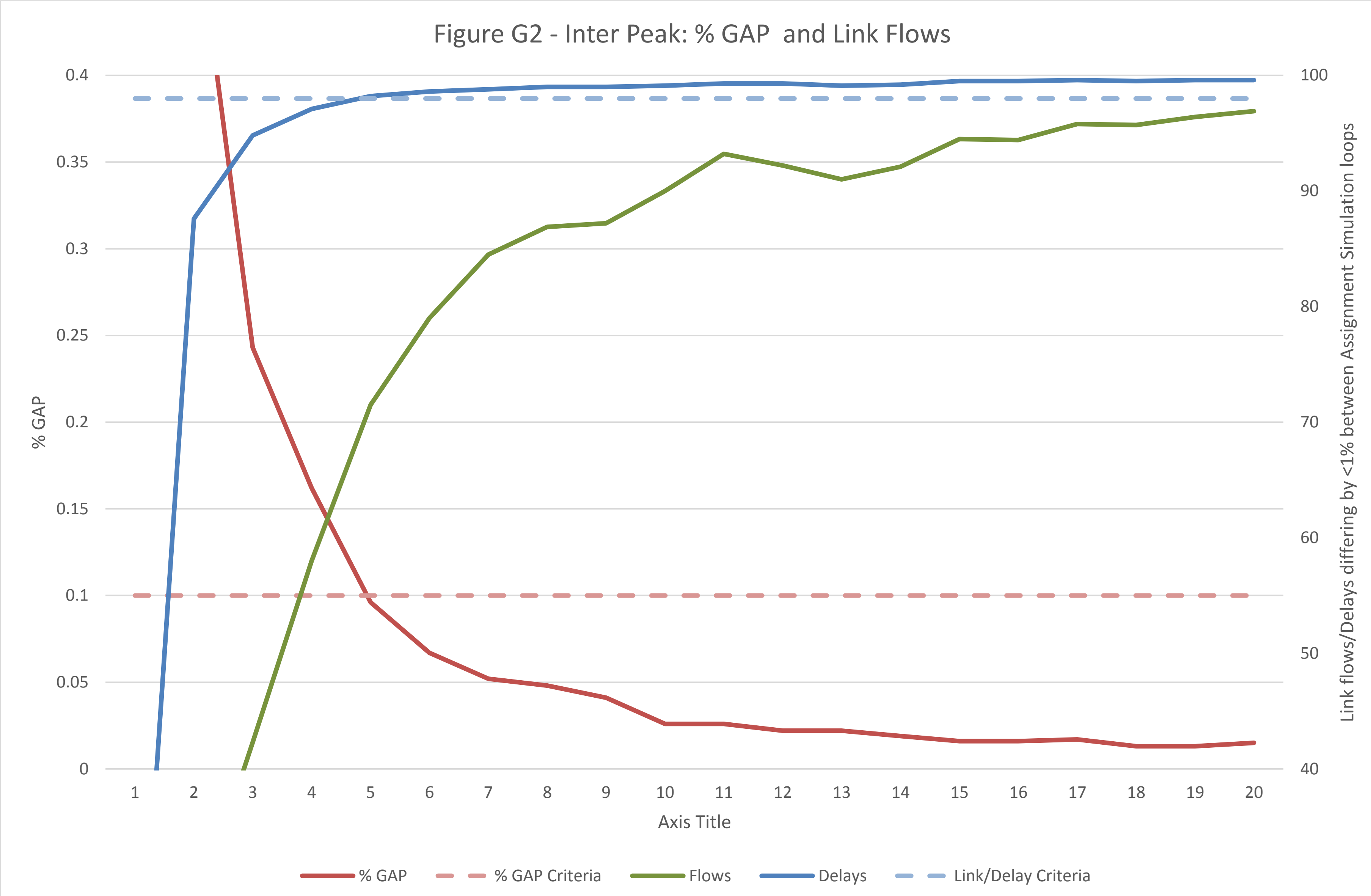


Figure G2 - Inter Peak: % GAP and Link Flows
% GAP
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
100
90
80
70
60
50
40
Link flows/Delays differing by <1% between Assignment Simulation loops
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Axis Title
% GAP
% GAP Criteria
Flows
Delays
Link/Delay Criteria

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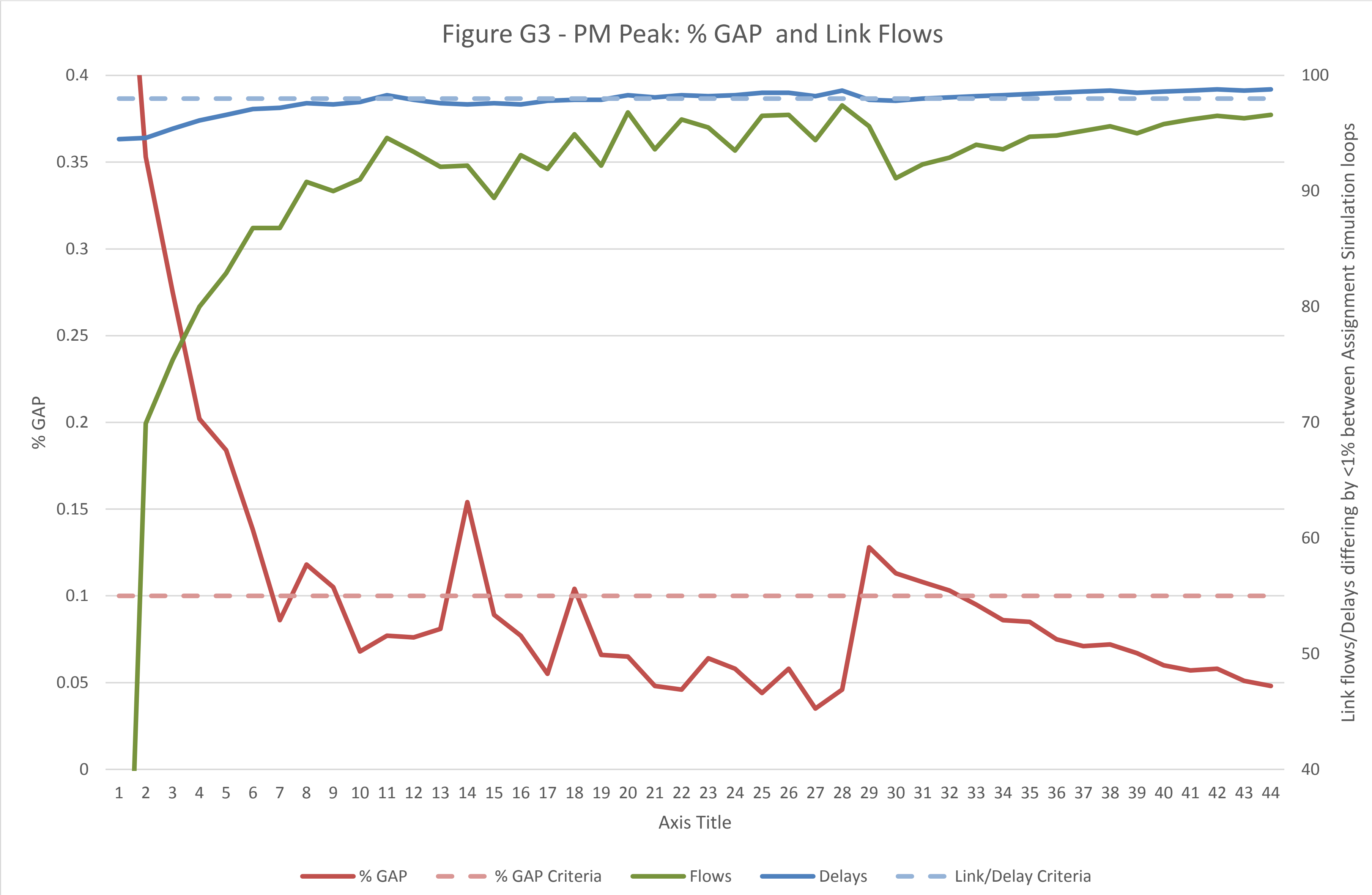

Figure G3 - PM Peak: % GAP and Link Flows
% GAP
Link flows/Delays differing by <1% between Assignment Simulation loops
Axis Title
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
100
90
80
70
60
50
40
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44
% GAP
% GAP Criteria
Flows
Delays
Link/Delay Criteria

G-BATS4M Model Update

Demand Model Report

Prepared for

West of England Authorities

10 August 2015

CH2MHILL®

1 The Square
Temple Quay
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BS1 6DG

Document History

GBATS4M Model Update

Demand Model Report

West of England Authorities

This document has been issued and amended as follows:

Version	Date	Description	Created by	Verified by	Approved by
1.0	08.05.15	Draft Demand Model Report	Katherine Williams/Jeff Tjiong	Chris Bushell	Chris Bushell
1.0	10.08.15	Final Report	Katherine Williams/Jeff Tjiong	Chris Bushell	Chris Bushell

Contents

SECTION 1

Introduction

1.1 Background

This report has been prepared by CH2M Hill as part of their commission to update to the Greater Bristol Area Transport Study (G-BATS) modelling suite for Bristol City Council (BCC), on behalf of the West of England authorities.   The updated model is called the GBATS4 Metro Model (GBATS4M).

This report shows that the updated the Demand Model meets WebTAG guidance (TAG) in terms of structure, parameters used and realism tests, to demonstrate it is fit for purpose to test the impact of proposed future year schemes, in conjunction with the G-BATS4M Highway and Public Transport (PT) models.

1.2 This Report

The remainder of this report consists of the following sections:

- Section 2 – Model Usage and Design Considerations;
- Section 3 – Model Structure;
- Section 4 – Data Requirements; and
- Section 5 – Model Standards and Calibration.

SECTION 2

Model Usage and Design Considerations

2.1 Metro West

The GBATS4M modelling suite provides a tool with which to test the ability of future transport proposals to support forecast travel demand. At a general level this includes:

- Investigation of new development proposals; and
- Longer-term strategic planning of the transport network.

The specific purpose of the model is for assessing the MetroWest major scheme Phases 1 and 2.

2.2 Potential Alternative Uses

The GBATS4M modelling suite could (with further validation if necessary) also be used to forecast and assess a range of alternative potential interventions. While not a definitive list, the following future year schemes could potentially be assessed:

- Bristol Arena
- Temple Circus Roundabout / Redcliffe Way;
- Temple Quarter Enterprise Zone;
- Central Area Action Plan;
- Changes to bus operations;
- Park and Ride schemes;
- M4 Link;
- North Fringe VISSIM interface;
- Strategic wider area schemes; and
- Major development proposals in the wider urban area.

2.3 Model Design Considerations

The GBATS Demand Model is a complex, strategic five-stage model developed to cover the greater Bristol area. The model structure is consistent with the previous GBATS3 suite of models, including time period choice and segmentation by income groups, which provides flexibility in terms of potential to assess a wide range of schemes.

To support better control and ease of specifying model assumptions a new spreadsheet-based model user interface which contains all relevant model parameters has been built.

SECTION 3

Model Structure

3.1 Software

The Demand Model has been implemented using the EMME modelling software platform through a series of macros, containing the required executable commands and matrix calculations. The Demand Model macros interface with the Saturn highway and EMME PT model. A ‘front-end’ Excel spreadsheet has been developed to hold calibrated parameters and where the user can define certain run-specific inputs. This Excel file contains a number of macros written in Visual Basic, which perform file manipulations and call the EMME macros and SATURN assignments / network skim functions, as required to provide a fully automated and integrated interface between the G-BATS4M highway, PT and Demand models.

3.2 Zone system

The zone system used by the Demand Model is the same as that used by the G-BATS4 highway and PT models.

3.3 Temporal Scope

The Demand Model operation covers a 12 hour period interfacing with the G-BATS4 highway and PT assignment modelled hours as follows:

- AM peak hour: 0800-0900
- Inter-Peak (IP) modelled hour: average of 1000-1600; and
- PM peak hour: 1700 – 1800.

3.4 Segmentation

The Demand Model uses a greater level of segmentation than the highway and PT assignment models, in order to represent demand responses for different journey purposes and person types as advised by TAG.

The Demand Model segmentation is as follows:

By car availability

- Car available; and
- Non-car available

By household income

- Income Low: under £23,000
- Income Medium: £23,000 to £46,000
- Income High: over £46,000

These bands are based on latest TAG advice. Income segmentation is only applied to commute and other car available demand segments.

By journey purpose

- Commuting / Home based work (HBW)
- Home based and non-home based employer’s business (EMP)
- Home based and non-home based other trips (OTH)

This yields 10 demand segments as shown in Table 3.1.

TABLE 3.1
Demand Model Segmentation

Description	Demand Purpose	Car Available (CA)			Non Car Available (NCA)
		<£23,000	£23,000 to £46,000	> £46,000	
Commute	HBW	1	2	3	8
Other	OTH	4	5	6	9
Work	EMP	7			10

3.5 Cost Formulation

Generalised costs (GCs) are calculated in terms of minutes from highway and PT model time and distance skims as described below. The cost calculations in the Demand Model are expressed as changes in GCs from the base year.

Car

Time and cost skims are extracted separately for the highway model user classes: HBW, EMP and OTH, which vary with respect to value of time (VOT) assumptions.

The GC calculation is of the form:

C_{ij} (car.^{p}) = T_{ij} + (f.c.D_{ij} + nf_{ij} + P_j)/($v^{(p)}$.$o^{(p)}$)

Where:

C_{ij} (car. p) = generalised cost by car between i and j, for segment p;
T = time in minutes (including in-vehicle time and walk access);
f = fuel cost in pence per litre;
c = fuel consumption in litres per kilometre;
nf = non fuel cost in p per kilometre (business trips only)
D = highway distance in km;
P = parking charge in pence obtained from local data (taken as half per trip);
v(p) = value of time for segment p in pence per minute; and
o(p) = car occupancy for segment p.
Fuel consumption is estimated using a function of the form:

$L = a/v + b + c.v + d.v^2$

Where:

L = consumption, expressed in litres per kilometre;
v = average speed in kilometres per hour; and
a, b, c, d are parameters defined for each vehicle category.

The non-fuel elements of vehicle operating costs (VOC) are combined in a formula of the form;

C = a1 + b1/V,

Where;

C = cost in pence per kilometre travelled,
V = average link speed in kilometres per hour,
a1 is a parameter for distance related costs defined for each vehicle category, and
b1 is a parameter for vehicle capital saving defined for each vehicle category (this parameter is only relevant to working vehicles).

Bus / rail

Public transport GCs are calculated for each purpose, differing in respect of VOT. They are derived as follows:

$C_{ij}^{(pt.p)} = f.D_{ij}/v^{(pt)} + I_{ij} + w.W_{ij} + x.X_{ij} + a.A_{ij}$

Where:

$C_{ij}^{(pt.p)}$= generalised cost by public transport between i and j for purpose segment (p);
f = fare per kilometre in pence;
D = travel distance in km;
$v^{(pt)}$ = value of time for segment p in pence per minute;
I = in-vehicle time in min;
w = wait time weight;
W = wait time in min;
x = transfer penalty in min;
X = number of transfers;
a = access and egress time weight; and
A = access and egress time in min.
Weights applied for walking and waiting are in line with TAG advice.

Park and Ride (submode)

P&R GCs are calculated as follows:

$C_{ij}^{(P\&R.p)} = C_{ik}^{(car.\ p)} + C_{kj}^{(bus.\ p)}$

Where:

$C_{ij}^{(P\&R.p)}$ = GC by P&R for purpose segment (p)
k = P&R site zone

Change in Generalised Cost

The changes in GC that drive the demand response calculations are calculated as follows:

$\Delta C_{ij}^{m(p.t)} = (C_{ij}^{m(p.t)} - C^{0}{}_{ij}^{m(p.t)})$

Where:

$\Delta\ C_{ij}^{m(p.t)}$= change in generalised cost for mode m, segment p and time period t;
$C_{ij}^{m(p.t)}$ = test cost for mode m, segment p and time period t; and
$C^{0}{}_{ij}^{m(p.t)}$ = base cost for mode m, segment p and time period t.

Where costs are used in demand response calculations that relate to alternatives considered 'lower' in the model hierarchy, these are composite costs calculated using logsum equations, as advised in TAG.

3.6 Demand responses

Demand response calculations are undertaken for travel demands and costs translated into Production-Attraction (PA) format in accordance with TAG, using OD to PA factors derived from survey data.

Calculations are undertaken for each demand response following incremental logit model form as outlined below, with future test travel costs pivoted off the base year model.

In order to preserve the integrity of the validated highway / PT model origin-destination (OD) assignment matrices, the implied demand changes in PA form are translated to OD form and used to incrementally adjust the assignment matrices.

Demand responses are as follows:

- Trip frequency
- Main mode choice (car vs PT)
- Time period choice
- Destination choice

- Sub-mode choice (car vs P&R and rail vs bus/BRT)

Appendix A provides the model formulation for demand responses and cost calculations using standard TAG notation.

The Demand Model does not explicitly model slow modes (walk / cycle), but models trip frequency instead in accordance with TAG.

Main mode choice is only applied to 'car available' trips.

Time period choice is only applied to 'other' trips, in line with TAG advice that commute and employer's business trips will have limited flexibility in terms of timing.

The destination choice response is handled for each mode / time period separately.

For HBW trips, the destination choice model is doubly constrained by balancing the travel demands according to the calculated zonal trip productions/attractions.

Sub-mode choice calculations are undertaken to forecast change in sub-modes with the same general model form as main mode choice, as follows:

- Main mode PT has sub-modes: bus/BRT and rail
- Main mode car has sub-modes: car only and P&R.

3.7 Park and Ride

P&R is modelled as a sub-mode choice of the car main mode to forecast P&R site usage for the seven car available demand segments on a PA basis. Three separate park-and-ride sites are covered within the model area, as follows:

- A4 Bath Road (~1300 car parking spaces)
- A4 Portway (~500 car parking spaces)
- A370 Long Ashton (~1500 car parking spaces)

Parking capacity restraint are not modelled explicitly in the Demand Model to avoid the complexities of a full modelling of parking which would be viewed as disproportionate as per the TAG guidance on modelling parking and park and ride.

The P&R sub-model is implemented in the following sequential steps:

1. Utilising the triple-index operation feature in Emme modelling software to determine the minimum park-and-ride journey cost and "best" P&R site for all PA pairs in the base year. The minimum P&R cost is computed based a combination of the journey cost for the car-only and bus sub-modes :

   $Min(GC\_P\&R_{pq}^{min}) = Min_k(GC\_Car_{pk}^{min} + GC\_Bus_{kq}^{min})$

   Where:

   p = trip production
   q = trip attraction
   k = P&R site
   GC_P&R = generalised cost for the entire P&R journey
   GC_Car = generalised cost for the car-leg of the P&R journey, which includes perceived parking costs at the P&R site
   GC_Bus = generalised cost for the bus-leg of the P&R journey

2. Prepare reference P&R trip productions and attractions and then distribute them through a matrix furness process. It is assumed that any P&R trip on a PA basis is essentially made by car leg to P&R site first, followed by a bus leg of the journey leaving the P&R site. As such, total number of trip productions and trip attractions can be computed using the following functions:

$P\&RTrip\_PA_p = CarTrip\_OD_{ik} + Transposed(CarTrip\_OD_{kj})$

$P\&RTrip\_PA_q = BusTrip\_OD_{kj} + Transposed(BusTrip\_OD_{ik})$

Where:

p = reference trip production
q = reference trip attraction
i = reference trip origin
j = reference trip destination
k = P&R site
P&RTrip_PA = reference P&R trip vector, either production or attraction, on a PA basis
CarTrip_PA = reference car trip OD pairs to/from P&R sites, on a PA basis
BusTrip_PA = reference bus trip OD pairs to/from P&R sites, on a PA basis

The matrix furness process balances the reference P&R trip productions and attractions based on distributional pattern as in the validated car-only PA demand matrices. The furness process is controlled to the trip productions (i.e., the car trip totals to/from P&R sites).

3. Generate incremental P&R productions and attractions at the P&R sub-model stage of the hierarchical logit model using the following function:

$$T_{ij}^{mts} = T_{ij}^{mt} \frac{T_{ij}^{0\,mts} e^{-\lambda_{sub} \Delta C_{ij}^{mts}}}{\sum_k T_{ij}^{0\,mtk} e^{-\lambda_{sub} \Delta C_{ij}^{mtk}}}$$

Where for each demand segment:

k = numeration of sub-modes

T_{ij}^{mts} = adjusted trips by submode

T_{ij}^{mt} = adjusted trips by submode from demand response at higher hierarchy

$T_{ij}^{0\,mts}$= reference trips by submode

ΔC_{ij}^{mts}= change in generalised cost for a given submode

λ_{sub}=P&R logit choice parameter

4. Split the adjusted P&R trips (PA) produced by the incremental model into car and bus legs using the trip-index operation in Emme, assuming these incremental trips would access the best P&R site with minimum combined P&R journey cost as in the base year condition.

3.8 Other Demand

Goods vehicles and external to external car / PT trips have been excluded from the above demand response calculations in the Demand Model. Rather for future years, growth for goods vehicles will be based on DfT regional traffic forecasts. Growth for external to external car / PT trips will be based on Tempro.

SECTION 4

Model Parameters

4.1 WebTAG Parameters

Model parameters have been used as follows:

- Initial parameters and scaling factors for each demand response to be obtained from TAG unit 3.10.3, then adjusted during model calibration, as shown in Tables 4.1 and 4.2; and
- Value of time (VOT) and Vehicle operating cost (VOC) from TAG unit 3.5.6, as shown in Tables 4.3 and 4.4.

TABLE 4.1

TAG M2 Table 5.1 - Illustrative Destination Choice Parameters (Lambda)

CAR	MIN	MEDIAN	MAX
Home-based work	0.054	0.065	0.113
Home-based employers business	0.038	0.067	0.106
Home-based other	0.074	0.090	0.160
Non-home-based employers business	0.069	0.081	0.107
Non-home-based other	0.073	0.077	0.105
PT	**MIN**	**MEDIAN**	**MAX**
Home-based work	0.023	0.033	0.043
Home-based employers business	0.030	0.036	0.044
Home-based other	0.033	0.036	0.062
Non-home-based employers business	0.038	0.042	0.045
Non-home-based other	0.032	0.033	0.035

TABLE 4.2

TAG M2 Table 5.2 - Illustrative Main Mode Choice Scaling Parameters (Theta)

TRIP PURPOSE	MIN	MEDIAN	MAX
Home-based work	0.50	0.68	0.83
Home-based employers business	0.26	0.45	0.65
Home-based other	0.27	0.53	1.00
Non-home-based employers business	0.73	0.73	0.73
Non-home-based other	0.62	0.81	1.00

TABLE 4.3

Value of Time by Income, Purpose and Vehicle Type (p/min)

TRIP PURPOSE / VEHICLE TYPE	Low Income	Medium Income	High Income
Home-based work - Car	6.91	10.22	15.23
Home-based other - Car	8.94	10.90	13.18
Employers business - Car	42.81	42.81	42.81
Employers business - Bus	26.30	26.30	26.30
Employers business - Rail	50.56	50.56	50.56

Calculated from TAG Tables A1.3.1 and M2.1 for VOT adjusted to 2013 prices and values in Table A1.3.2 and the retail price index.

TABLE 4.4
Vehicle Operating Costs

VOC Type	Value
Fuel cost - Non-work (p/litre)	51.20
Fuel cost - Business (p/litre)	40.96
Fuel Consumption Parameter a	0.964023
Fuel Consumption Parameter b	0.041448
Fuel Consumption Parameter c	-0.000045
Fuel Consumption Parameter d	0.000002
Non Fuel Cost Parameter a1 (p/km)	5.25
Non Fuel Cost Parameter b1 (p/hr)	143.73

Values from TAG Tables A1.3.7, A1.3.8 and A1.3.14

4.2 OD to PA Factors

OD to PA and purpose split factors have been applied to derive matrices segmented by purpose for use in the Demand Model have been derived from roadside interview and PT survey data for car and PT trips respectively. The factors are shown in Tables 4.5 and 4.6.

TABLE 4.5
Highway OD to PA Factors

PURPOSE/DIRECTION	AM	IP	PM
Home-based work Out	0.98	0.50	0.05
Home-based work Return	0.02	0.50	0.95
Home-based other Out	0.88	0.49	0.54
Home-based other Return	0.12	0.51	0.46
Employers business	1.00	1.00	1.00

TABLE 4.6
PT OD to PA Factors

PURPOSE/DIRECTION	AM	IP	PM
Home-based work Out	0.95	0.30	0.06
Home-based work Return	0.05	0.70	0.94
Home-based other Out	0.88	0.49	0.15
Home-based other Return	0.12	0.51	0.85
Employers business	1.00	1.00	1.00

4.3 Car Occupancy and Availability

Car occupancy factors have been derived from local roadside interview survey data. Table 4.7 shows the values used for each time period and purpose.

TABLE 4.7
Car Occupancy

PURPOSE	AM	IP	PM
Home-based work	1.22	1.19	1.16
Home-based other	1.65	1.62	1.58
Employers business	1.30	1.22	1.27

Car availability factors have been derived from PT survey data. This is more appropriate than population-based car availability data, such as census data, as it is the PT demand in particular that is segmented according to car availability. Table 4.8 shows the PT car availability factors.

TABLE 4.8
PT Car Availability Factors

PURPOSE	Car Available	No Car Available
Home-based work	0.58	0.42
Home-based other	0.48	0.52
Employers business	0.59	0.41

4.4 PT Fares

Rail fares have been derived from MOIRA data. Bus fares have been derived from local operator data.

Table 4.9 shows the PT fares used together with the weight and transfer penalties used from TAG M3.2. The PT fares used are weighted averages that include concessionary fares and use of season tickets.

TABLE 4.9
PT Fares

Sector	Value
Bus fare (p/km)	26.70
Rail fare (p/km)	15.00
Wait time weight	2.00
Walk time (Aux) weight	2.00
Transfer Penalty (min)	10.00

4.5 Parking Charges

Parking charges have been obtained from published data. Weighted average parking charges have been calculated per zone within the city centre, based on parking usage data, the number of spaces of each parking type (public, private non-residential and on-street parking) and length of stay data. The parking charges are then used in the highway generalised cost calculations.

Table 4.10 shows half the cost of parking in the city centre zones, which were sectored into 3 areas, Temple Meads/Redcliffe, Broadmead/Cabots Circus/Colston and Waterfront/Floating Harbour/Queens Square. Work parking charges were based on long stay (>5 hours) parking costs and free spaces, whereas the other and employer's business parking charges were based on short stay (<5 hours) parking costs and free spaces.

TABLE 4.10
Parking Charges (in pence, half the cost of parking)

Sector	Home-based work	Home-based other	Employers business
1	676	360	360
2	285	216	216
3	527	225	225

SECTION 5

Model Calibration

5.1 Calibration

An initial run of the Demand Model was undertaken using median TAG demand response parameters. Demand Model parameters were then adjusted with small increments until a final set of parameter values were reached which produce model behaviour satisfying the realism tests criteria to demonstrate demand responses lie within TAG elasticity ranges.

The realism tests applied are specified in TAG unit 3.10.4 to test model response to changes in travel costs. These have been undertaken for 10% increases in the following:

- Car fuel cost;
- Car journey times;
- PT fares; and
- Bus Fares.

The arc elasticity formula recommended by TAG was used for calculating the resulting realism test outputs:

$e = \log(T^1) - \log(T^0) / \log(C^1) - \log(C^0) = \log(T^1) - \log(T^0) / \log(1.1)$

where the subscripts 0 and 1 indicate values before and after the change in cost respectively, and for:

- Car fuel cost elasticity: T = car-kms travelled and C = fuel costs;
- Car journey time elasticity: T = car trips and C = journey time;
- PT fare elasticity: T = PT trips and C = bus and rail fares; and
- Bus fare elasticity: T = Bus trips and C = bus fares.

Table 5.1 shows a summary of the realism test changes required to the demand model, the measure of demand change and the resulting output criteria.

TABLE 5.1
Realism Test Summary

Test	Adjustment	Measure of cost change	Measure of demand change	Criteria
Car Fuel Cost	Increase PPK in SATURN and fuel cost (p/l) in demand model by 10%	Fuel cost pence / litre	Car km for each time period and UC calculated from sum of trips x distance skim (need to skim all time periods) - matrix based and network based. Exclude ext-ext and ex-int trips.	By purpose -0.1 to -0.4 (business closer to -0.1 and Other closer to -0.4). Average -0.25 to -0.35
Car Journey Time	Increase the journey time skims by 10% in the highway GC calculation for each UC - calculated on a single iteration of the demand model	Identify weighted average car journey time from the model across all OD pairs	Car trips for each time period and UC for matrix based and for network based the new assigned car journey times.	0 to -2.0
PT fares	Increase average PT fare / km by 10%	PT fare pence / km	Total PT trips (bus + rail) for each time period and UC - exclude ext-ext trips	-0.2 to -0.9
Bus Fares	Increase average Bus fare / km by 10%	Bus fare pence / km	Total bus trips each time period and UC - exclude ext-ext trips	-0.4 to -0.9

5.2 Convergence

As part of the calibration process model convergence using the GAP statistic calculation is checked to ensure the model is sufficiently stable as specified in TAG M2. The recommended criterion for measuring convergence between demand and supply models is the demand/supply gap calculated by:

$(\sum_a C(X_a^n) | D(C(X_a^n)) - X_a^n | / \sum_a C(X_a^n) X_a^n) * 100$

Where:

X_a^n is cell *a* in the previous assignment matrix for iteration *n*;

$C(X_a^n)$ is cell *a* in the generalised costs resulting from assigning that matrix;

$D(C(X_a^n))$ is cell *a* in the matrix output by the demand model based on costs $C(X_a^n)$; and

a represents every combination of origin, destination, demand segment/user class, time period and mode.

TAG requires a high level of convergence to be achieved, where the %Gap should be lower than 0.2%. If this cannot be achieved then a more relaxed criterion related to the projected benefits of a scheme can be used. Table 5.2 shows the GAP values achieved for each of the realism tests.

TABLE 5.2
Realism Test Convergence Results (%)

Iteration number	Bus Fares	PT Fares	Car Fuel
1	1.49	5.54	1.66
2	0.38	0.41	0.58
3	0.46	0.26	0.42
4	0.40		0.23
5	0.26		

The convergence results show that the achieved GAP value is slightly higher than the recommended 0.2. Performing additional demand model loops did not result in lower GAP values. However, during model calibration, the realism test results indicated a high degree of stability hence the level of convergence is considered sufficient for the purposes of model calibration.

5.3 Calibrated Parameters

During model calibration, the demand response sensitivity parameters were adjusted to meet the realism test criteria. This section provides a comparison between the calibrated model parameters and the illustrative parameter ranges in TAG.

Destination Choice

Table 5.3 shows the destination choice parameters used to calibrate the demand model. These are all within the illustrative TAG range (see Table 4.1) with the exception of the parameters used for employer's business trips. These values required to calibrate the model are slightly higher than the maximum illustrative TAG values.

TABLE 5.3
Calibrated Destination Choice Parameter Values (Lambda)

TIME PERIOD / PURPOSE	CAR	PT
AM - Home-based work	0.081	0.033
AM - Home-based other	0.104	0.036
AM - Employers business	0.134	0.056
IP - Home-based work	0.081	0.033
IP - Home-based other	0.104	0.036
IP - Employers business	0.134	0.056
PM - Home-based work	0.075	0.033
PM - Home-based other	0.104	0.036
PM - Employers business	0.134	0.056

Time of Day Choice

Table 5.4 shows the time of day choice parameters used for home-based other. In accordance with TAG M2 advice the sensitivity of the time period choice parameters are the same as those used for main mode choice.

TABLE 5.4
Calibrated Time of Day Choice Parameters (Lambda)

MODE	VALUE
Car	0.033
PT	0.033

Main Mode Choice

Table 5.5 shows the main mode scaling parameters used. These values fall within the illustrative TAG ranges (see Table 4.2). These scaling parameters were then applied to the average of the car and PT destination choice parameters shown in Table 5.2 above. The resulting main mode choice parameters are shown in Table 5.6.

TABLE 5.5
Calibrated Main Mode Choice Scaling Parameters (Theta)

PURPOSE	VALUE
Home-based work	0.59
Home-based other	0.47
Employers business	0.59

TABLE 5.6
Calibrated Main Mode Choice Parameters (Lambda)

PURPOSE	VALUE
Home-based work	0.033
Home-based other	0.033
Employers business	0.056

Trip Frequency

Trip frequency elasticity parameters for both car available and no car available, all modes and income segments has been set to 0.005 to avoid unrealistic model sensitivity.

5.4 Realism Test Results

Car Fuel Cost Elasticities

The network based car fuel elasticities in terms of car vehicle kilometres with respect to fuel costs are shown in Table 5.7 and the matrix based car fuel elasticities are shown in Table 5.8. The tables show the elasticities according to the highway model segmentation, i.e. by household income and purpose. The results are also shown by time period and annual average.

TABLE 5.7

Network Based Car Fuel Elasticity

Time Period	Home base work + other			Employer's Business
	Low Income	Medium Income	High Income	
AM	-0.31	-0.18	-0.14	-0.07
IP	-0.29	-0.20	-0.14	-0.06
PM	-0.29	-0.20	-0.14	-0.06
Annual Average	-0.29	-0.20	-0.14	-0.06
	-0.18			

TABLE 5.8

Matrix Based Car Fuel Elasticity

Time Period	Home base work + other			Employer's Business
	Low Income	Medium Income	High Income	
AM	-0.29	-0.20	-0.15	-0.07
IP	-0.36	-0.28	-0.22	-0.07
PM	-0.39	-0.29	-0.22	-0.08
Annual Average	-0.35	-0.27	-0.21	-0.07
	-0.25			

The results demonstrate that the car fuel elasticities reduce as income increases due to a higher value of time in the higher income bands, for home-based work and other trips. The elasticities for these purpose/income segments, for both network and matrix based, fall within the TAG M2 Table 6.2 recommended ranges.

The employer's business purpose displays elasticities slightly weaker than -0.1, for both the network and matrix based tests which reflects the higher value of time for this demand segment.

Whilst the annual average value for the network based test lies out of range of -0.25 to -0.35, the pattern of elasticities across income groups and purposes follows the expected pattern, with the annual average reduced by the lower response values for home based work / other high income and employer's business trips. The network based annual average is within the suggested range.

Car Journey Time Elasticities

The outturn car journey time elasticities from the demand model should be no stronger than -2.0, from one iteration of the model. Table 5.9 shows the car journey time elasticities on a network basis while Table 5.10 shows them on a matrix basis. The tables show the elasticities by the highway model segmentation, i.e. by household income and purpose. The results are also shown by times period and annual average.

TABLE 5.9
Network Based Car Journey Time Elasticity

Time Period	Home base work + other			Employer's Business
	Low Income	Medium Income	High Income	
AM	-0.16	-0.13	-0.08	-0.01
IP	-0.10	-0.08	-0.07	-0.02
PM	-0.13	-0.09	-0.08	-0.02
Annual Average	-0.11	-0.09	-0.07	-0.02
	-0.09			

TABLE 5.10
Matrix Based Car Journey Time Elasticity

Time Period	Home base work + other			Employer's Business
	Low Income	Medium Income	High Income	
AM	-0.15	-0.15	-0.18	-0.08
IP	-0.11	-0.11	-0.13	-0.08
PM	-0.15	-0.15	-0.17	-0.10
Annual Average	-0.12	-0.12	-0.15	-0.08
	-0.13			

The results show that the model responses within the TAG M2 recommended range.

PT Fare Elasticities

The outturn PT fare elasticities from increasing both rail and bus fares by 10% should fall with the range of -0.2 to -0.9. Table 5.11 shows the matrix based PT fare elasticities, by purpose and time period, and the annual average.

TABLE 5.11
PT Fares Elasticity

Time Period	Home base work + other			Employer's Business
	Low Income	Med Income	High Income	
AM	-0.88	-0.69	-0.50	-0.75
IP	-0.72	-0.62	-0.48	-0.47
PM	-0.98	-0.78	-0.57	-0.48
Annual Average	-0.82	-0.68	-0.51	-0.50
	-0.67			

The results show that all but the PM low income home based work and other demand segment meet the TAG criteria, which is only 0.08 outside the recommended range.

Bus Fare Elasticities

The outturn bus fare elasticities from increasing bus fares only by 10% should fall with the range of -0.4 to -0.9. Table 5.12 shows the matrix based bus fare elasticities, by purpose and time period, with the annual average calculated. This shows realism test results broadly within the expected range and showing the expected relative differences between income groups.

TABLE 5.12
Bus Fares Elasticity

Time Period	Home base work + other			Employer's Business
	Low Income	Med Income	High Income	
AM	-0.46	-0.36	-0.25	-0.85
IP	-0.50	-0.42	-0.31	-0.42
PM	-0.50	-0.39	-0.27	-0.44
Annual Average	-0.49	-0.40	-0.29	-0.46
	-0.39			

Overall, the realism test results are generally within the expected ranges in line with TAG advice and reflect the correct pattern of responses with high income segments showing lower sensitivity to fuel costs and PT fare changes.

SECTION 6
Summary

The G-BATS4M Demand Model has been developed primarily to assess the Metro West Phases 1 and 2.

The demand model is a five-stage multi-modal incremental model that calculates trip frequency choice, main mode choice, time period choice, destination choice and sub mode choice with regards to changes in generalised cost for both the highway and PT models. The G-BATS4M Demand Model follows the current TAG guidance with respect to this structure of model.

The demand model iterates between the hourly-based SATURN highway and EMME PT supply models and the 12 hour demand model, using factors derived from local data collected from surveys.

The calculated Gap values for convergence based on current TAG guidance are close to the target value of 0.2% and the model provides stable realism test results in relation to minor changes in input parameters. Hence sufficient convergence has been achieved for demand model calibration. Further steps may be undertaken during scheme testing to either reduce the GAP value or check projected scheme benefits in relation to model stability to verify that model convergence is not adversely affecting assessment results.

The destination choice lambda parameters and main mode scaling theta parameters are mostly within the illustrative TAG value ranges, with the exception of the employer’s business destination choice parameters, which are slightly higher than the maximum illustrative TAG values.

In general the realism test results are within the expected ranges in line with TAG advice and reflect the correct pattern of responses with high income segments showing lower sensitivity to fuel costs and PT fare changes.

Appendix A
Demand Model Formulation

OTH	HBW	EMP
Trip Frequency		
Negative Exponential	**Negative Exponential**	**Negative Exponential**
$T_i = T_i^0 e^{-\lambda_{freq}\Delta C_i}$ $\Delta C_i = \frac{1}{-\lambda_{mode}} ln \sum_m \frac{T_i^{0m}}{T_i^0} e^{-\lambda_{mode}\Delta C_i^m}$ *m: numeration over main modes*	$T_i = T_i^0 e^{-\lambda_{freq}\Delta C_i}$ $\Delta C_i = \frac{1}{-\lambda_{mode}} ln \sum_m \frac{T_i^{0m}}{T_i^0} e^{-\lambda_{mode}\Delta C_i^m}$ *m: numeration over main modes*	$T_i = T_i^0 e^{-\lambda_{freq}\Delta C_i}$ $\Delta C_i = \frac{1}{-\lambda_{mode}} ln \sum_m \frac{T_i^{0m}}{T_i^0} e^{-\lambda_{mode}\Delta C_i^m}$ *m: numeration over main modes*
Main Mode Choice (m)		
Logit	**Logit**	**Logit**
$T_i^m = T_i \frac{T_i^{0m} e^{-\lambda_{mode}\Delta C_i^m}}{\sum_k T_i^{0k} e^{-\lambda_{mode}\Delta C_i^k}}$ *k: numeration over main modes* $\Delta C_i^m = \frac{1}{-\lambda_{tod}} ln \sum_t \frac{T_i^{0mt}}{T_i^{0m}} e^{-\lambda_{tod}\Delta C_i^{mt}}$ *t: numeration over time periods* *must satisfy:* $0 < \frac{-\lambda_{mode}}{-\lambda_{tod}} \le 1$	$T_i^m = T_i \frac{T_i^{0m} e^{-\lambda_{mode}\Delta C_i^m}}{\sum_k T_i^{0k} e^{-\lambda_{mode}\Delta C_i^k}}$ *k: numeration over main modes* $\Delta C_i^m = \sum_t \frac{T_i^{0mt}}{T_i^{0m}} \Delta C_i^{mt}$ *t: numeration over time periods*	$T_i^m = T_i \frac{T_i^{0m} e^{-\lambda_{mode}\Delta C_i^m}}{\sum_k T_i^{0k} e^{-\lambda_{mode}\Delta C_i^k}}$ *k: numeration over main modes* $\Delta C_i^m = \sum_t \frac{T_i^{0mt}}{T_i^{0m}} \Delta C_i^{mt}$ *t: numeration over time periods*
Time of Day (m,t)		
Logit	**Factor**	**Factor**
$T_i^{mt} = T_i^m \frac{T_i^{0mt} e^{-\lambda_{tod}\Delta C_i^{mt}}}{\sum_k T_i^{0mk} e^{-\lambda_{tod}\Delta C_i^{mk}}}$ *k: numeration over time periods* $\Delta C_i^{mt} = \frac{1}{-\lambda_{dest}} ln \sum_j \frac{T_{ij}^{0mt}}{T_i^{0mt}} e^{-\lambda_{dest}\Delta C_{ij}^{mt}}$ *j: numeration over all attractions* *must satisfy:* $0 < \frac{-\lambda_{tod}}{-\lambda_{dest}} \le 1$	$T_i^{mt} = T_i^m \frac{T_i^{0mt}}{\sum_k T_i^{0mk}}$ *k: numeration over time periods* $\Delta C_i^{mt} = \frac{1}{-\lambda_{dest}} ln \sum_j \frac{B_j^0 T_{ij}^{0mt}}{T_i^{0mt}} e^{-\lambda_{dest}\Delta C_{ij}^{mt}}$ *j: numeration over all attractions*	$T_i^{mt} = T_i^m \frac{T_i^{0mt}}{\sum_k T_i^{0mk}}$ *k: numeration over time periods* $\Delta C_i^{mt} = \frac{1}{-\lambda_{dest}} ln \sum_j \frac{T_{ij}^{0mt}}{T_i^{0mt}} e^{-\lambda_{dest}\Delta C_{ij}^{mt}}$ *j: numeration over all attractions*
Destination Choice (m,t,j)		
Singly constrained	**Doubly constrained**	**Singly constrained**
$T_{ij}^{mt} = T_i^{mt} \frac{T_{ij}^{0mt} e^{-\lambda_{dest}\Delta C_{ij}^{mt}}}{\sum_k T_{ik}^{0mt} e^{-\lambda_{dest}\Delta C_{ik}^{mt}}}$ *k: numeration of all destinations* $\Delta C_{ij}^{mt} = \frac{1}{-\lambda_{sub}} ln \sum_s \frac{T_{ij}^{0mts}}{T_{ij}^{0mt}} e^{-\lambda_{sub}\Delta C_{ij}^{mts}}$ *s: numeration over all sub-modes* *must satisfy:* $0 < \frac{-\lambda_{dest}}{-\lambda_{sub}} \le 1$	$T_{ij}^{mt} = T_i^{mt} \frac{B_j T_{ij}^{0mt} e^{-\lambda_{dest}\Delta C_{ij}^{mt}}}{\sum_k B_k T_{ik}^{0mt} e^{-\lambda_{dest}\Delta C_{ik}^{mt}}}$ *Attractions* ***extracted from the reference case ("Do-Min") matrix*** *are normalized to the trip end total of the productions from the time of day choice stage above.* *k: numeration of all destinations* *B: attraction-based balancing factors, estimated iteratively in this destination choice stage by Emme* $\Delta C_{ij}^{mt} = \frac{1}{-\lambda_{sub}} ln \sum_s \frac{T_{ij}^{0mts}}{T_{ij}^{0mt}} e^{-\lambda_{sub}\Delta C_{ij}^{mts}}$ *s: numeration over all sub-modes* *must satisfy:* $0 < \frac{-\lambda_{dest}}{-\lambda_{sub}} \le 1$	$T_{ij}^{mt} = T_i^{mt} \frac{T_{ij}^{0mt} e^{-\lambda_{dest}\Delta C_{ij}^{mt}}}{\sum_k T_{ik}^{0mt} e^{-\lambda_{dest}\Delta C_{ik}^{mt}}}$ *k: numeration of all destinations* $\Delta C_{ij}^{mt} = \frac{1}{-\lambda_{sub}} ln \sum_s \frac{T_{ij}^{0mts}}{T_{ij}^{0mt}} e^{-\lambda_{sub}\Delta C_{ij}^{mts}}$ *s: numeration over all sub-modes* *must satisfy:* $0 < \frac{-\lambda_{dest}}{-\lambda_{sub}} \le 1$
Sub mode choice (m,t,j,s)		
Logit	**Logit**	**Logit**
$T_{ij}^{mts} = T_{ij}^{mt} \frac{T_{ij}^{0mts} e^{-\lambda_{sub}\Delta C_{ij}^{mts}}}{\sum_k T_{ij}^{0mtk} e^{-\lambda_{sub}\Delta C_{ij}^{mtk}}}$ *k: numeration of sub-modes* $\Delta C_{ij}^{mts} = C_{ij}^{mts} - C_{ij}^{Bmts}$	$T_{ij}^{mts} = T_{ij}^{mt} \frac{T_{ij}^{0mts} e^{-\lambda_{sub}\Delta C_{ij}^{mts}}}{\sum_k T_{ij}^{0mtk} e^{-\lambda_{sub}\Delta C_{ij}^{mtk}}}$ *k: numeration of sub-modes* $\Delta C_{ij}^{mts} = C_{ij}^{mts} - C_{ij}^{Bmts}$	$T_{ij}^{mts} = T_{ij}^{mt} \frac{T_{ij}^{0mts} e^{-\lambda_{sub}\Delta C_{ij}^{mts}}}{\sum_k T_{ij}^{0mtk} e^{-\lambda_{sub}\Delta C_{ij}^{mtk}}}$ *k: numeration of sub-modes* $\Delta C_{ij}^{mts} = C_{ij}^{mts} - C_{ij}^{Bmts}$

GBATS4M Model Update

METROWEST Public Transport Local Model Validation Report

Prepared for
West of England Authorities

08 October 2015

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Document History

GBATS4M Model Update

METROWEST Public Transport LMVR

West of England Authorities

This document has been issued and amended as follows:

Version	Date	Description	Created by	Verified by	Approved by
1.0	22.4.15	Draft Report	Simon Guy / Gareth Walters / Esperança Corella Peris	Simon Guy	Chris Bushell
1.1	8.10.15	Final Report	Simon Guy / Gareth Walters / Esperança Corella Peris	Simon Guy	Chris Bushell

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SECTION 1
Introduction

1.1 Background

This report has been prepared by CH2M Hill as part of their commission to update the Greater Bristol Area Transport Study (GBATS) modelling suite for Bristol City Council (BCC), on behalf of the West of England authorities.

The updated GBATS model has been specified to be suitable for assessing the MetroWest major scheme Phases 1 and 2. The Bristol Area Traffic Study (BATS) model was originally built and validated to a base year of 2001. Since then it has been updated to BATS2 as a part of the Greater Bristol Bus Network study in 2004 and further updated to the GBATS3 strategic model with a base year of 2006. The GBATS3 model was used as the starting point for four localised studies. In each case the model was updated, recalibrated and revalidated with the local study area core as its focus. Figure 1.1 shows the core areas of the localised models. The four studies are below:

- Ashton Vale to Temple Meads Rapid Transit (AVTM, 2006 Base year, 580 active zones);
- Northern Fringe to Hengrove Package (NFHP, 2009, 584);
- South Bristol Link (SBL, 2009 & 2012, 616); and
- South Gloucestershire Core Strategy (SGCS, 2011, 591).

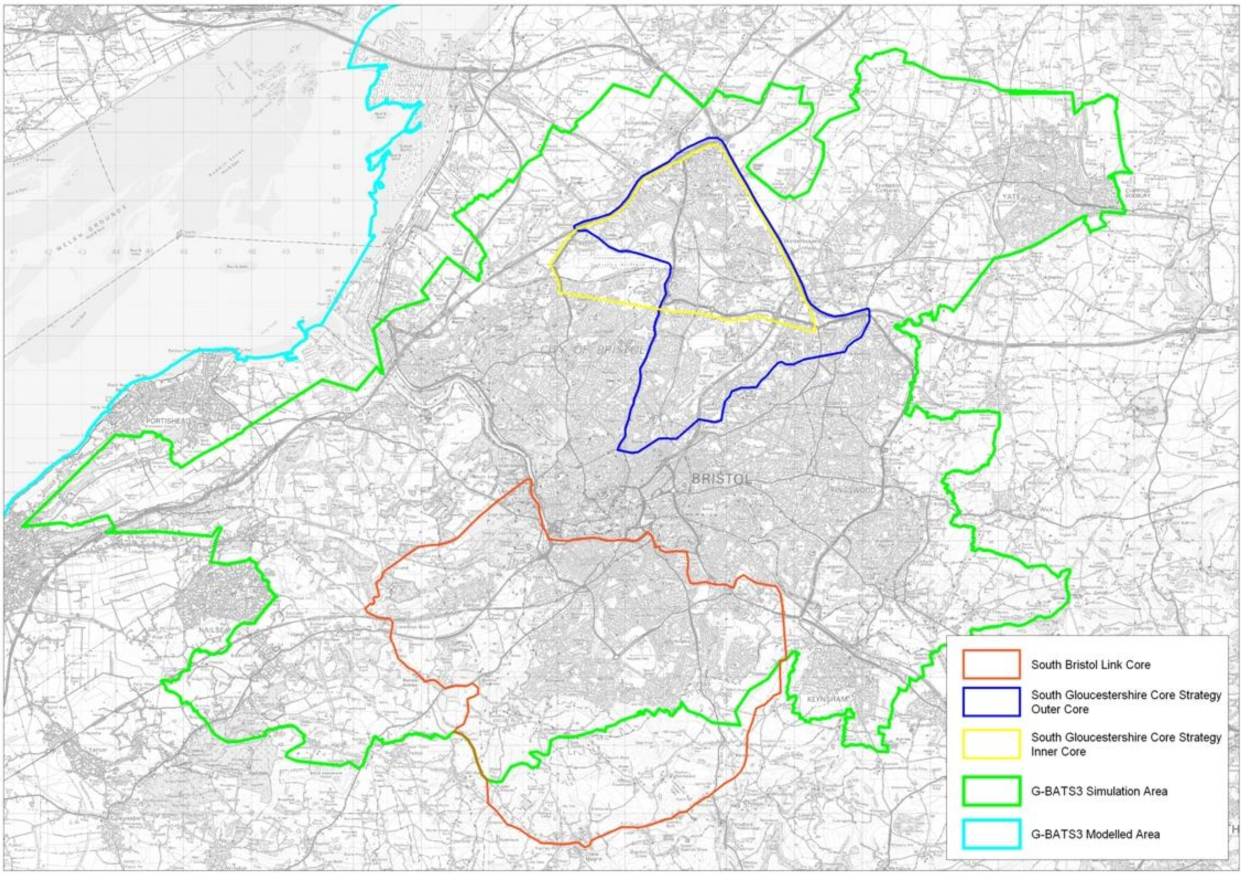

Figure 1.1: GBATS3 Localised Core Areas

The updated model is called the GBATS4 Metro Model (GBATS4M). The GBATS4M model consists of:

- A Highway Assignment Model representing vehicle based movements across the Greater Bristol area for a 2013 autumn weekday morning peak hour (08:00-09:00), an average inter-peak hour (10:00-16:00) and an evening peak hour (17:00-18:00);
- A Public Transport (PT) Assignment Model representing bus and rail based movements across the same area and time periods; and

- A five-stage multi-modal incremental Variable Demand Model (VDM) that forecasts changes in trip frequency and choice of main mode, time period of travel, destination, and sub-mode choice, in response to changes in generalised costs across the 12-hour period (07:00 – 19:00).

The GBATS4M PT model is closely integrated with the GBATS4M Highway model. The two models use different software packages (EMME and SATURN, respectively) but are identical in terms of road network structure, and zone system. The bus routes and frequencies in the PT model are used in the Highway model.

The GBATS4M PT model is fully integrated within the GBATS4M VDM. The GBATS4M PT model provides public transport costs to the GBATS4M VDM which, in turn, provides trip matrices for the GBATS4M PT model. The relationship between the elements of the modelling system is shown in Figure 1.2.

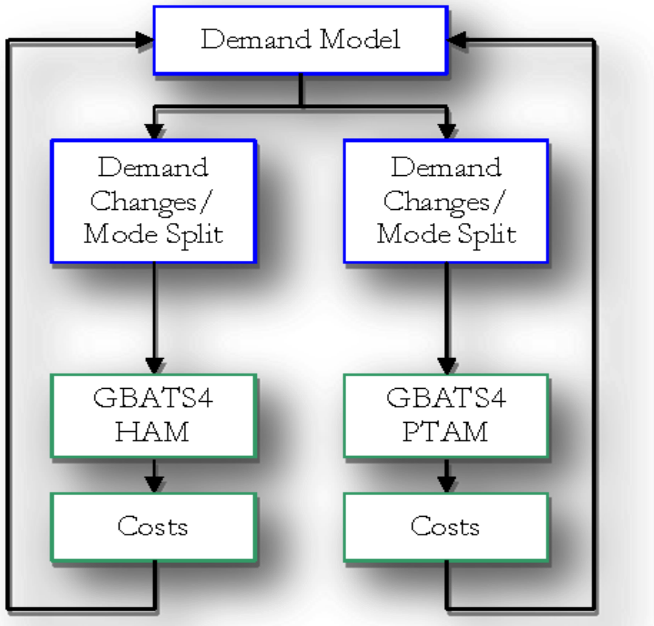

Figure 1.2: GBATS4M Modelling Suite

1.2 This Report

The remainder of this report consists of the following sections:

- Section 2 – Model Usage and Design Considerations;
- Section 3 – Model Standards, Criteria and Acceptability Guidelines;
- Section 4 – Key Features of the model;
- Section 5 – Trip Matrix Development;
- Section 6 – Model Calibration and Validation;
- Section 7 – Conclusions.

SECTION 2

Model Usage and Design Considerations

2.1 MetroWest

The GBATS4M modelling suite provides a tool with which to test the ability of future transport proposals to support forecast travel demand. At a general level this includes:

- Investigation of new development proposals; and
- Longer-term strategic planning of the transport network.

The specific purpose of the model is for assessing the MetroWest major scheme Phases 1 and 2. Figure 2.1 shows schematics of the MetroWest scheme. The primary focus of GBATS4M highway model is the MetroWest scheme corridors.

2.2 Potential Alternative Uses

The GBATS4M modelling suite could (with further validation if necessary) also be used to forecast and assess a range of alternative potential interventions. While not a definitive list, the following future year schemes could potentially be assessed:

- Bristol Arena
- Temple Circus Roundabout / Redcliffe Way;
- Temple Quarter Enterprise Zone;
- Central Area Action Plan;
- Changes to bus operations;
- Park and Ride schemes;
- M4 Link;
- North Fringe VISSIM interface;
- Strategic wider area schemes; and
- Major development proposals in the wider urban area.

2.3 Model Design Considerations

The principal objective of the GBATS4M PT model is to represent PT demand and travel times for the appraisal of the MetroWest scheme and should therefore provide:

- changes in the travel cost between the base year and forecast years for input to the GBATS4M VDM;
- changes in passenger flows along the MetroWest corridors for input to the appraisal; and
- changes in wider area PT travel costs for input to the economic appraisal.

The GBATS4M PT model is an EMME model that covers the whole of the Bristol urban area in detail, and is suitable for testing a wide range of transport interventions. The PT model covers bus, rail, and park and ride modes in the base year, with the ability to include BRT in the future reference cases. The focus of data collection for creating demand matrices has been the city centre, Park and Ride, and MetroWest scheme corridors.

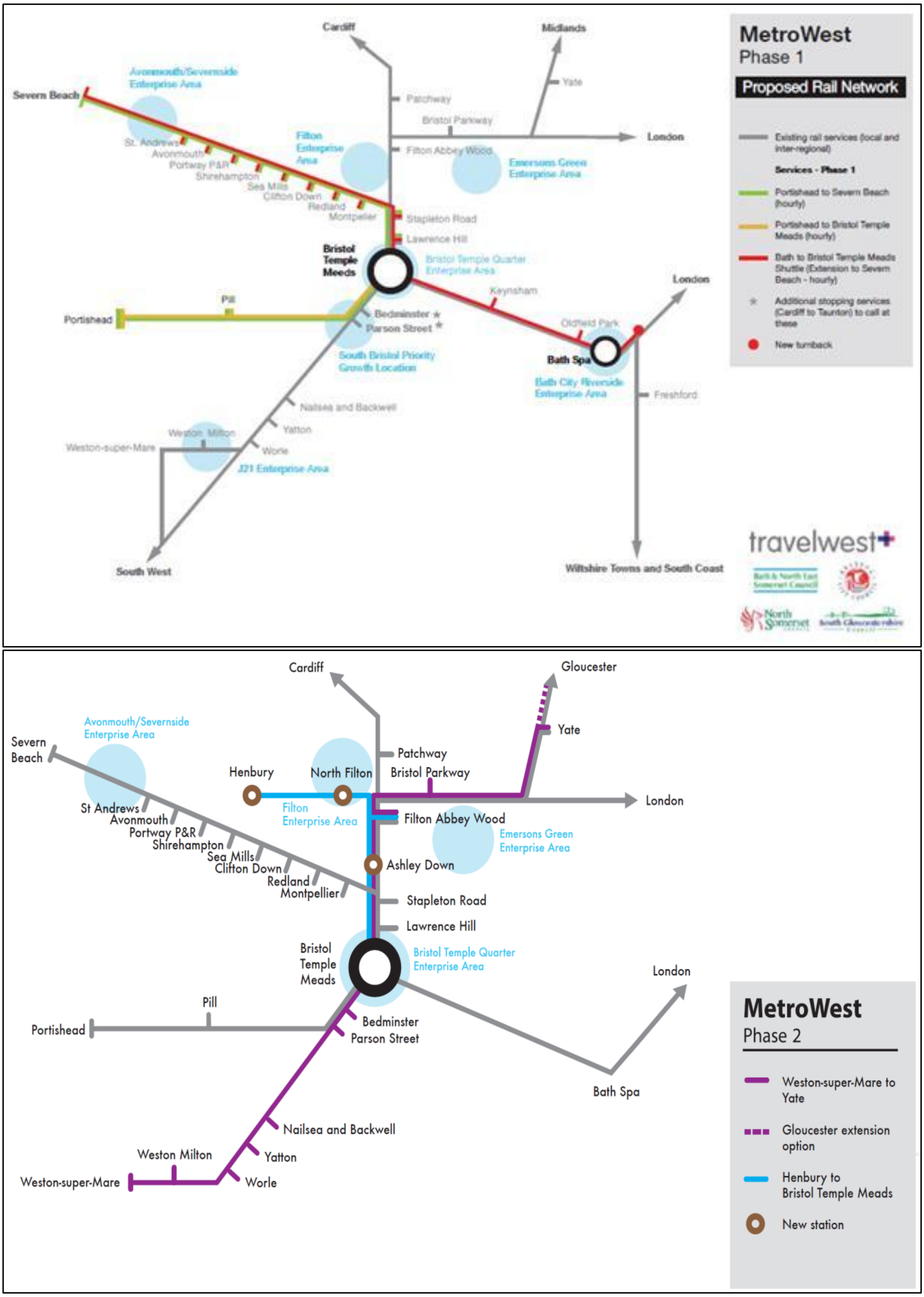

Figure 2.1: MetroWest Corridors

SECTION 3

Model Standards, Criteria and Acceptability Guidelines

3.1 Overview

The GBATS4M model has been designed and developed using the UK Department for Transport (DfT) Transport Analysis Guidance (TAG). The current, relevant guidance is: DfT TAG UNIT M3.2 Public Transport Assignment, January 2014. Referenced throughout this report as: 'TAG M3.2'.

The aim for the GBATS4M PT model was to achieve the validation acceptability guidelines specified in TAG M3.2. As indicated in the public transport calibration guidelines in TAG M3.2, the PT model validation includes:

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

3.2 Trip Matrix Validation

TAG Unit M3.2 states that "Wherever possible, a check should be made between the annual patronage derived from the model and annual patronage derived by the operator". No specific targets are defined for what is considered acceptable.

3.3 Network and Service Validation

The PT model bus network is identical in structure to the validated highway network. Checks on the accuracy of the coded network geometry are covered in the Highway Model LMVR. The coding of bus services was verified by checking the modelled flows of buses by route against the roadside bus count data.

Modelled bus journey times were compared against published timetables. TAG M3.2 does not contain a specific target for the accuracy of modelled journey times. However for the model validation an acceptability target of +/-15% was used, which is consistent with highway model journey time validation criteria.

The rail network was coded using industry accepted network diagrams to ensure distances between stations are accurate. Rail service station to station run times were explicitly included in the transit lines coding and therefore do not require validation.

3.4 Assignment Validation Criteria

TAG M3.2, paragraph 7.1.5 states that the validation of the assignment should involve comparing modelled and observed:

- Passenger flows across screenlines and cordons
- Passengers boarding and alighting in urban centres

The criteria in TAG M3.2 states 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 the observed flows are particularly low (less than 150)."

In order to give a measure of the fit of the model to counts less than 150, we have used the GEH statistic. A GEH of less than 5 indicates a good fit of the modelled link flow to the observed count on low volume links, as specified in highway model validation criteria.

3.4.1 GEH Statistic

The GEH statistic has been included as an indicator of 'goodness of fit', i.e. the extent to which the modelled flows match the corresponding observed flows. This is recommended in the guidelines contained in TAG M3.1 and is defined as:

$$GEH = \sqrt{\frac{(M-C)^2}{0.5(M+C)}}$$

Where:
M = modelled flow; and
C = observed flow.

3.4.2 Bus Assignment Validation

For the bus assignment validation, bus occupancy counts were collected on 12 key corridors around Bristol City Centre. The counts were aggregated by corridor and time period and compared against the modelled flows along these corridors. Modelled flows on individual links were expected to be within +/-25% of observed links flows (or GEH < 5 for observed flow under 150 per hour). Total screenline flows were to be within +/-15% of the total observed flow.

Observed bus stop boardings and alightings totals (collected in the November 2013 surveys) were compared against the modelled passenger movements at surveyed bus stops. Modelled B&A were to be within +/-15% of observed passenger movements.

Checks were also undertaken of modelled bus passenger flows against First bus operator data on a corridor basis.

3.4.3 Rail Assignment Validation

For the rail assignment validation, (single day) boarding and alighting counts were available from the West of England Rail Survey, with cross-checks against NRTS and ORR data. As with the link flow validation for the bus matrices, we adopted the criterion that modelled boardings and alightings should be within 25% of the counts (or GEH < 5 where observed flows are less than 150 per hour).

SECTION 4

Key Features of the Model

4.1 Basic Model Setup

4.1.1 Source Models

The GBATS4M PT Model is a completely new model. The highway network definition is based on the GBATS4M Highway model, and this is supplemented by additional coding for the rail network.

The definition of transit lines (the public transport services included in the model) have been recoded to represent the service timetable in place in autumn 2013.

Bus demand matrices have been rebuilt using the data collected in November 2013 together with demand matrices included in the 2012 SBL version of GBATS3 covering bus movements with both their origin and destination outside Bristol city centre. The bus matrices used in the 2012 SBL GBATS3 model include all the OD data that were used in the development of the various other GBATS3 models, such as North-Fringe Hengrove (NFH) model and South Gloucestershire Core Strategy Model (CSM). Rail demand matrices have largely been rebuilt from new data sources, with only external to external trips sourced from the SBL GBATS3 model.

4.1.2 Software

The GBATS4M PT model uses EMME 4. The software is a well-established and robust transport planning package that has been used for previous versions of the GBATS model. The software is used also for the VDM that is developed as part of the GBATS model suite.

4.1.3 Base Year

The GBATS4M modelling system has a 2013 base year and represents the travel conditions for a typical autumn weekday.

4.1.4 Network Area

The GBATS4M PT model area retains the same geographical coverage as the GBATS3 model. The focus of the improvements for the GBATS4M was primarily the corridors most likely to be impacted by MetroWest, the central area and key radial routes. This included a review / update of all bus routes and bus priority measures in the central area and radial routes approaching the city centre. Figure 4.1 shows the central area. Figure 4.2 shows the wider model area, including the extents of both the simulation and buffer network in the highway model.

4.1.5 Time Periods

The GBATS4M PT model is based on trip making patterns on a typical autumn weekday in 2013. The three time periods modelled have been defined as:

- AM peak, representing hourly traffic flow between 08:00 and 09:00;
- Inter peak, representing average hourly traffic flow between 10:00 and 16:00; and
- PM peak, representing hourly traffic flow between 17:00 and 18:00.

4.1.6 Zoning System

The GBATS4M PT model zone system exactly matches that of the GBATS4M Highway model.

The GBATS4M zoning system comprises 650 zones covering the whole of Great Britain. A detailed zoning system was developed to represent the Greater Bristol Urban area and its surroundings. This is shown in Figure 4.3 and 4.4.

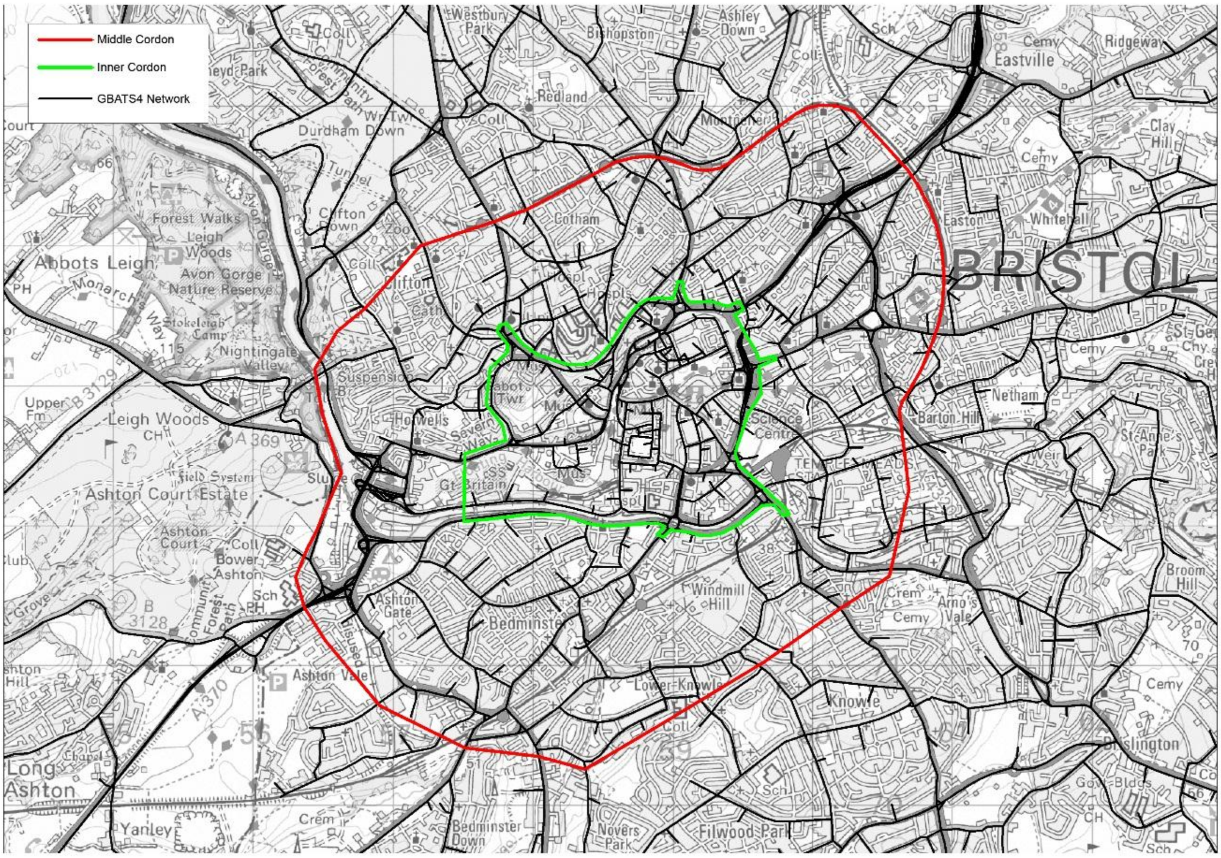

Figure 4.1: GBATS4M Highway model Central Modelled Area

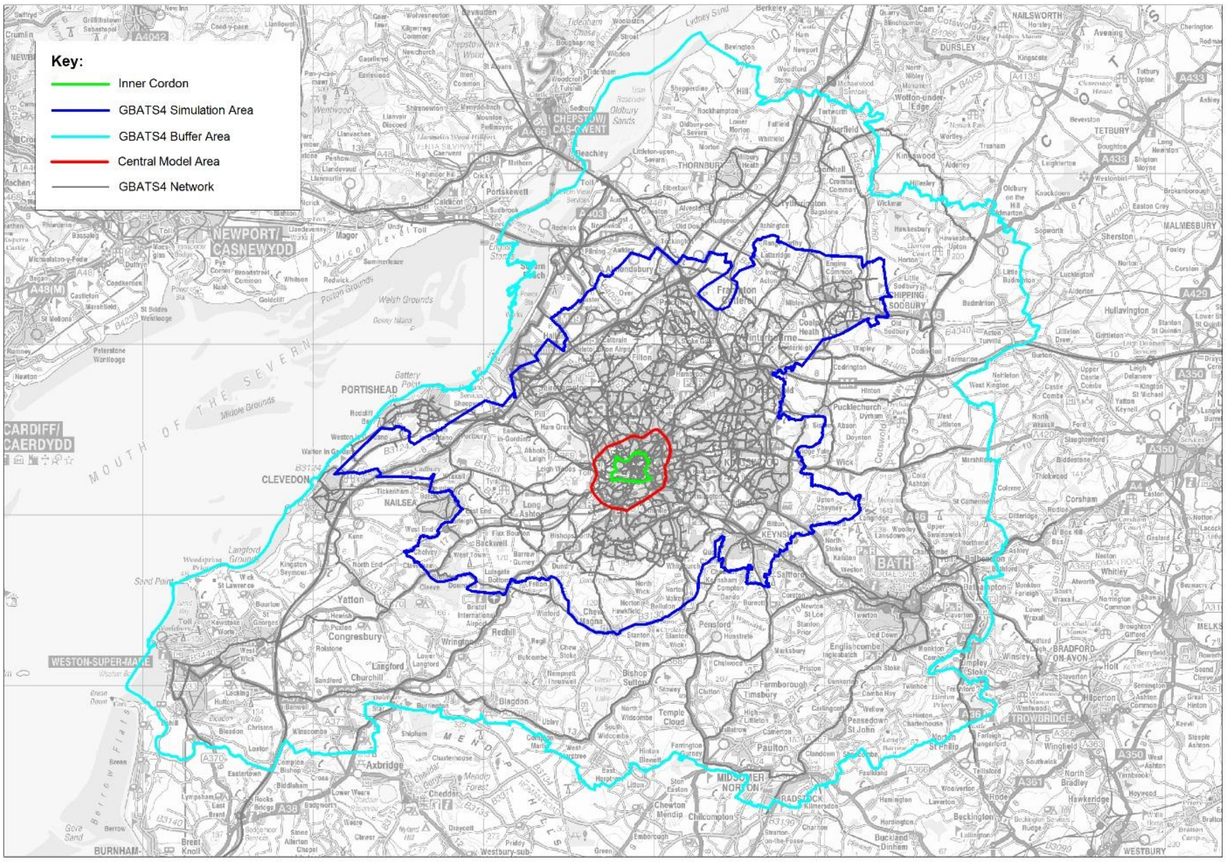

Figure 4.2: GBATS4M Highway model Fully Modelled Area

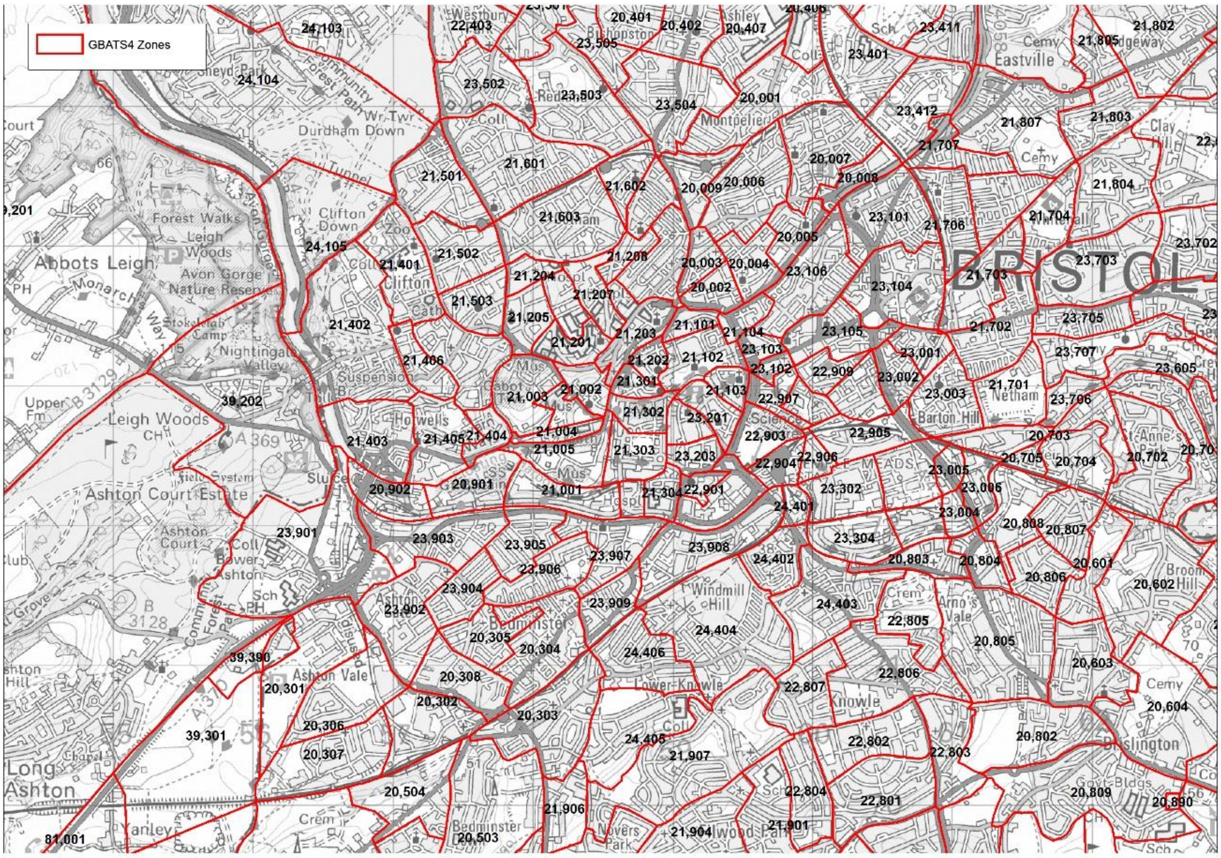

Figure 4.3: GBATS4M Central Model Area Zones

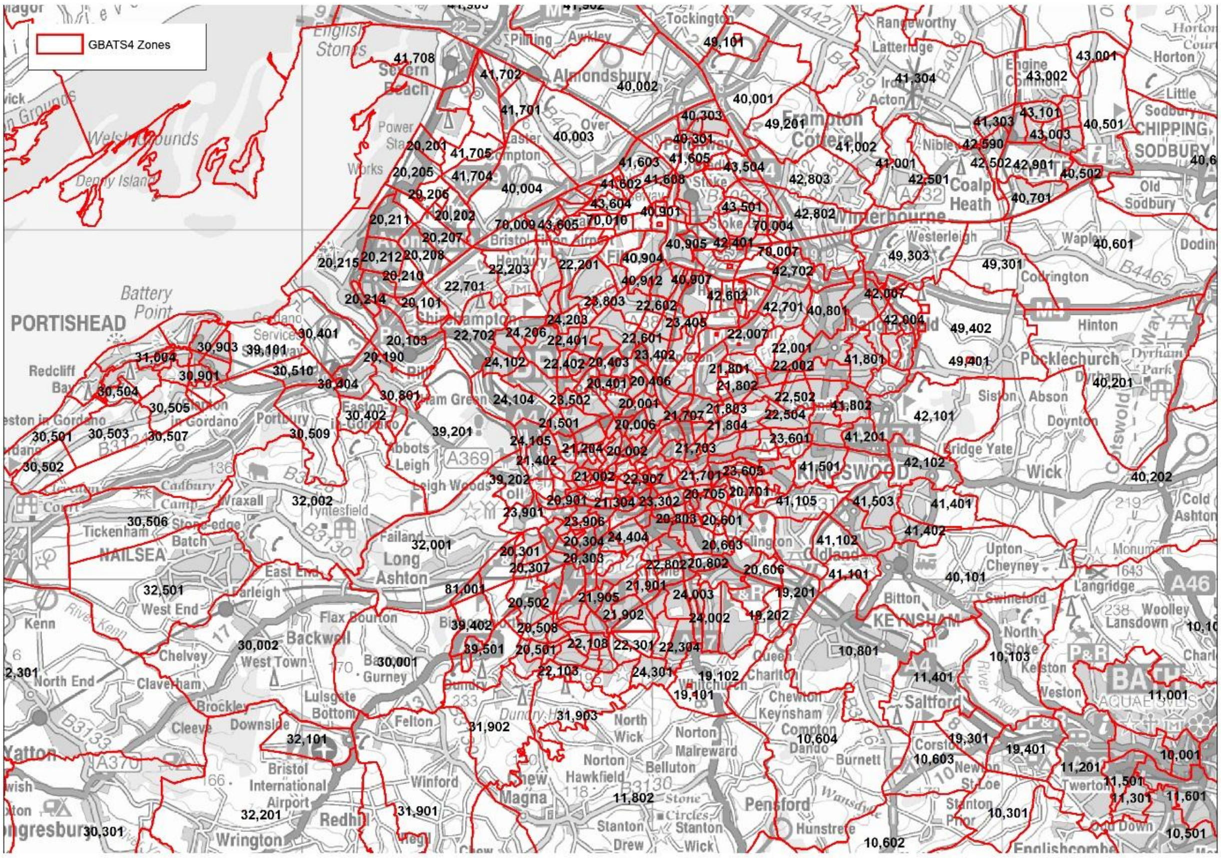

Figure 4.4: GBATS4M Wider Model Area Zones

4.2 Transit Representation

4.2.1 Transit Modes

Within EMME two categories of mode are required for public transport modelling; transit modes and auxiliary transit modes. The transit mode is used to define the modes that provide passenger services. The base year PT model includes the two currently available public transport modes:

- Bus; and
- Rail

Five individual transit modes have been defined in EMME. Four of these refer to bus services; the fifth refers to rail services. With regard to the bus modes, the differentiation between operators does not affect the assignment.

Table 4-1: Transit Modes in GBATS4M PT model

Mode	ID
Bus – First Group	B
Bus – Wessex	G
Bus – Other Operator	O
Bus – Park and Ride	P
Rail	R

The auxiliary transit mode is used to define the access/egress from transit services. Four auxiliary transit modes are defined. Mode D is used only in the rail assignment, and allows for the modelling of kiss & ride/ P&R at rail stations.

Table 4-2: Auxiliary Transit Modes in GBATS4M PT model

Mode	ID	Default speed (kph)
Walk	Q	5 kph
Slow Walk	E	3 kph
'Unmodelled' PT Access mode	X	35 kph
Rail Station Access – Car mode	D	70 kph

4.3 Transit Lines

The development of the PT model involved the complete recoding of the transit lines to represent the service pattern and timetable as of autumn 2013. Service routings were initially extracted from ATCO cif files[1] and matched to the model network link / node structure. Particular attention was paid in the city centre to ensure that bus stopping pattern was accurately reflected. Table 4.3 details the number of transit lines included in the three time periods.

Table 4-3: Transit Line Summary – by time period

Time Period	No. Bus Transit Lines	No. Rail Transit Lines	Total
AM	165	27	192
IP	189	41	230
PM	174	24	196

[1] ATCO cif files were obtained that contain bus services as represented in Traveline

The majority of services are provided by First Bus, with other operators including Wessex, and ABUS also providing services. Figure 4.5 shows the extent of the coded public transport network for the AM peak. The red lines represent links with at least one public transport service. The inter-peak and PM peak networks provide similar coverage.

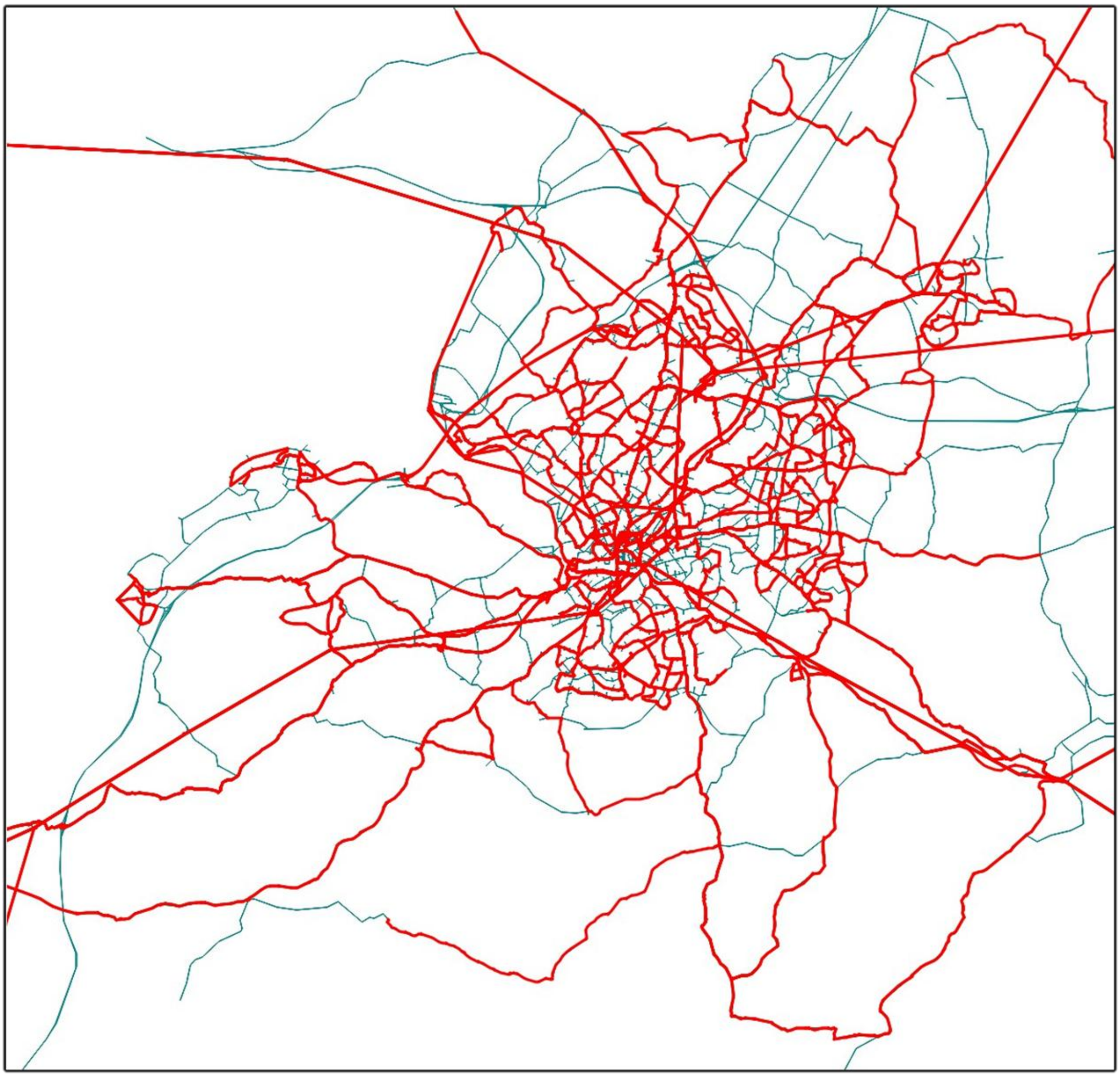

Figure 4.5: Extent of AM Peak public transport network

Appendix A details the services included in the base model and the modelled service frequency.

4.4 Assignment Methodology

The PT model uses EMME's Extended Transit Assignment algorithm. This offers an improved assignment methodology over the standard EMME transit assignment algorithm, by taking better account of service headways and journey times in the allocation of trips to PT services. This is particularly useful in representing more accurate route choice between potentially competing services, including bus and rail.

4.4.1 Generalised Cost Formulation

The generalised time utilised in EMME consists of the following formula:

GTime = (Access + Egress Time) * Aux Transit Weight +
(Average Wait Time * Wait Time Weight) +
Board Penalty + In-Vehicle Time

The parameters values used for the generalised cost calculation in the PT model are set out in Table 4.4. All values fall within thresholds described in TAG M3.2

Table 4-4: Generalised Cost Parameters

Parameter	Value
Wait Time Factor	0.5
Wait Time Weight	2
Auxiliary Transit Time Weight	2
Boarding Penalty (Bus)	10 mins
Boarding Penalty (Rail)	5 mins

The 'wait time factor' is applied to the service headway (or effective headway) to determine the average wait time. A factor of 0.5 indicates that the average wait time is equal to 50% of the service headway (i.e. an hourly service would be modelled as having an average wait time of 30mins). The "wait time weight" is applied to this average wait time.

The auxiliary transit time weight is applied to access, egress and any inter-service transfer from one node to another (e.g. walking). Access time is defined as the time required to move from an origin zone to the node at which the first PT service is boarded. Conversely egress time is the time required after disembarking from the last PT service to reach the destination zone.

Boarding penalties of 5 and 10 minutes are defined for rail and bus services respectively. These are penalties that are incurred every time a service is boarded. Therefore a trip from Portishead to Filton Abbey Wood utilising the X2/X3 service and a stopping train service from Bristol Temple Meads would incur a total boarding penalty of 15 minutes. If an additional bus service was used to access Temple Meads (e.g. 8 or 9) then total boarding penalty would increase to 25minutes.

4.4.2 Transit Line Time

An important attribute in the generalised cost formulation is the 'In- vehicle Time' – the time spent travelling on a service between stops. Travel time on a service is set utilising the travel time functions (TTF) in EMME. Two travel time functions are defined in the PT model for bus (TTF1) and rail (TTF2) as follows:

- TTF1 = (Length / Link Speed) * 60
- TTF2 = (Length / Service Specific Link Speed) * 60

As the rail model contains relatively few services, together with a relatively simple network, it was possible to code each rail service with a transit line specific link speed directly derived from the service timetable. Rail timetables in place in autumn 2013 were used for this process.

This approach was not possible for the bus mode and an alternative approach was adopted. The approach adopted involved deriving an average bus speed for links in the model, weighted according to service frequency, for the majority of modelled bus services. The data source were bus timetables valid during autumn 2013.

The resultant link speeds were input into EMME as link attributes. Separate values were calculated for each time period (@spdam, @spdip and @spdpm). All other links (i.e. links for which no bus service currently operate or those used by bus services that were not sampled were set to the time period average bus speed. These are listed in Table 4.5.

Table 4-5: Average bus speeds by time periods

Time Period	Average Bus Speed (kph)
AM	18.85
IP	22.18

Table 4-5: Average bus speeds by time periods

Time Period	Average Bus Speed (kph)
PM	20.73

4.4.3 Effective Headways

EMME allows several approaches for how wait time is calculated, as follows:

- Using actual service headway. This approach looks at the service frequency and applies a common factor for all services to derive the average wait time. Typically a factor of 0.5 is assumed; therefore an hourly service would be modelled with a wait time of 30 minutes, while a 4 per hour service would have a modelled wait time of 7.5 minutes. This approach has the benefit of reflecting differences between all services with different headways, but can overestimate passenger response to improvements in low frequency services, as in practice people will tend to arrive at a stop soon before the scheduled departure time to avoid long wait times.
- Setting a ceiling for the maximum weight time allowed. This approach is based on the previous example, but sets an upper limit for the wait time. Whilst this approach prevents unrealistically long wait time from being derived, it means that the assignment procedure is not always able to reflect changes in service frequencies for infrequent services.
- Defining an "effective" service headway from which service wait time is derived. This approach enables a more sophisticated treatment of wait time to be modelled, for example a non-linear relationship between service frequency and wait time.

The third approach was judged to be most appropriate as it would enable more realistic modelling of responses to service frequency changes, without generating excessive time saving benefits for improvements to infrequent services.

A non-linear effective headway curve has been developed for the PT model, adopting values proposed by the Passenger Demand Forecasting Handbook. This yields effective headways close to actual service headway for high frequency services. However, as the service headway increases (and the frequency decreases), effective headway also increases but the differences between actual and effective headways become greater.

4.4.4 Relationship with Highway Assignment Model and Demand Model

In the base model the highway and PT assignment models operate independently of each other. Travel time skims are produced by the Highway and PT models and then used as an input to the demand model.

Forecast year runs of the models necessitate an interaction between highway and PT models to allow changes in highway delay (both positive and negative) to be reflected in the bus journey times (i.e. in mixed traffic conditions increased delay suggested by the Highway model should be reflected in the bus runtime). An automated procedure has been developed that allows changes in SATURN link speeds to be reflected in the EMME link speeds, whilst also taking account of operational changes to the network (i.e. addition/removal of bus lanes). This methodology will be described in detail in later Reports.

SECTION 5

Trip Matrix Development

5.1 Introduction

New demand matrices were developed for the bus and rail sub-models of the PT model. The starting point for the development of the bus matrices was the surveys undertaken in November 2013. Details of these surveys can be found in the 'GBATS4 Model Update - Report of Surveys and Existing Data Review'. In summary these surveys consisted of:

- Boarding and Alighting Counts;
- At Stop Passenger Origin – Destination (OD) surveys;
- On-board OD surveys completed on Park and Ride services;
- Cordon Counts.

In addition, data was made available by BCC regarding boarding & alightings on Park and Ride services during a one week period in October 2013, and by NSC regarding the X2/X3 Bristol – Portishead services for May 2014.

Rail matrices were developed using West of England Rail survey data, together with data from LENNON and ORR datasets.

The remainder of this section describes the methodology adopted to derive 2013 assignment matrices.

5.2 Bus Matrices

The process for developing the bus matrices is illustrated in Figure 5.1.

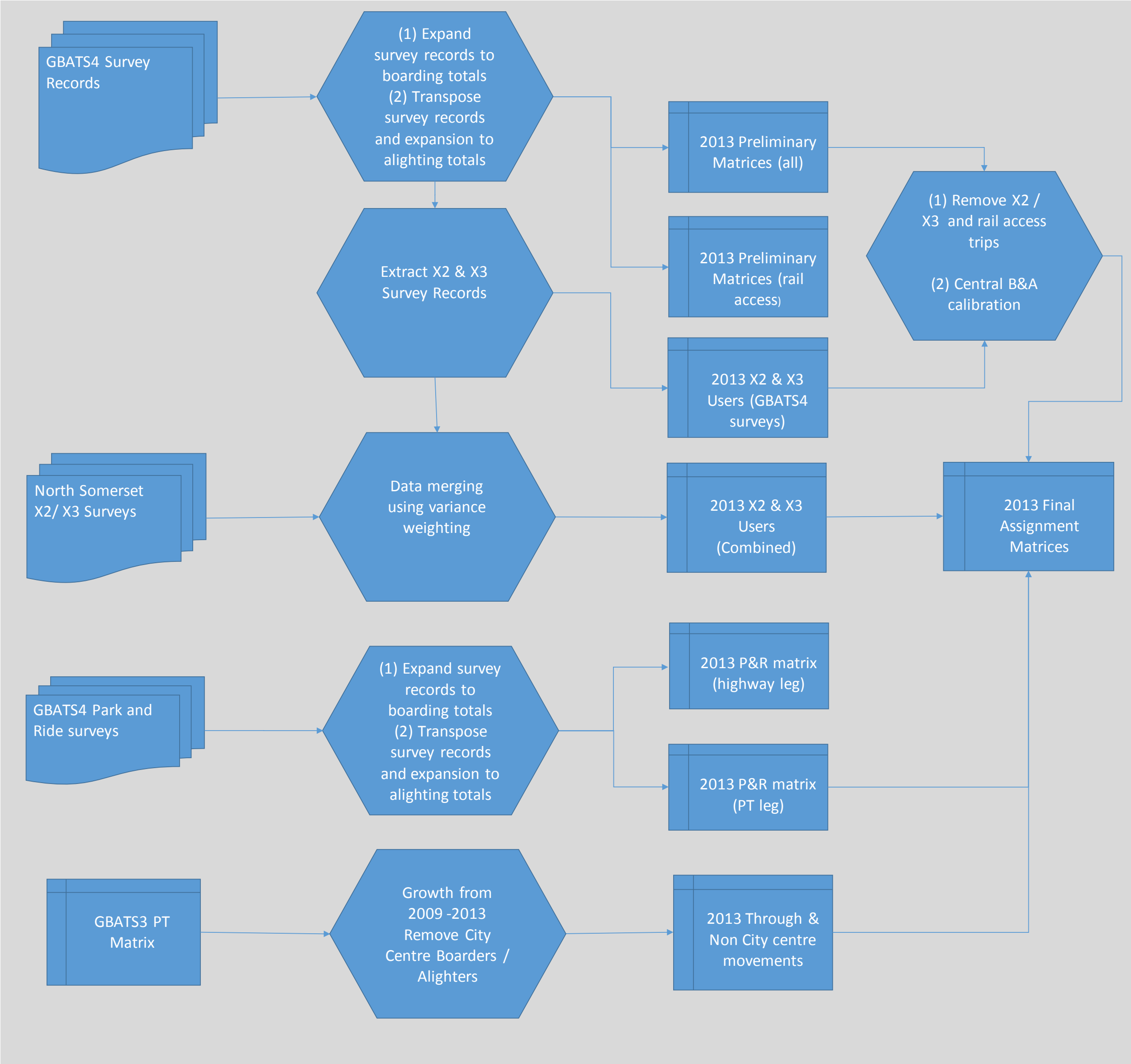

Figure 5.1: Bus matrix development process

5.2.1 Boarding and Alighting Counts

Boarding and alighting counts were matched to stops and time periods (AM, IP and PM). The total number of observations for each service number, stop and time period was derived. This was then compared to the total number of services expected at the stop per time period. This allowed a sample rate factor to be derived, and a correction factor used to uplift /reduce the observed number of boardings/alightings at the stop.

To aid the matrix building process and avoid potentially spurious expansion factors, stops were grouped into expansion clusters. This process also corrected for some misallocation of survey records to adjacent bus stops. Table 5.1 details the B&A sample rate per group and Figure 5.2 illustrates the expansion groupings utilised.

As detailed in the report of surveys, at-stop counts and passenger interview surveys did not include all bus stops, but included the busiest city centre stops.

Table 5-1: Sample rate by expansion group

Expansion Group	AM	IP	PM
1	79%	81%	70%
2	103%	103%	83%
3	84%	92%	85%
4	65%	85%	85%
5	59%	72%	70%
6	100%	99%	97%
7	71%	52%	64%
8	102%	68%	72%
9	99%	101%	63%

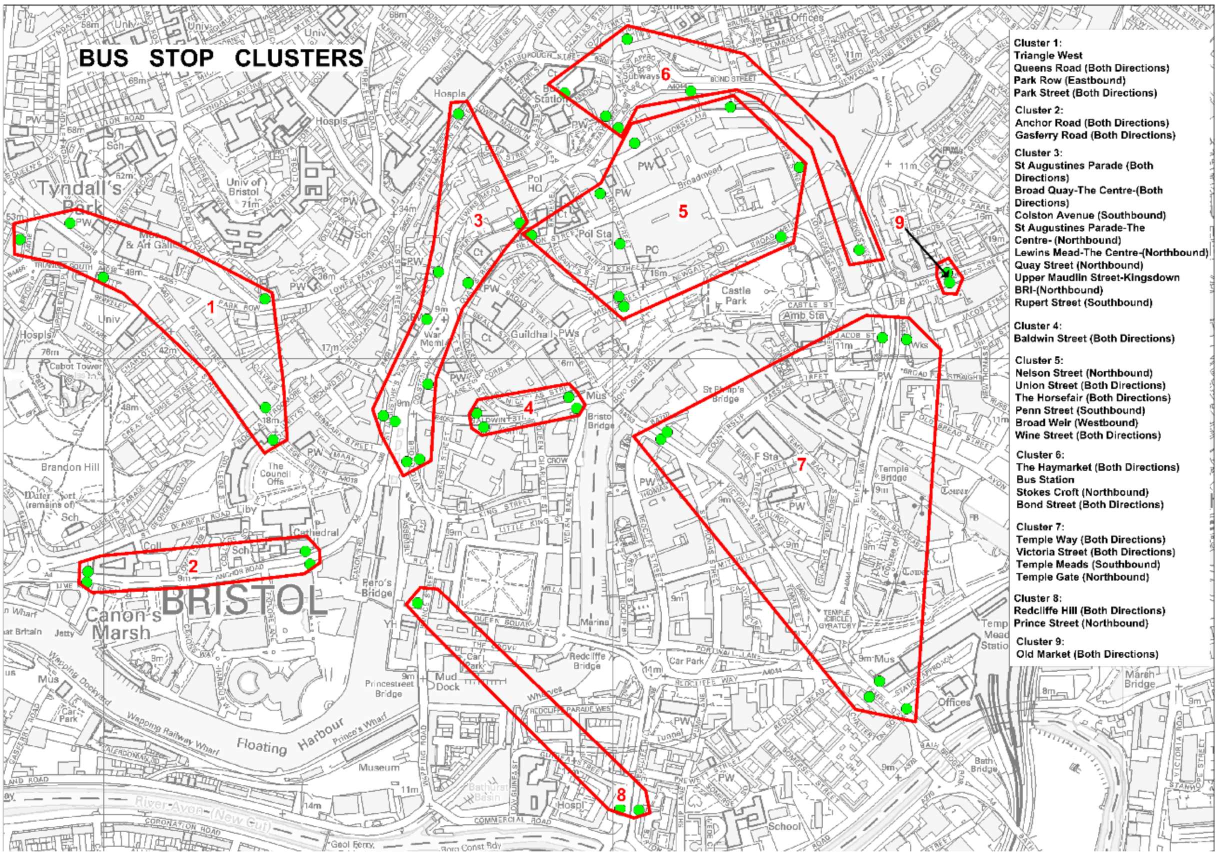

Figure 5.2: Bus Stop expansion groups

5.2.2 'At-Stop' Surveys

The 'at-stop' passenger surveys recorded trip origin and destination, trip purpose, time of return trip, access & egress mode from respondents and the number of passengers travelling together with the interviewee.

This data was comprehensively checked to ensure that data was reliable, referred to the correct stop, and had OD recorded in the correct direction. Suspect records were investigated and corrective action taken where possible (i.e. trip record reversed, reallocated to another stop, access mode adjusted). If no corrective action could be taken the survey record was removed from the dataset.

5.2.3 Boarding Expansion Factors

Boarding expansion factors to expand the survey records were determined using the expansion area groups. This technique was adopted to help avoid "lumpiness" that can occur when calculating expansion factors at the individual stop level. The expansion factor for a given survey response is calculated by:

$$BoardingExpansionFactor = \frac{N_{S,mTH}}{n_{S,sTP}}$$

Where:

- $N_{S,mTH}$ is the total number of boarders at expansion area group S during the modelled time hour mTH.
- $n_{R,S,sTP}$ is the total number of passenger OD surveys at expansion area group S during the surveyed time period sTP.

Table 5.2 details the boarding expansion factor per expansion group.

Table 5-2: Boarding expansion factors by time period

Expansion Group	AM	IP	PM
1	1.73	1.25	4.49
2	0.92	1.09	7.41
3	4.57	2.54	10.59
4	1.59	0.70	4.89
5	2.65	2.47	9.55
6	3.57	2.67	8.12
7	2.82	1.89	9.44
8	2.25	3.26	2.77
9	1.75	0.78	5.12

These expansion factors were applied to the number of passengers associated with each survey record, to produce an expanded total number of trips between origin and destination zone.

5.2.4 Transposition of Survey Records

The 'at stop' surveys only obtained OD information for boarders. As the stops surveyed were all located in the city centre, this generally meant that passengers leaving the city centre were interviewed. To generate the "city-centre bound" leg of the trip required the transposing of trips records and allocation to the three model time periods. The allocation of trip record to time period was based on a cross-tabulation of trip purpose and return timing of trip based on an analysis of survey records.

Table 5.3 summarises the transposition of trips records to the "non-observed" direction. For example, of the surveys completed in the AM Peak, 7% were transposed and allocated to the AM peak, 23% to the Inter peak and 64% to the PM peak. 7% were not transposed as the "un-surveyed" leg of the journey was outside of the modelled period, or the trip was "single".

Table 5-3: Transpose factors by time period

Interview Time	Number of Surveys completed in time period	Un-surveyed trip time			
		AM	IP	PM	Single Trip or Outside model period
AM (07:00 – 10:00)	832	7%	23%	64%	6%
IP (10:00 – 16:00)	1452	24%	45%	21%	10%
PM (16:00 -19:00)	790	56%	24%	8%	12%

5.2.5 Alighting Expansion Factors

Alighting Expansion Factors were derived for the transposed data in a similar fashion to the boarding expansion factor. The expansion factor for a given survey response is calculated by:

$$AlightingExpansionFactor = \frac{N_{S,mTH}}{n_{S,sTP}}$$

Where:

- $N_{S,mTH}$ is the total number of alighters at expansion area group S during the modelled time hour mTH.
- $n_{S,sTP}$ is the total number of passenger OD surveys at expansion area group S during the surveyed time period sTP.

Table 5-4: Alighting expansion factors by time period

Expansion Group	AM	IP	PM
1	9.46	1.54	2.67
2	6.56	1.34	1.58
3	9.35	2.69	3.15
4	12.14	1.33	1.46
5	3.78	2.28	2.26
6	9.54	4.52	3.87
7	11.24	2.67	2.00
8	11.60	2.35	2.22
9	5.15	1.17	1.75

The alighting expansion factors were applied to each transposed survey record to produce the total number of trips alighting at the node. Table 5.4 details the alighting expansion factors by expansion group.

To avoid double counting in the transpose and expansion process, a weight of 0.5 was applied to records for users who stated they had travelled by bus to reach the stop where they were surveyed, waiting for another bus service.

5.2.6 Preliminary bus matrix calibration

Following initial assignment, the production of preliminary matrices included some adjustment to calibrate the matrices to the central area boarding and alighting data. Figures 5.3- 5.5 illustrate the pattern of demand in the GBATS4M preliminary matrices. The resulting matrices show a pattern of trips consistent with what would be expected. In the AM peak it can be seen that there is a predominance of trip destinations in and around the city centre. The UWE Frenchay campus also appears as a major destination – reflecting its size and importance. The inter-peak preliminary matrix is generally more balanced with the number of trips originating from any zone of a similar magnitude to the number of trips travelling to the zone. In the PM peak it can be seen that the trips primarily originate from zones in and around the city centre.

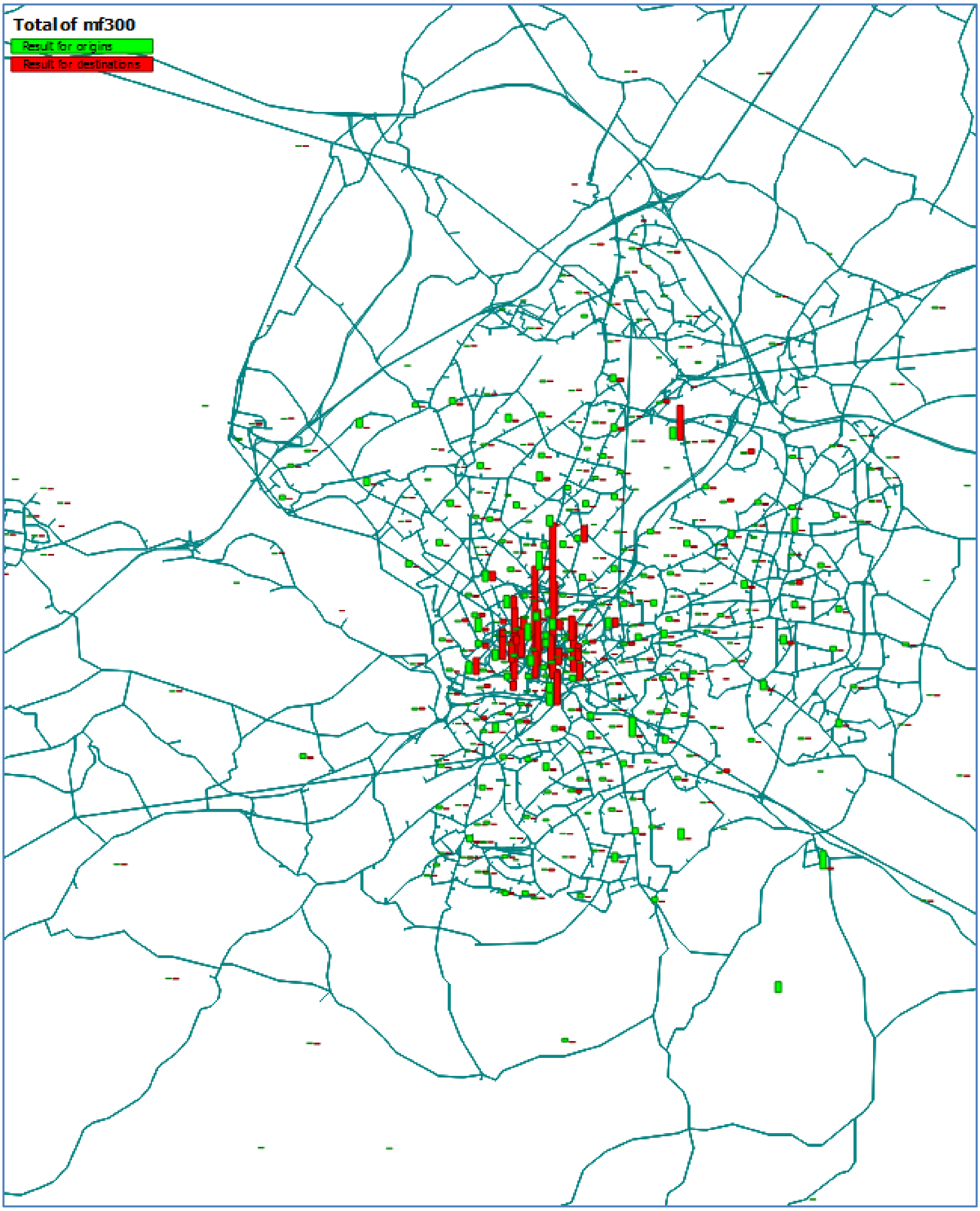

Figure 5.3: GBATS4M AM peak preliminary bus matrix

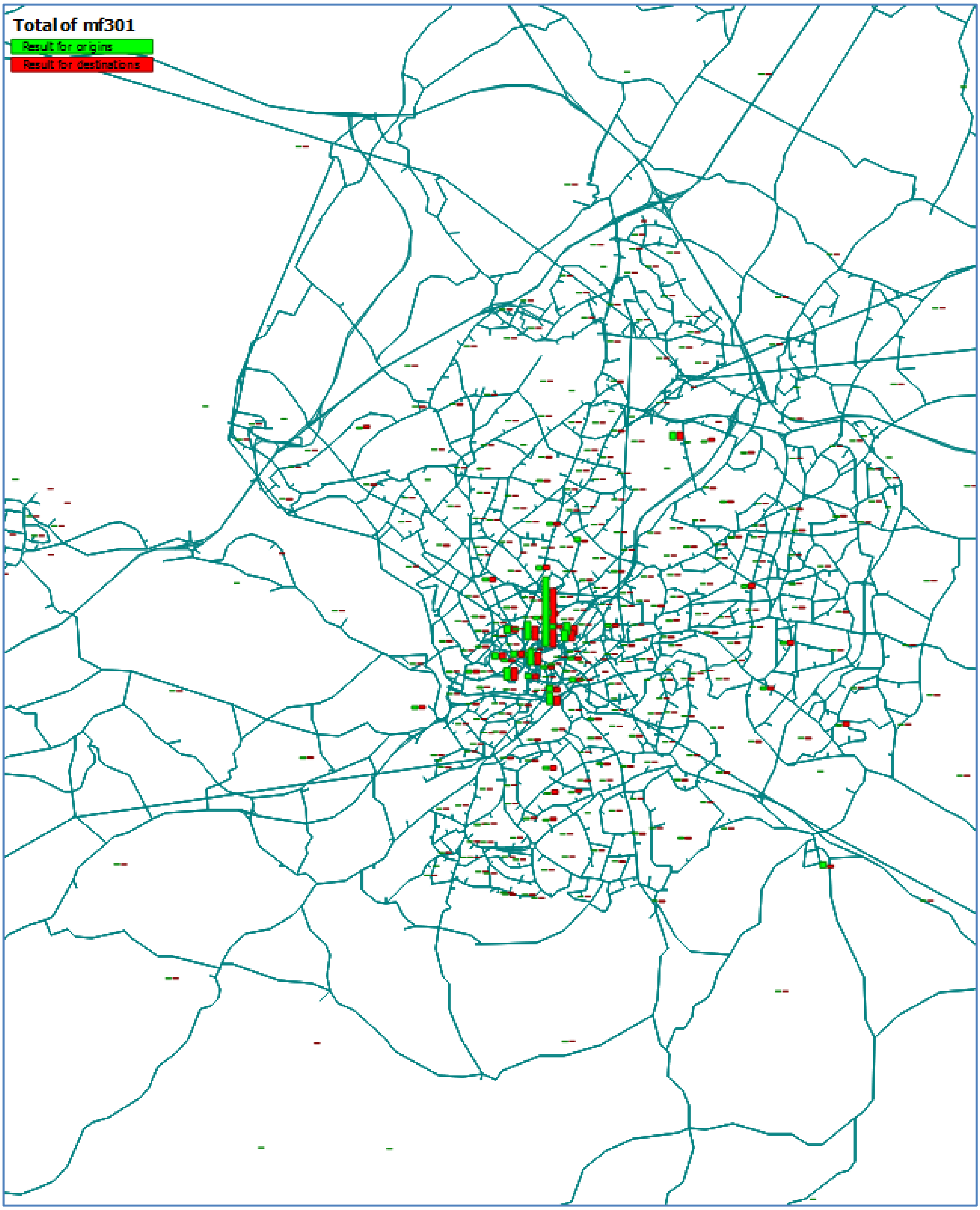

Figure 5.4: GBATS4M Inter peak preliminary bus matrix

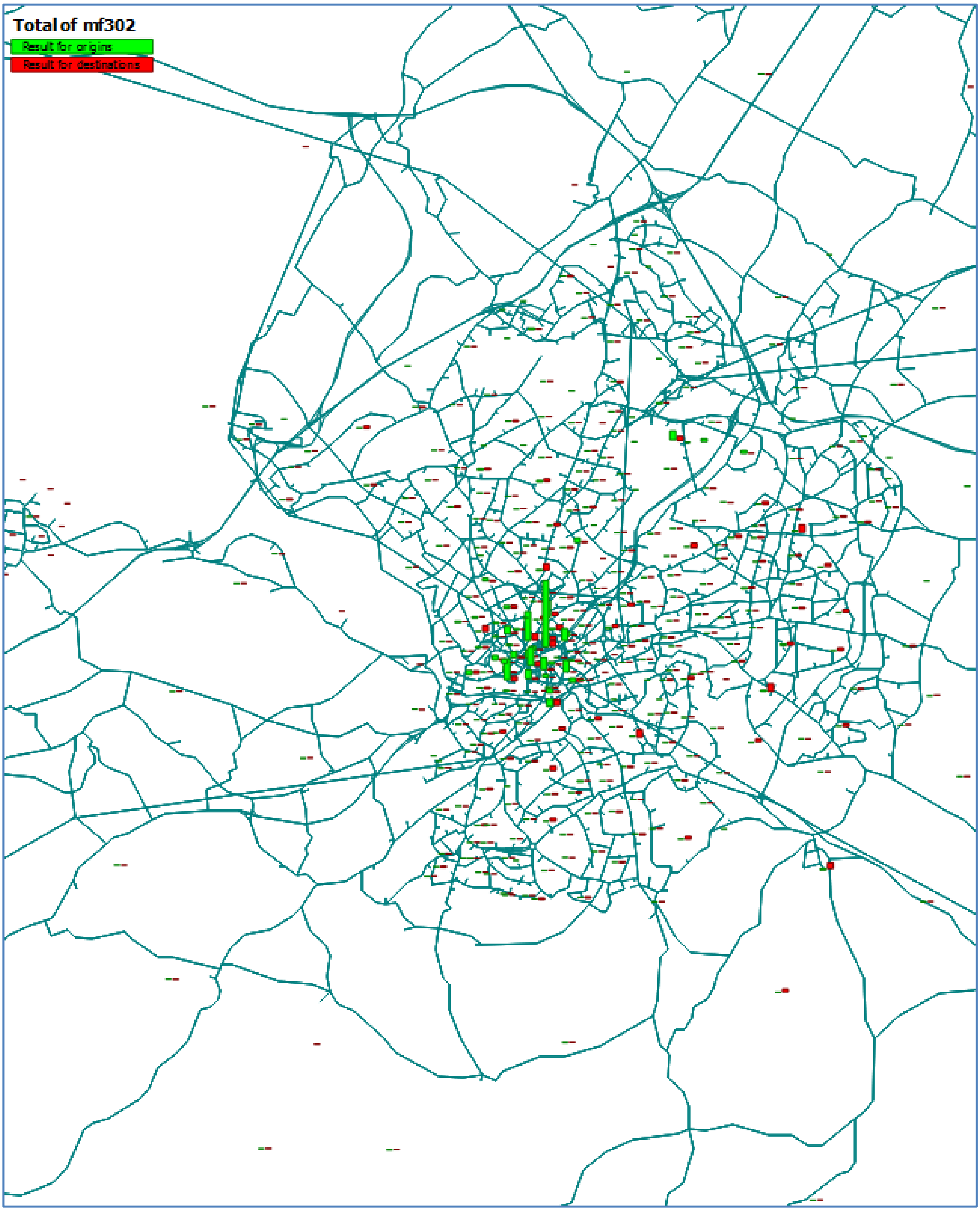

Figure 5.5: GBATS4M PM peak preliminary bus matrix

Table 5.5 summarises the matrix totals for the three time periods. These are the core building blocks of the final 2013 assignment matrices.

Table 5-5: GBATS4M preliminary matrix totals

Period	AM	IP	PM
GBATS4M preliminary matrix	8172	5584	8037

5.2.7 Merging of X2 / X3 Matrices

Two sources of demand data were available for the X2/X3 bus service; the main GBATS4M 'At Stop' surveys conducted in November 2013 and the "on-board" surveys conducted by North Somerset Council (NSC) in May 2014.

The North Somerset survey data was analysed to create two separate datasets. The first covered 'local' movements – essentially those trips between Portishead / Pill / Clanage Road. These trips were not surveyed in the GBATS4M surveys and therefore the NSC data is the only recent source of data. The second dataset covered the inter-urban movement (i.e. trips between Portishead and Bristol). This dataset potentially covers some of the movements that the November 2013 surveys included.

A weighted merge was applied to make best use of the most reliable estimate of demand for each OD pair. Firstly all trips in the preliminary GBATS4M matrices relating to the X2/X3 service were identified and removed from the GBATS4M preliminary matrices. These were then combined with the NSC dataset for inter-urban trips to form a sub-matrix of X2/X3 users using a weighted merge based on indices of dispersion. More precisely, from two matrices containing $\dot{X}_1$ and $\dot{X}_2$ for the same ij pair a merged estimate of $\dot{X}$ is:

$$\dot{X}_m = \frac{I_2\dot{X}_1 + I_1\dot{X}_2}{I_1 + I_2}$$

where:

- $I = Var(\dot{X}) / \dot{X}$
- $\dot{X} = \sum e$
- e = N/n, the expansion factor

Table 5.6 details the various sub-components of the X2/X3 demand included in the final assignment matrices.

Table 5-6: X2/X3 Demand Matrices

Source	AM	IP	PM
NSC "Local" X2/X3 Matrix	32	60	29
X2/X3 users from preliminary matrix	148	113	110
Merged X2/X3 Matrix (combined NSC and GBATS4M surveys)	165	128	190

5.2.8 Park and Ride Matrices

New Park and Ride matrices have been developed using the OD surveys conducted in November 2013. Survey records were expanded to the weekday average B&A counts provided by BCC. Trip records were analysed and two sets of matrices derived – one covering the "car-leg" part of the trip (i.e. the trip from the home end to the Park and Ride site), the other the PT based part of the trip (the trip from the P&R site to the ultimate destination). The car-leg portions of the trips were included in the highway model assignment.

Processing of survey records from the Portway P&R service took account of the fact that the 902 service also collects passengers from Sea Mills and Shirehampton. These trips were included in the survey records. However it would be incorrect to create a "car-leg" matrix for these trips as access to the service does not involve driving to the P&R site.

Table 5.7 details the different segments of matrices to be added included in the main assignment matrices.

Table 5-7: Park and Ride Demand Matrices

Source	AM	IP	PM
Portway 'non car' users	32	60	29
P&R Users (all sites)	665	280	554

5.2.9 Inter-modal transfers

Trip records where 'rail' was used as access mode to the bus stop or subsequent onwards mode to their final destination were separated out and stored in separate time period matrices. These trips are already theoretically included in the rail matrix and therefore including them in the bus matrix would constitute double counting. These trips are therefore removed from the final assignment matrices.

Table 5-8: Bus/ Rail intermodal transfers

Source	AM	IP	PM
Bus/Rail Intermodal matrix	284	196	266

5.2.10 Non-city centre movements

The emphasis of the GBATS4M survey programme was on city centre boardings/alightings. As a consequence any matrices built purely from these survey records would almost entirely be city centre focussed. Movements from/ to areas outside the city centre would be excluded, unless an inter-bus city centre transfer was involved. Passengers on "cross-city" services such as the Service 75 (Hengrove – Cribbs) would not be surveyed or represented in the matrix.

The SBL version of GBATS3 PT model incorporated bus matrices based upon on-board bus OD surveys collected in July/ November 2009 together with Wayfarer data. The use of these data sources mean that the GBATS3 matrices theoretically cover not only movements to/from the city centre, but also movements to and from areas outside the city centre.

In order to capture these "non-city centre" movements and incorporate them in the GBATS4M PT model matrices, a process was developed to remove the OD movements from the SBL matrices that used any of the city centre bus stops that had been surveyed in November 2013. Any local trips between Portishead, Pill and Clanage Road were also removed as these were covered by the more recent North Somerset on-board surveys. As stated in section 4.1, the SBL model bus matrices include all OD data contained in the North Fringe Hengrove (NFH) model and South Gloucestershire Core Strategy Model (CSM). This included a number of count and interview surveys across Bristol, including the North Fringe area, as documented in the data collection report relevant to those models[2].

The resulting matrix of trips not observed by the GBATS4M PT surveys, was then added to the November 2013 bus user matrix before the Final Assignment matrices were produced. This included adjustment of demand outside the central modelled area to provide a good fit to available bus operator corridor demand data. Table 5.10 details the matrix totals of the source matrix and the resultant estimate for non-observed trips.

[2] South Bristol Link North Fringe Hengrove Package Data Collection Report, Atkins August 2011

Table 5-9: Non City Centre Matrix

Source	AM	IP	PM
SBL Matrix (all trips)	13467	9930	11826
2013 non city-centre Matrix	5047	4930	4660

5.2.11 Bus Matrix Totals

Table 5.10 summarises the main component parts of the GBATS4M Public transport matrices. The Final Assignment Matrices were filtered to remove any "walk" only trips (i.e. trips that were completed in their entirety without utilising a bus service).

Table 5-10: Components of Final Assignment Matrices

Source	AM	IP	PM
GBATS4M preliminary matrix	8172	5584	8037
2013 Non city centre matrix	5047	4930	3486
Combined Matrix (inc adjustments for P&R, X2/X3 etc)	13743	10662	13124
Final Assignment Matrix (walk only trips removed)	12506	9590	11852

Figure 5.6 details the trip length distribution of the final bus assignment matrices. The average trip length suggested by these matrices is 8.1km in the AM peak, 8.8 km in the inter-peak and 8.7km in the PM peak.

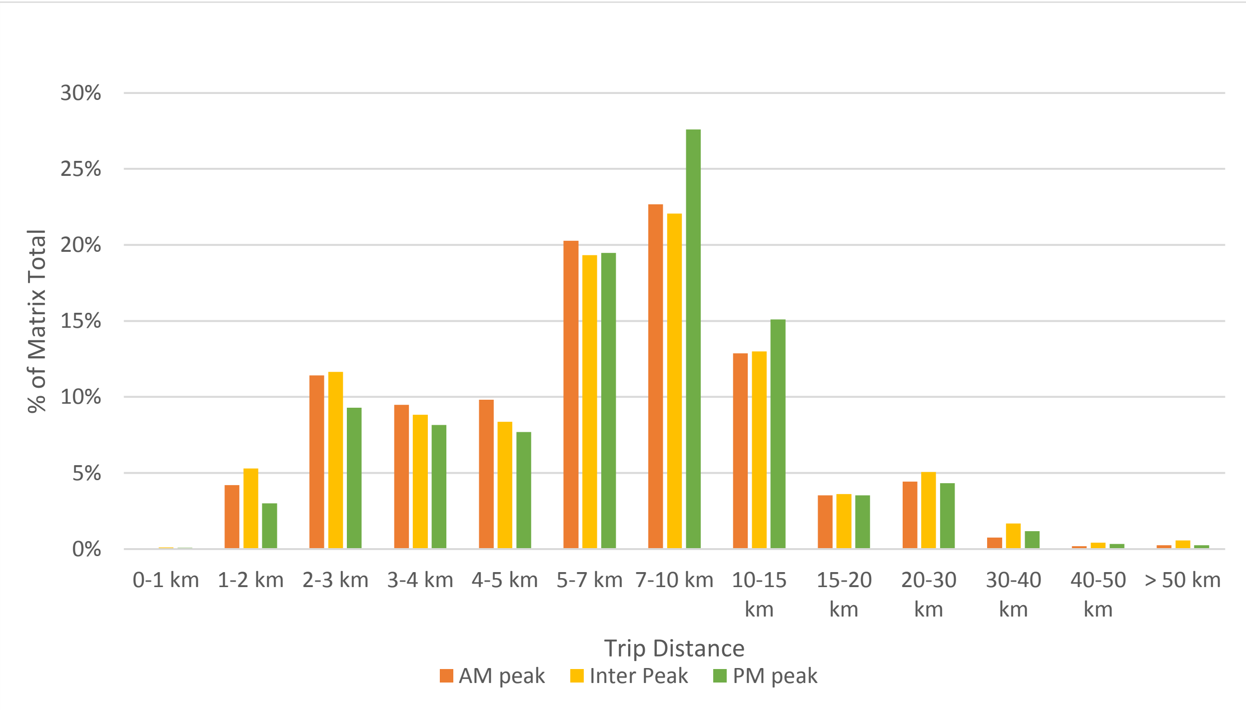

Figure 5.6: Trip length distribution of Final Assignment Matrices

5.3 Rail Matrices

5.3.1 Data sources

New rail matrices were developed for GBATS4M, making use of a number of available datasets. Note that while this included use of local survey data, no specific surveys of rail usage were carried out for model development. The principal sources of OD data used in the matrices were:

- West of England Rail Survey (WoE survey) – used for OD information and station entries and exits (where available);
- National Rail Travel Survey (NRTS) – used for OD information and station entries and exits (where WoE data was not available);
- Office of Rail Regulation (ORR) station usage estimates – used to update WoE survey information to 2013 values and adjust station entries and exits accordingly;
- MOIRA (rail industry model) – extracts from MOIRA have been used to assist in developing the rail matrices, including annual-to-daily and daily-to-period usage profiles and station-to-station movement calibration; and
- GBATS3 rail matrices – used for external-to-external rail movements, updated to 2013 figures using relationships derived from ORR station usage.

WoE Survey & NRTS data

The WoE surveys consist of an annual boarding and alighting count supplemented on a biannual basis by more detailed questionnaires. The development of rail matrices in the GBATS PT model makes use of station boarding and alighting counts carried out in November 2013, with questionnaire details from November 2012. Further surveys in the series took place in November 2014, but these were too late for inclusion in base year model. Surveys take place at all stations in the WoE area, but are limited to Severn Beach Line services only at Bristol Temple Meads, and coverage at other larger stations can be variable at busier times (such as Bristol Parkway and Bath Spa).

Comparison of WoE survey results with ORR station usage estimates has tended to yield differences that can be significant. This is partly as a result of differing methodologies, where the WoE survey is a one day snapshot in November and ORR usage estimates are based on ticket receipts. Both the WoE survey and NRTS provide an important element of OD information in that the trips included are ‘true’ origin to ‘true’ destination whereas MOIRA and LENNON ticketing data are station-to-station only.

Station entries and exits

Note that station entries and exits are used in the derivation and validation of the rail model rather than specific train boarding and alighting counts. Typically, larger station entry and exit values will be lower than counts of passengers actually boarding and alighting trains, as there is some element of train-to-train interchange, where the passengers concerned do not enter or leave the station. This distinction is related to the data available. Most of the stations in the WoE surveys (and indeed in the GBATS modelled area) are local stations at which there is no interchange, so entry and exit are the same as boarding and alighting respectively. The most significant interchange station in the modelled area, by far, is Bristol Temple Meads, but as this is not covered fully by the WoE surveys there is no record of interchange movements. However, NRTS and ORR provide station entries and exits on a consistent basis for all stations.

As such, while the primary source of station entries and exits is the WoE survey boarding and alighting counts, cross-reference has been made to NRTS derived information and ORR station entries and exits to identify the most appropriate values to use in matrix building and validation.

Table 5.11 shows station entries and exits derived for use in validating the rail elements of the model. These are compared with assigned rail mode trips later in this report.

Table 5-11: Station entries and exits – calculated from WoE survey & ORR figures (2013)

Station	AM peak		Inter Peak		PM peak	
	Entries	Exits	Entries	Exits	Entries	Exits
Bristol Temple Meads	892	2688	533	583	3395	870
Bedminster	54	26	6	6	17	43
Parson Street	68	15	6	4	22	48
Lawrence Hill	97	48	15	19	56	106
Avonmouth	20	33	8	9	38	22

Table 5-11: Station entries and exits – calculated from WoE survey & ORR figures (2013)

Station	AM peak		Inter Peak		PM peak	
	Entries	Exits	Entries	Exits	Entries	Exits
Shirehampton	28	10	6	8	10	41
Clifton Down	70	151	37	38	137	85
Montpelier	153	64	20	13	63	80
Stapleton Road	133	32	29	25	53	148
Redland	84	54	15	11	40	49
Sea Mills	42	4	6	7	8	51
Severn Beach	27	6	3	6	6	15
St Andrews Road	1	2	2	0	6	2
Bristol Parkway	427	412	160	125	251	764
Filton Abbeywood	117	554	88	47	503	106
Patchway	20	52	4	3	60	22
Yate	138	13	16	15	24	150
Bath Spa	993	1240	361	390	1238	1098
Keynsham	226	72	21	20	43	152
Oldfield Park	157	46	16	16	48	141
Nailsea & Backwell	171	105	40	72	90	250
Yatton	226	9	16	20	26	256
Weston Milton	41	13	6	7	8	37
Weston-super-Mare	304	113	77	69	155	337
Worle	128	26	22	23	34	175

5.3.2 Matrix development

The methodology for developing the base year rail matrices went through the following steps:

- Initial OD matrix developed from WoE survey data;
- Initial OD matrix developed from NRTS data;
- WoE and NRTS data merged;
- External-external movements added;
- Matrix smoothing; and
- Matrix calibration.

Initial OD matrix developed from WoE survey data

True origins and destinations are recorded in the WoE questionnaire surveys as postcodes. Around 90% are full postcodes, with others being partial, which can readily be allocated to GBATS zones.

The surveys record the time of departure, enabling direct allocation of movements to AM peak, Inter Peak and PM peak periods. Initially, in order to include the most comprehensive pattern the matrices included a 3-hour morning peak (07:00-10:00) and 3- hour PM peak (16:00-19:00), as well as including all movements in the inter peak period (between 10:00 and 16:00). However, closer examination of the data identified a significant drop-off in completed questionnaires through the day and especially in the PM peak, with de facto sample rates around 1% in the afternoon and evening, where up to 10% samples were recorded in the morning. This is not especially surprising, as a significant proportion of rail users at the WoE local stations are making return journeys, and moreover many are to Bristol Temple Meads (which was not surveyed).

As such, while boarding and alighting information is used from the whole day, origin and destination information from the WoE surveys is only taken from questionnaires undertaken prior to 13:00. This pattern is transposed to provide a combined direction Inter Peak and a PM peak pattern. Expansion factors derived from the boarding and alighting counts that accompanied the questionnaire surveys were used to convert the OD patterns to AM peak period (3-hour), Inter Peak (6-hour) and PM peak period (3-hour) matrices. Subsequently, hourly values were calculated for each period using a combination of the initial survey results and profiles from MOIRA.

Table 5.12 shows matrix totals derived from the WoE survey data.

Table 5-12: WoE survey initial matrix totals

2013 trips	AM	IP	PM
Total trips	5807	1342	5077

Initial OD matrix developed from NRTS data

True origins and destinations of rail trips are also recorded in the NRTS as postcodes, but unlike the WoE surveys, the most detailed postcode level included is postcode sector (for example, 'BS1 1'). This cannot always be allocated directly to a GBATS zone, particularly in urban areas, where postcode sectors can be much bigger than zones. As such, an origin and destination 'smoothing' process is subsequently required (described briefly below).

Like the WoE surveys, it is possible to identify time periods of movements directly from NRTS data. A key difference between the NRTS dataset and WoE survey data though, is that the NRTS dataset as issued to end users has been normalised and expanded to match ticketing data. As such, it is possible to directly collate information from the NRTS dataset into OD matrices that requires no further manipulation. However, to recognise that rail journeys are driven by the timetable and that patterns may slip just inside or outside arbitrary defined peak hours, a similar process was followed as with the WoE survey data to collate patterns from multi-hour periods initially, prior to final output as 1-hour values. Hourly values were calculated for each period using profiles from MOIRA.

ORR station entry and exit information is used to re-base NRTS trips to 2013 for the base year model. Table 5.13 shows matrix totals derived from NRTS data

Table 5-13: NRTS survey initial matrix totals

2013 trips	AM	IP	PM
Total trips	9587	3279	10083

WoE and NRTS data merged

With two sets of source matrices that essentially 'overlap' to a reasonable extent, it is not appropriate to simply add or average these datasets to produce combined matrices. As such, a weighted merge was applied to make best use of the most reliable estimate of demand for each OD pair from the respective matrices. The process followed is the same as that set out in the earlier section of this section that described bus matrix development, used to merge X2/X3 service matrices into the main preliminary bus matrices.

External-external movements added

While not specifically impacting on assignment, as there are currently no capacity based procedures involved, in order to better reflect all movements in the modelled area, external (to the detailed model area) trips are required. This cannot be determined from local surveys, and to do so from NRTS would be prohibitively complex, as this would require obtaining NRTS data for virtually all of the UK rail network (data was obtained for stations in the West of England area in order to derive the base year matrices). As such, it was determined that the best approach would be to capture external movements from the previous GBATS model – specifically the 2009 base year rail matrices from the predecessor SBL model.

ORR station entry and exit information has been used to re-base the external-external trips from 2009 to 2013, operating on pairs of stations using the average change (growth) over the ensuing period to 2013.

External-external trips were the added to the merged WoE survey and NRTS matrices to give a set of total initial rail matrices. Table 5.14 shows component parts and merged matrix totals.

Table 5-14: Merging rail matrices – 2013 trips

Source	AM	IP	PM
WoE Survey	5807	1342	5077
NRTS [1]	9358	3122	9790
External-external	936	312	506
Merged [2]	**9081**	**2841**	**9310**

(1) Note that the initial NRTS matrices included some trips that were external zone to external zone. These were removed prior to the merging process

(2) Merged totals exclude a small amount of intra-zonal trips, also eliminated in the process

Matrix smoothing

Once the initial matrices were developed it became apparent that some areas exhibited a coarse distribution of trips between adjacent zones. This was particularly an issue in the denser urban areas, and follows from the situation outlined earlier that postcode data used to reference true origin and destination could not always be allocated to concurrent zones. As such, all trips within a postcode sector would be allocated to a particular zone, leaving other adjacent zones empty.

Hence, a matrix smoothing process was employed that re-distributed trips within these areas. Matrix smoothing did not adjust trip totals, but rather re-distributed trips among groups of zones where particularly coarse distribution was observed, including:

- Central Bristol;
- North Fringe (two separate sections);
- Around Montpelier and Redland stations
- Around Clifton Down station
- Around Bedminster and Parson Street stations;
- Easton; and
- Bath

Smoothing was accomplished using a combination of population and employment figures derived from the 2011 Census. Population data was applied to origin zones in the AM peak and destination zones in the PM peak. Employment data was applied to destination zones in the AM peak and origin zones in the PM peak. An aggregate of population and employment was used for both origin and destination in the Inter Peak.

Matrix calibration

Trial assignment of the smoothed matrices indicated that whilst there was a good fit with entry and exit data at some locations, there were significant differences in others. This was to be expected as a result of the dominance of Bristol Temple Meads in the rail market in the area, but a comparative lack of local data to explain its usage. While the national datasets cover stations across the whole of the rail network in a consistent way, they do not always interact well with local data, as witnessed by previous discussions about differences between WoE survey and ORR figures.

Hence, the rail matrices were calibrated using the ‘demadjt’ process within EMME. This takes movements on key links and adjust trip matrices to match (as well as possible) assigned flows to values derived from counts.

Table 5.15 shows matrix totals before and after adjustment. As an indication of modelled demand patterns, Figure 5.7 shows the origin and destination totals of rail matrices on a network plot for the AM peak.

Table 5-15: Final Base Year rail matrix totals – 2013 trips

Source	AM	IP	PM
Initial matrices (merged)	9081	2841	9310
Final matrices (post adjustment)	9138	3219	10360

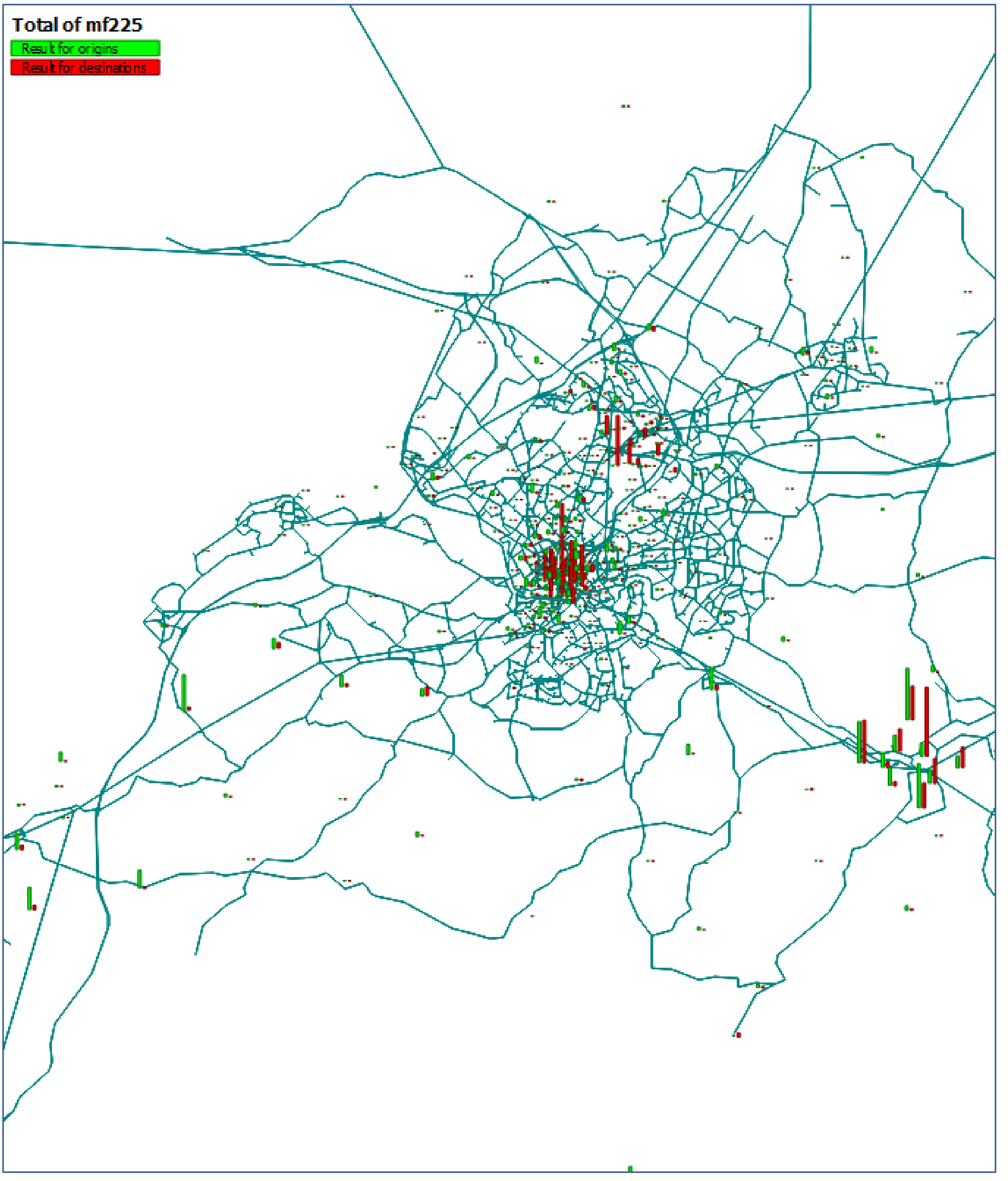

Figure 5.7: Base year rail matrix totals – AM peak

Model Calibration and Validation

6.1 Introduction

Following the construction of the public transport network and services (Section 4) and the accompanying public transport demand matrices (Section 5), a calibration and validation exercise was undertaken to assess the robustness of the resulting model.

The validation process has been carried out in-line with current guidelines as set-out in the TAG M3.2. This states that validation should involve checks of:

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

The validation of the public transport network was an on-going iterative process during the model construction. A number of assignments were undertaken to achieve a validated model. The results of the final assignment are outlined in the following paragraphs.

The steps in the validation and calibration process were:

- Bus and rail demand matrices were assigned onto the network for each time period;
- Passenger demand flows and boarding flows in the modelled assignment were analysed and compared with the public transport passenger count dataset obtained from the surveys and or other datasets.

6.2 Bus Mode Validation

6.2.1 Matrix Validation – Bus

TAG Unit M3.2 states that "Wherever possible, a check should be made between the annual patronage derived from the model and annual patronage derived by the operator". No specific targets are defined for what is considered acceptable. However for the purpose of this exercise a target of +/- 15% was set.

Table 6.1 details the bus user matrix totals, together with the total number of bus boardings suggested by the PT model final assignment. It can be seen that the average trip involves the use of approximately 1.22 trips in the AM peak; similar levels are suggested for the inter-peak and PM peak.

Table 6-1: Matrix totals and bus boardings by time period

Time Period	Matrix Total	Bus Boardings	Average Bus Boardings / Trip
AM	12505	15332	1.22
IP	9590	11451	1.19
PM	11852	14624	1.23

Expansion factors derived from survey data and ETM data supplied by First have been used to enable the assignment results to be expanded to annual patronage. Table 6.2 details the expansion values and the patronage totals (49.5m).

Table 6-2: Matrix totals and bus boardings by time period

Expansion Factor	Expansion Value	Source	Total
Modelled AM peak Hour Boardings-> 3 hour total	2.22	Survey Data	34,071
Modelled Inter-peak boardings –> 6 hour total	6.0	Average	68,706
Modelled PM Peak boardings– >3 hour total	2.78	Survey Data	40,622
12 Hour Total –>24 hour total	1.12	ETM data	160,607
Weekend Estimate (applied to IP Total)	1.38	ETM data	94,814
Annual Weekday	253	Number of weekdays	40,633,635
Annual Weekend	112	Number of weekend days	10,619,199
Seasonal Adjustment (Autumn –> Average Monthly)	0.966	ETM Data	49,519,646

The estimated annual patronage has been compared against patronage data provided by the Department for Transport (Annual Bus Statistics 2013/2014: Table Bus 0109a). This data is presented in Table 6.3. Data for three local authorities has been adjusted downwards to take account for the fact that not all services operating in this regions are modelled in the MetroWest PT model. This shows a reasonably close fit to the operator data.

Table 6-3: Comparison of annualised model boardings and operator data

Authority	2013/2014	Estimate for Modelled Area
Bath and North East Somerset	12	4.8
Bristol	29.8	29.8
North Somerset	5.0	4.3
South Gloucestershire	6.9	5.9
All	53.7	44.8
Estimate of Annual Patronage Metrowest PT model		49.5
% Difference between actual and model		+10.5%

6.2.2 Assignment Validation Results – Bus

TAG Unit M3.2 states that validation of model assignment should involve comparing modelled and observed patronage flows across screenlines and passengers boarding and alighting in urban centres.

The TAG recommendation is that across modelled screenlines, modelled flows should, in total, be within 15% of the observed values. On individuals links modelled flows should be within 25% of the counts for observed flows exceeding 150. For links with observed flows under 150, GEH < 5 has been used as validation criteria. Tables 6.4-6.6 detail the screenline flows during the three modelled time periods.

Based on the data in Tables 6.4-6.6 the model can be considered to be successfully validated against individual cordon flows (+/- 25% or GEH<5) and screenline (+/-15%) totals.

Table 6-4: AM Peak Screenline Flows

Cordon Site	Count	Model	% Difference	Abs Diff	GEH	Pass / Fail
			INBOUND			
Newfoundland Street	326	339	4%	12	0.7	Pass
Old Market Street	1773	1520	-14%	-252	6.2	Pass
Bath Road/ Wells Road	1612	1824	13%	212	5.1	Pass
Bedminster Parade	663	744	12%	81	3	Pass
St John's Road	119	124	5%	6	0.5	Pass
Coronation Road	6	23	290%	17	4.5	Pass
Cumberland Road	10	9	-11%	-1	0.3	Pass
Hotwells Road	825	693	-16%	-132	4.8	Pass
Queens Road	1046	882	-16%	-164	5.3	Pass
Horfield Road	14	28	100%	14	3.1	Pass
Cheltenham Road	1121	1021	-9%	-100	3.1	Pass
City Road	145	123	-15%	-22	1.9	Pass
Total	**7659**	**7330**	**-4%**	**-330**	**3.8**	**Pass**
			OUTBOUND			
Newfoundland Street	172	193	12%	21	1.6	Pass
Old Market Street	438	442	1%	5	0.2	Pass
Bath Road/ Wells Road	201	228	13%	27	1.8	Pass
Bedminster Parade	166	200	20%	33	2.5	Pass
St John's Road	77	54	-30%	-23	2.9	Pass
Coronation Road	38	23	-39%	-15	2.7	Pass
Cumberland Road	6	10	66%	4	1.4	Pass
Hotwells Road	164	136	-17%	-28	2.3	Pass
Queens Road	1006	814	-19%	-191	6.3	Pass
Horfield Road	4	10	174%	6	2.4	Pass
Cheltenham Road	723	549	-24%	-174	6.9	Pass
City Road	32	47	48%	15	2.4	Pass
Total	**3026**	**2706**	**-11%**	**-319**	**6**	**Pass**

Table 6-5: Inter Peak Screenline Flows

Cordon Site	Count	Model	% Difference	Abs Diff	GEH	Pass / Fail
			INBOUND			
Newfoundland Street	139	162	17%	23	1.9	Pass
Old Market Street	823	691	-16%	-132	4.8	Pass
Bath Road/ Wells Road	563	655	16%	92	3.7	Pass
Bedminster Parade	391	367	-6%	-24	1.2	Pass
St John's Road	78	62	-21%	-16	2	Pass
Coronation Road	35	31	-11%	-4	0.7	Pass
Cumberland Road	4	17	273%	12	3.7	Pass
Hotwells Road	247	258	4%	10	0.7	Pass
Queens Road	453	502	11%	49	2.2	Pass
Horfield Road	12	11	-9%	-1	0.3	Pass
Cheltenham Road	481	484	1%	3	0.1	Pass
City Road	79	54	-32%	-26	3.1	Pass
Total	**3307**	**3294**	**0%**	**-13**	**0.2**	**Pass**
			OUTBOUND			
Newfoundland Street	167	160	-4%	-6	0.5	Pass
Old Market Street	891	788	-11%	-102	3.5	Pass
Bath Road/ Wells Road	590	711	20%	121	4.7	Pass
Bedminster Parade	400	450	13%	50	2.4	Pass
St John's Road	91	63	-31%	-28	3.2	Pass
Coronation Road	37	58	55%	21	3	Pass
Cumberland Road	3	7	155%	4	1.9	Pass
Hotwells Road	298	339	14%	40	2.3	Pass
Queens Road	605	502	-17%	-104	4.4	Pass
Horfield Road	11	33	205%	22	4.7	Pass
Cheltenham Road	490	504	3%	14	0.6	Pass
City Road	52	84	61%	32	3.9	Pass
Total	**3635**	**3700**	**2%**	**65**	**1.1**	**Pass**

Table 6-6: PM Peak Screenline Flows

Cordon Site	Count	Model	% Difference	Abs Diff	GEH	Pass / Fail
			INBOUND			
Newfoundland Street	145	208	44%	64	4.8	Pass
Old Market Street	695	533	-23%	-162	6.5	Pass
Bath Road/ Wells Road	421	486	15%	65	3.1	Pass
Bedminster Parade	309	276	-11%	-32	1.9	Pass
St John's Road	78	71	-9%	-7	0.8	Pass
Coronation Road	58	26	-54%	-32	4.9	Pass
Cumberland Road	8	14	72%	6	1.7	Pass
Hotwells Road	220	184	-17%	-37	2.6	Pass
Queens Road	612	674	10%	62	2.4	Pass
Horfield Road	8	9	9%	1	0.3	Pass
Cheltenham Road	523	397	-24%	-126	5.9	Pass
City Road	53	48	-9%	-5	0.6	Pass
Total	**3129**	**2926**	**-6%**	**-203**	**3.7**	**Pass**
			OUTBOUND			
Newfoundland Street	387	403	4%	16	0.8	Pass
Old Market Street	2016	1831	-9%	-185	4.2	Pass
Bath Road/ Wells Road	1543	1646	7%	104	2.6	Pass
Bedminster Parade	792	754	-5%	-38	1.4	Pass
St John's Road	142	119	-16%	-22	2	Pass
Coronation Road	8	7	-9%	-1	0.3	Pass
Cumberland Road	11	30	170%	19	4.1	Pass
Hotwells Road	644	584	-9%	-60	2.4	Pass
Queens Road	1028	824	-20%	-203	6.7	Pass
Horfield Road	24	41	70%	17	2.9	Pass
Cheltenham Road	896	844	-6%	-52	1.8	Pass
City Road	93	117	26%	24	2.4	Pass
Total	**7582**	**7201**	**-5%**	**-382**	**4.4**	**Pass**

Table 6.7 compares the modelled boardings and alighting with the observed data. Across all three time periods it can be seen that modelled figures are within the TAG acceptability criteria.

Table 6-7: Central area validation of bus boarding and alighting

Time period	Count	Model	% Difference	Pass / Fail
		BOARDING		
AM	2774	2809	1%	35
IP	3555	3498	-2%	-57
PM	6832	6558	-4%	-274
		ALIGHTING		
AM	7262	7291	0%	30
IP	3276	3327	2%	51
PM	2708	3015	11%	307

It should be noted that central area boardings and alightings have been included in the matrix calibration process. The check against cordon counts by corridor provide validation of the bus model assignment using an independent data source.

6.2.3 Journey Time Validation – Bus

Modelled journey times were compared to bus timetables. Primary emphasis was placed on the six MetroWest corridors. In addition, checks were made of the most frequent bus services in the model (defined as the top 40% of services in terms of frequency). Table 6.8 and Appendix C have of this validation exercise and the services included in the comparison.

TAG M3.2 does not detail a specific target for the validation of journey times. However for the purpose of this exercise a target of +/-15% was set, which is consistent with highway model journey time validation criteria.

Based on the data in Table 6.8 the model journey times can be considered to be successfully validated against published bus journey times.

Table 6-8: Validation of bus journey times

Corridor	Total Number of Services	Number of Services within JT threshold	% of Services
	AM PEAK		
Corridor 1 - Weston Super Mare	10	10	100%
Corridor 2 – Portishead	11	11	100%
Corridor 3 - Severn Beach	18	18	100%
Corridor 4 – Henbury	69	69	100%
Corridor 5 - Bristol Parkway/Yate	64	64	100%
Corridor 6 - Keynsham/Bath Spa	30	30	100%
Total Metrowest Corridors	**202**	**202**	**100%**
Top 40% of Services (ordered by frequency)	**155**	**155**	**100%**

Table 6-8: Validation of bus journey times

Corridor	Total Number of Services	Number of Services within JT threshold	% of Services
	INTER PEAK		
Corridor 1 - Weston Super Mare	9	9	100%
Corridor 2 – Portishead	12	11	92%
Corridor 3 - Severn Beach	17	17	100%
Corridor 4 – Henbury	85	85	100%
Corridor 5 - Bristol Parkway/Yate	78	78	100%
Corridor 6 - Keynsham/Bath Spa	20	20	100%
Total Metrowest Corridors	**221**	**220**	**99.5%**
Top 40% of Services (ordered by frequency)	**174**	**174**	**100%**
	PM PEAK		
Corridor 1 - Weston Super Mare	8	8	100%
Corridor 2 – Portishead	12	12	100%
Corridor 3 - Severn Beach	17	17	100%
Corridor 4 – Henbury	73	73	100%
Corridor 5 - Bristol Parkway/Yate	70	70	100%
Corridor 6 - Keynsham/Bath Spa	30	28	93%
Total Metrowest Corridors	**210**	**208**	**99.0%**
Top 40% of Services (ordered by frequency)	**152**	**152**	**100%**

6.2.4 Check against ETM data

Individual service boardings were checked against ETM data provided by FIRST Bristol for 20 bus services operating along the MetroWest corridors. Data from other operators was not available. The ETM was processed to derive an estimate of service loadings by modelled hour and then assigned to a MetroWest corridor. Some services fell in more than one corridor. The ETM data was then compared against modelled service loadings. TAG M3.2 does not contain a specific target for checks against operator data. Table 6-9 shows a good fit against operator data in most cases. It should be noted that other services also operate on these corridors and hence a precise match would not always be expected in this type of model, but this nevertheless provides further assurance that the model provides a good representation of patronage on these corridors.

Table 6-9: Check against ETM data

Corridor	Operator ETM Patronage Data	Model Patronage Data	Model / ETM data
	AM PEAK		
Corridor 1 - Weston Super Mare	160	220	1.38
Corridor 2 – Portishead	316	308	0.97
Corridor 3 - Severn Beach	623	673	1.08
Corridor 4 – Henbury	3722	4293	1.15
Corridor 5 - Bristol Parkway/Yate	1274	1602	1.26
Corridor 6 - Keynsham/Bath Spa	879	1083	1.23

Table 6-9: Check against ETM data

Corridor	Operator ETM Patronage Data	Model Patronage Data	Model / ETM data
	INTER PEAK		
Corridor 1 - Weston Super Mare	224	262	1.17
Corridor 2 – Portishead	210	199	0.95
Corridor 3 - Severn Beach	570	565	0.99
Corridor 4 – Henbury	3561	3272	0.92
Corridor 5 - Bristol Parkway/Yate	1327	1307	0.99
Corridor 6 - Keynsham/Bath Spa	856	877	1.02
	PM PEAK		
Corridor 1 - Weston Super Mare	200	255	1.28
Corridor 2 – Portishead	229	264	1.16
Corridor 3 - Severn Beach	555	560	1.01
Corridor 4 – Henbury	3540	4241	1.20
Corridor 5 - Bristol Parkway/Yate	1292	1567	1.21
Corridor 6 - Keynsham/Bath Spa	812	1014	1.25

6.3 Rail Mode Validation

6.3.1 Journey Time Validation – Rail

Rail journey times in the model are based directly on timetables, including travel and dwell time as advertised. Table 6.10 shows a comparison between modelled travel times and timetable times, indicating a very good fit.

Table 6-10: Rail journey time comparison – total times all lines (minutes)

	In vehicle travel	Dwell time	Total Time	Model time	Difference
AM peak	2118	252	2370	2360	-0.43%
Inter Peak	2847	278	3125	3133	0.25%
PM peak	1650	168	1818	1812	-0.34%

6.3.2 Matrix assignment – Rail

Table 6.11 shows the number of rail trips assigned to the network. This indicates that virtually all of the trips in the matrices are being assigned.

Table 6-11: Assigned rail trips – 2013 trips

Source	AM	IP	PM
Matrix totals (post adjustment)	9138	3219	10360
Trips assigned	9125	3193	10340
Not assigned	13 (0.14%)	26 (0.81%)	20 (0.19%)

6.3.3 Assignment Validation Results – Rail

TAG Unit M3.2 states that validation of model assignment should involve comparing modelled and observed patronage flows across screenlines and passengers boarding and alighting in urban centres.

However, screenline data is not available to assess rail assignment, so for rail elements of the PT model, validation has been undertaken for station entries and exits at rail stations in the model area.

The TAG recommendation on individual links modelled flows should be within 25% of the counts for observed flows over 150. Comparison with GEH statistic values has been used for flows under 150, where a GEH of less than 5 is considered a reasonable fit.

The validation results for rail entries and exits are shown in Tables 6.12-6.14. The boarding and alighting counts validate at all stations with differences less than 25% (or GEH < 5 for flows under 150), in all three time periods. Further, it can also be seen that the criteria of GEH < 5 is actually satisfied for all stations.

Table 6-12: Rail assignment validation– AM peak

Station	**ENTRANCE**						**EXIT**					
	count	**model**	**diff**	**%**	**GEH**	**pass /fail**	**count**	**model**	**diff**	**%**	**GEH**	**pass /fail**
Bristol TM	892	847	-45	-5%	1.51	PASS	2,688	2,538	-150	-6%	2.93	PASS
Bedminster	54	52	-2	-4%	0.27	PASS	26	57	31	119%	4.81	PASS
Parson Street	68	78	10	15%	1.17	PASS	15	37	22	151%	4.38	PASS
Lawrence Hill	97	100	3	3%	0.31	PASS	48	79	31	64%	3.85	PASS
Avonmouth	20	3	-17	-85%	4.99	PASS	33	23	-10	-31%	1.92	PASS
Shirehampton	28	45	17	61%	2.81	PASS	10	29	19	203%	4.42	PASS
Clifton Down	70	73	3	4%	0.31	PASS	151	114	-37	-25%	3.25	PASS
Montpelier	153	159	6	4%	0.48	PASS	64	55	-9	-14%	1.17	PASS
Stapleton Rd	133	162	29	22%	2.39	PASS	32	62	30	91%	4.30	PASS
Redland	84	100	16	19%	1.67	PASS	54	46	-8	-15%	1.15	PASS
Sea Mills	42	57	15	35%	2.08	PASS	4	7	3	58%	1.08	PASS
Severn Beach	27	10	-17	-62%	3.87	PASS	6	-	-6	-	3.54	PASS
StAndrews Rd	1	-	-1	-	1.21	PASS	2	-	-2	-	1.92	PASS
Bristol Prkwy	427	341	-86	-20%	4.38	PASS	412	346	-66	-16%	3.40	PASS
Filton AW	117	81	-36	-31%	3.60	PASS	554	514	-40	-7%	1.74	PASS
Patchway	20	25	5	28%	1.16	PASS	52	65	13	25%	1.70	PASS
Yate	138	164	26	19%	2.10	PASS	13	31	18	147%	3.96	PASS
Bath Spa	993	1,133	140	14%	4.30	PASS	1,240	1,174	-66	-5%	1.89	PASS
Keynsham	226	224	-2	-1%	0.13	PASS	72	41	-31	-43%	4.12	PASS
Oldfield Park	157	128	-29	-19%	2.45	PASS	46	78	32	71%	4.11	PASS
Nailsea & Bkwl	171	202	31	18%	2.25	PASS	105	104	-1	-1%	0.06	PASS
Yatton	226	219	-7	-3%	0.47	PASS	9	25	16	192%	4.02	PASS
Weston Mlton	41	18	-23	-56%	4.27	PASS	13	4	-9	-70%	3.15	PASS
Weston-s-M	304	354	50	17%	2.78	PASS	113	133	20	18%	1.80	PASS
Worle	128	144	16	13%	1.39	PASS	26	43	17	67%	2.93	PASS
Total	**4,616**	**4,719**	**103**	**2%**	**1.51**	**PASS**	**5,787**	**5,605**	**-182**	**-3%**	**2.41**	**PASS**

Table 6-13: Rail assignment validation – inter peak

Station	ENTRANCE						EXIT					
	count	model	diff	%	GEH	pass /fail	count	model	diff	%	GEH	pass /fail
Bristol TM	533	553	20	4%	0.84	PASS	583	622	39	7%	1.57	PASS
Bedminster	6	3	-3	-45%	1.21	PASS	6	8	2	30%	0.69	PASS
Parson Street	6	10	4	62%	1.35	PASS	4	15	11	246%	3.43	PASS
Lawrence Hill	15	15	-	-	-	PASS	19	28	9	46%	1.82	PASS
Avonmouth	8	1	-7	-87%	3.25	PASS	9	2	-7	-76%	2.84	PASS
Shirehampton	6	8	2	26%	0.62	PASS	8	19	11	148%	3.10	PASS
Clifton Down	37	28	-9	-24%	1.52	PASS	38	46	8	21%	1.21	PASS
Montpelier	20	37	17	87%	3.22	PASS	13	26	13	95%	2.86	PASS
Stapleton Rd	29	28	-1	-2%	0.13	PASS	25	48	23	91%	3.78	PASS
Redland	15	26	12	79%	2.56	PASS	11	19	8	70%	2.02	PASS
Sea Mills	6	10	4	58%	1.28	PASS	7	13	7	100%	2.08	PASS
Severn Beach	3	1	-2	-65%	1.32	PASS	6	2	-4	-67%	2.00	PASS
StAndrews Rd	2	-	-2	-	1.73	PASS	0	-	-0	-	0.82	PASS
Bristol Prkwy	160	141	-19	-12%	1.58	PASS	125	102	-23	-19%	2.17	PASS
Filton AW	88	66	-22	-25%	2.45	PASS	47	30	-17	-36%	2.76	PASS
Patchway	4	10	6	131%	2.12	PASS	3	6	3	125%	1.60	PASS
Yate	16	29	13	85%	2.82	PASS	15	26	11	71%	2.39	PASS
Bath Spa	361	362	1	0%	0.06	PASS	390	392	2	1%	0.11	PASS
Keynsham	21	14	-7	-33%	1.67	PASS	20	18	-2	-11%	0.50	PASS
Oldfield Park	16	11	-5	-31%	1.36	PASS	16	18	2	11%	0.44	PASS
Nailsea & Bkwl	40	40	0	0%	0.03	PASS	72	51	-21	-29%	2.64	PASS
Yatton	16	23	7	45%	1.61	PASS	20	21	1	5%	0.20	PASS
Weston Mlton	6	1	-5	-83%	2.61	PASS	7	3	-4	-56%	1.73	PASS
Weston-s-M	77	81	4	6%	0.49	PASS	69	72	3	5%	0.38	PASS
Worle	22	15	-7	-31%	1.59	PASS	23	27	4	19%	0.87	PASS
Total	**1,510**	**1,513**	**3**	**0%**	**0.07**	**PASS**	**1,536**	**1,614**	**78**	**5%**	**1.96**	**PASS**

Table 6-14: Rail assignment validation – PM peak

Station	ENTRANCE						EXIT					
	count	model	diff	%	GEH	pass /fail	count	model	diff	%	GEH	pass /fail
Bristol TM	3,395	3,380	-15	-0%	0.26	PASS	870	773	-97	-11%	3.38	PASS
Bedminster	17	35	18	104%	3.49	PASS	43	70	27	62%	3.55	PASS
Parson Street	22	42	20	92%	3.57	PASS	48	69	21	45%	2.81	PASS
Lawrence Hill	56	44	-12	-21%	1.66	PASS	106	106	0	0%	0.03	PASS
Avonmouth	38	13	-25	-66%	4.92	PASS	22	7	-15	-68%	3.91	PASS
Shirehampton	10	30	20	208%	4.54	PASS	41	45	4	10%	0.62	PASS
Clifton Down	137	106	-31	-23%	2.83	PASS	85	114	29	35%	2.95	PASS
Montpelier	63	72	9	15%	1.12	PASS	80	112	32	41%	3.32	PASS
Stapleton Rd	53	56	3	5%	0.35	PASS	148	183	35	24%	2.72	PASS
Redland	40	48	8	21%	1.24	PASS	49	86	37	76%	4.54	PASS
Sea Mills	8	11	3	34%	0.91	PASS	51	83	32	63%	3.90	PASS
Severn Beach	6	1	-5	-84%	2.75	PASS	15	18	3	18%	0.69	PASS
StAndrews Rd	6	-	-6	-	3.42	PASS	2	-	-2	-	1.77	PASS
Bristol Prkwy	251	281	30	12%	1.82	PASS	764	761	-3	-0%	0.10	PASS
Filton AW	503	447	-56	-11%	2.57	PASS	106	85	-21	-20%	2.12	PASS
Patchway	60	41	-19	-32%	2.67	PASS	22	50	28	127%	4.67	PASS
Yate	24	34	10	41%	1.82	PASS	150	187	37	25%	2.85	PASS
Bath Spa	1,238	1,282	44	4%	1.24	PASS	1,098	1,196	98	9%	2.90	PASS
Keynsham	43	36	-7	-17%	1.16	PASS	152	190	38	25%	2.87	PASS
Oldfield Park	48	23	-25	-52%	4.19	PASS	141	136	-5	-3%	0.40	PASS
Nailsea & Bkwl	90	81	-9	-10%	0.94	PASS	250	298	48	19%	2.91	PASS
Yatton	26	40	14	51%	2.36	PASS	256	208	-48	-19%	3.18	PASS
Weston Mlton	8	8	0	3%	0.07	PASS	37	14	-23	-62%	4.56	PASS
Weston-s-M	155	160	5	3%	0.41	PASS	337	363	26	8%	1.38	PASS
Worle	34	17	-17	-49%	3.29	PASS	175	216	41	23%	2.93	PASS
Total	**6,331**	**6,288**	**-43**	**-1%**	**0.54**	**PASS**	**5,046**	**5,370**	**324**	**6%**	**4.50**	**PASS**

SECTION 7

Summary & Conclusions

The GBATS4M model includes a detailed public transport model of the rail and bus networks and services in the West of England area. It has been developed utilising EMME modelling software.

The validation of the public transport model has been undertaken as a rigorous and comprehensive exercise adhering to relevant DfT guidance. Count data from a variety of sources has been compared to modelled flows in all represented time-periods. This has demonstrated that in the majority of cases the resulting validation has been good.

The public transport model provides a robust platform to test and evaluate strategic public transport initiatives within the West of England region.

Appendix A
PT Model Transit Lines

Appendix A1: GBATS4 Bus Services by time period

Time Period	Id	Route Description	Headway (mins)
AM	1&01	1BrmHill-Cribbs	12
AM	1&11	1Cribbs-BrmHill	12
AM	11&02	11BowerAshton-UWEFC	20
AM	11&11	11UWEFC-BowerAshton	20
AM	12&01	12Centre-UWEFC	30
AM	12&12	12UWEFC-Centre	30
AM	121&01	121BrisBS-WSM	60
AM	121&12	121WSM-BrisBS	60
AM	13&02	13Brdmead-WilowBrks	30
AM	13&11	13WilowBrks-Brdmead	30
AM	13&X02	13Brdmead-UWEFC	30
AM	13&X11	13UWEFC-Brdmead	60
AM	14&X11	14Centre-UWEFC	30
AM	14&X13	14UWEFC-Centre	60
AM	15&01	15Centre-UWEFC	30
AM	15&12	15UWEFC-Centre	20
AM	16&X02	16TyndPark-UoBBS	10
AM	16&X11	16UoBBS-TyndPark	6
AM	178&01	178BristolBS-BathBS	60
AM	178&11	178BathBS-BristolBS	60
AM	18&02	18SmeadHosp-EmGreen	30
AM	18&11	18EmGreen-SmeadHosp	30
AM	19&01	19Centre-UWEFC	15
AM	19&11	19UWEFC-Centre	15
AM	1W&01	1BrisBS-WSM	30
AM	1W&11	1WSM-BrisBS	60
AM	2&01	2Stockwood-Cribbs	12
AM	2&11	2Cribbs-Stockwood	12
AM	20&01	20Centre-Southmead	30
AM	20&11	20Southmead-Centre	30
AM	222&11	222ChpSod-LgwellGr	60
AM	222&X0	222Kngswood-ChpSod	60
AM	24&01	24AshtVale-Horfld	20
AM	24&11	24Horfld-AshVale	20
AM	25&01	25AshVale-Horfld	20
AM	25&11	25Horfld-AshVale	20
AM	310&01	310BrisBS-Thrnbry	30
AM	310&11	310Thrnbry-BrisBS	30
AM	312&12	312Thrnbry-Dwnend	60
AM	312&X1	312Thrnbry-Frenchay	60
AM	319&02	319Cribbs-BathBS	60
AM	319&11	319BathBS-Cribbs	30
AM	319&X0	319PrkwayS-BathBS	60
AM	327&02	327Yate-BrisBS	60
AM	327&11	327BrisBS-Yate	60
AM	332&01	332BrisBS-BathBS	60
AM	332&11	332BathBS-BristolBS	60
AM	338&01	338BristolBS-BathBS	30
AM	338&11	338BathBS-BristolBS	30
AM	342&02	342ChpSod-BrisBS	30
AM	342&11	342BrisBS-ChpSod	30
AM	349&11	349Kynshm-Horsefair	30
AM	36&01	BldwinSt-Withywod	20
AM	36&11	36Withywod-BldwinSt	20
AM	376&03	376Wells-BristolBS	30
AM	376&14	376BristolBS-Wells	30
AM	379&01	379Radstock-BrisBS	60
AM	379&12	379BrisBS-Radstock	60
AM	3A&01	3ACentre-AztecWest	30
AM	3A&11	3AAztecWest-Centre	15
AM	3C&01	3CClifton-AztecWest	60
AM	3X&01	3XCentre-AztecWest	60
AM	4&01	4RupertSt-Downend	30
AM	4&11	4Downend-RupertSt	30
AM	40&01	40UnionSt-Cribbs	20
AM	40&11	40Cribbs-UnionSt	20
AM	41&01	41UnionSt-Avonmouth	20
AM	41&11	41Avonmouth-UnionSt	20
AM	42&01	42Centre-Keysham	20
AM	42&11	42Keysham-Centre	20
AM	43&01	43Centre-CdburyHth	20
AM	43&11	43CdburyHth-Centre	20

Time Period	Id	Route Description	Headway (mins)
IP	1&01	1BrmHill-Cribbs	10
IP	1&11	1Cribbs-BrmHill	10
IP	11&02	11BowerAshton-UWEFC	21
IP	11&11	11UWEFC-BowerAshton	21
IP	12&01	12Centre-UWEFC	20
IP	12&12	12UWEFC-Centre	20
IP	121&01	121BrisBS-WSM	120
IP	121&12	121WSM-BrisBS	120
IP	13&02	13Brdmead-WilowBrks	24
IP	13&11	13WilowBrks-Brdmead	24
IP	13&X02	13Brdmead-UWEFC	24
IP	13&X11	13UWEFC-Brdmead	24
IP	14&11	14UWEFC-Centre	20
IP	15&01	15Centre-UWEFC	20
IP	15&12	15UWEFC-Centre	20
IP	16&02	16Centre-UoBBS	13
IP	16&11	16UoBBS-Centre	13
IP	178&01	178BristolBS-BathBS	60
IP	178&11	178BathBS-BristolBS	60
IP	18&02	18SmeadHosp-EmGreen	30
IP	18&11	18EmGreen-SmeadHosp	33
IP	19&01	19Centre-UWEFC	12
IP	19&11	19UWEFC-Centre	12
IP	1W&01	1BrisBS-WSM	60
IP	1W&11	1WSM-BrisBS	60
IP	2&01	2Stockwood-Cribbs	10
IP	2&11	2Cribbs-Stockwood	10
IP	20&01	20Centre-Southmead	30
IP	20&11	20Southmead-Centre	30
IP	222&X0	222Kngswood-ChpSod	60
IP	222&X1	222ChpSod-Kngswood	60
IP	24&01	24AshtVale-Horfld	20
IP	24&11	24Horfld-AshVale	20
IP	25&01	25AshVale-Horfld	20
IP	25&11	25Horfld-AshVale	20
IP	3&01	3Centre-Cribbs	16
IP	3&11	3Cribbs-Centre	15
IP	309&01	309BrisBS-Thrnbry	33
IP	309&11	30Thrnbry-BrisBS	30
IP	309&X0	309BrisBS-CribbsC	40
IP	309&X1	309CribbsC-BrisBS	40
IP	312&01	312Dwnend-Thrnbry	60
IP	312&12	312Thrnbry-Dwnend	60
IP	319&02	319Cribbs-BathBS	30
IP	319&11	319BathBS-Cribbs	30
IP	327&02	327Yate-BrisBS	60
IP	327&11	327BrisBS-Yate	60
IP	332&01	332BrisBS-BathBS	60
IP	332&11	332BathBS-BristolBS	60
IP	338&01	338BristolBS-BathBS	30
IP	338&11	338BathBS-BristolBS	30
IP	342&02	342ChpSod-BrisBS	30
IP	342&11	342BrisBS-ChpSod	33
IP	349&11	349Kynshm-Horsefair	30
IP	36&01	BldwinSt-Withywod	19
IP	36&11	36Withywod-BldwinSt	20
IP	376&03	376Wells-BristolBS	30
IP	376&14	376BristolBS-Wells	28
IP	379&01	379Radstock-BrisBS	60
IP	379&12	379BrisBS-Radstock	60
IP	3A&01	3ACentre-AztecWest	360
IP	3B&01	3bCentre-BradleyStok	180
IP	4&01	4RupertSt-Downend	30
IP	4&11	4Downend-RupertSt	30
IP	40&01	40UnionSt-Cribbs	20
IP	40&11	40Cribbs-UnionSt	20
IP	41&01	41UnionSt-Avonmouth	20
IP	41&11	41Avonmouth-UnionSt	20
IP	42&01	42Centre-Keysham	20
IP	42&11	42Keysham-Centre	20
IP	43&01	43Centre-CdburyHth	20
IP	43&11	43CdburyHth-Centre	20

Time Period	Id	Route Description	Headway (mins)
PM	1&01	1BrmHill-Cribbs	12
PM	1&11	1Cribbs-BrmHill	12
PM	11&02	11BowerAshton-UWEFC	20
PM	11&11	11UWEFC-BowerAshton	30
PM	12&01	12Centre-UWEFC	30
PM	12&12	12UWEFC-Centre	30
PM	121&01	121BrisBS-WSM	60
PM	121&12	121WSM-BrisBS	60
PM	13&02	13Brdmead-WilowBrks	30
PM	13&11	13WilowBrks-Brdmead	30
PM	13&X02	13Brdmead-UWEFC	30
PM	13&X11	13UWEFC-Brdmead	30
PM	14&X12	14UWEFC-Centre	30
PM	14&X13	14UWEFC-Centre	60
PM	15&01	15Centre-UWEFC	20
PM	15&12	15UWEFC-Centre	20
PM	16&X02	16TyndPark-UoBBS	8
PM	16&X11	16UoBBS-TyndPark	8
PM	178&01	178BristolBS-BathBS	60
PM	178&11	178BathBS-BristolBS	60
PM	18&02	18SmeadHosp-EmGreen	30
PM	18&11	18EmGreen-SmeadHosp	30
PM	19&01	19Centre-UWEFC	15
PM	19&11	19UWEFC-Centre	15
PM	1W&01	1BrisBS-WSM	60
PM	1W&11	1WSM-BrisBS	30
PM	2&01	2Stockwood-Cribbs	12
PM	2&11	2Cribbs-Stockwood	12
PM	20&01	20Centre-Southmead	30
PM	20&11	20Southmead-Centre	30
PM	222&05	222LgwellGr-ChpSod	60
PM	24&01	24AshtVale-Horfld	20
PM	24&11	24Horfld-AshVale	20
PM	25&01	25AshVale-Horfld	20
PM	25&11	25Horfld-AshVale	20
PM	309&01	309BrisBS-Thrnbry	60
PM	309&11	309Thrnbry-BrisBS	30
PM	310&01	310BrisBS-Thrnbry	60
PM	312&X1	312Thrnbry-Frenchay	60
PM	319&02	319Cribbs-BathBS	30
PM	319&11	319BathBS-Cribbs	30
PM	327&02	327Yate-BrisBS	60
PM	327&11	327BrisBS-Yate	60
PM	332&01	332BrisBS-BathBS	60
PM	332&11	332BathBS-BristolBS	60
PM	338&01	338BristolBS-BathBS	30
PM	338&11	338BathBS-BristolBS	30
PM	342&02	342ChpSod-BrisBS	30
PM	342&11	342BrisBS-ChpSod	30
PM	349&11	349Kynshm-Horsefair	30
PM	36&01	BldwinSt-Withywod	20
PM	36&11	36Withywod-BldwinSt	30
PM	376&03	376Wells-BristolBS	30
PM	376&14	376BristolBS-Wells	30
PM	379&01	379Radstock-BrisBS	60
PM	379&12	379BrisBS-Radstock	60
PM	3A&01	3ACentre-AztecWest	30
PM	3A&11	3AAztecWest-Centre	30
PM	3B&01	3ACentre-BradleyStok	60
PM	3C&11	3CAztecWest-Clifton	60
PM	4&01	4RupertSt-Downend	30
PM	4&11	4Downend-RupertSt	30
PM	40&01	40UnionSt-Cribbs	20
PM	40&11	40Cribbs-UnionSt	20
PM	41&01	41UnionSt-Avonmouth	20
PM	41&11	41Avonmouth-UnionSt	20
PM	42&01	42Centre-Keysham	20
PM	42&11	42Keysham-Centre	20
PM	43&01	43Centre-CdburyHth	20
PM	43&11	43CdburyHth-Centre	20
PM	44&01	44Centre-Kingswood	20
PM	44&11	44Kingswood-Centre	30

Appendix A1: GBATS4 Bus Services by time period

Time Period	Id	Route Description	Headway (mins)
AM	44&01	44Centre-Kingswood	30
AM	44&11	44Kingswood-Centre	20
AM	45&01	45Centre-LngwllGrn	30
AM	45&11	45LngllGrn-Centre	20
AM	462&14	462EmerGreen-BTM	30
AM	48&01	48RupertSt-EmGreen	15
AM	48&11	48EmGreen-RupertSt	15
AM	49&01	49RupertSt-EmGreen	15
AM	49&11	49EmGreen-RupertSt	15
AM	5&01	5RupertSt-Downend	30
AM	5&11	5Downend-RupertSt	30
AM	50&01	50Centre-HgrveDepot	20
AM	50&11	50HgrveDepot-Centre	20
AM	501&03	501Amouth-AbWood	60
AM	501&11	501AbWood-Amouth	60
AM	502&02	502Shirhmpton-UWEFC	60
AM	502&11	502UWEFC-Shirhmpton	60
AM	505&02	505SmeadHosp-BowAsh	30
AM	505&11	505BowAsh-SmeadHosp	30
AM	506&X0	506SmeadHosp-CREATE	30
AM	506&X1	506CREATE-SmeadHosp	30
AM	507&02	507SmeadHosp-Kynshm	60
AM	507&11	507Kynshm-SmeadHosp	60
AM	507&X0	507SmeadHosp-Kngswd	60
AM	507&X1	507Kngswd-SmeadHosp	60
AM	508&02	508SeaMills-Smead	60
AM	508&11	508Smead-SeaMills	60
AM	51&01	51Centre-HgrveDepot	20
AM	51&11	51HgrveDepot-Centre	20
AM	512&X1	Totterdown-Bedminst	60
AM	515&01	Stockwood-Hartcliffe	60
AM	515&11	Hartcliffe-Stockwood	60
AM	533&01	533Kynshm-Mngtsfld	60
AM	533&13	533Mngtsfld-Kynshm	60
AM	57&11	57Stockwood-Centre	60
AM	581&03	581ChpSod-Hnham	60
AM	581&11	581Hnham-ChpSod	60
AM	6&01	6BaldwinSt-Kingswod	20
AM	6&11	6Kingswod-BaldwinSt	20
AM	622&14	622ChippSod-Cribbs	60
AM	624&15	624SevBch-Centre	60
AM	635&03	635Centre-Chipham	60
AM	635&16	635Chipham-Centre	60
AM	672&13	672ChwVly-Broadmead	60
AM	672&X0	672Broadmead-ChwVly	60
AM	689&11	689Yate-Centre	60
AM	689&X0	689Mngtsfld-Yate	60
AM	7&01	7BldwnSt-StapleHill	20
AM	7&11	7StapleHill-BldwnSt	20
AM	70&01	70BTM-UWEFrenchay	15
AM	70&11	70UWEFrenchay-BTM	15
AM	73&01	73Centre-Cribbs	15
AM	73&11	73Cribbs-Centre	15
AM	75&01	75Cribbs-Hengrove	12
AM	75&11	75Hengrove-Cribbs	12
AM	76&01	76Cribbs-Hengrove	12
AM	76&11	76Hengrove-Cribbs	10
AM	8&11	8TempleMeads-Cotham	12
AM	86&01	86Yate-Wotton-Under-	60
AM	86&13	86Wotton-Under-Edge-	60
AM	86&15	86Yate-Kgwood	60
AM	9&11	9BTM-Redland	12
AM	90&01	90Broadmead-Hngrve	10
AM	90&11	90Hngrve-Broadmead	10
AM	902&11	902PortPR-Centre	12
AM	903&11	903LongAshPR-Centre	10
AM	904&11	904BrstonPR-Centre	12
AM	A1&04	A1BrisAir-Broadmead	10
AM	A1&13	A1Broadmead-BrisAir	10
AM	A4&04	A4BrisAir-BathCntre	60
AM	A4&13	A4BathCntre-BrisAir	60
AM	NHS&2	BTM-StMichaelsHospit	30

Time Period	Id	Route Description	Headway (mins)
IP	44&01	44Centre-Kingswood	20
IP	44&11	44Kingswood-Centre	20
IP	45&01	45Centre-LngwllGrn	20
IP	45&11	45LngllGrn-Centre	20
IP	48&01	48RupertSt-EmGreen	15
IP	48&11	48EmGreen-RupertSt	15
IP	482&01	482Cribbs-ChippSod	180
IP	482&11	482ChippSod-Cribbs	120
IP	49&01	49RupertSt-EmGreen	15
IP	49&11	49EmGreen-RupertSt	14
IP	5&01	5RupertSt-Downend	30
IP	5&11	5Downend-RupertSt	30
IP	50&01	50Centre-HgrveDepot	20
IP	50&11	50HgrveDepot-Centre	20
IP	501&03	501Amouth-AbWood	60
IP	501&11	501AbWood-Amouth	60
IP	502&02	502Shirhmpton-UWEFC	60
IP	502&11	502UWEFC-Shirhmpton	60
IP	505&02	505SmeadHosp-BowAsh	30
IP	505&11	505BowAsh-SmeadHosp	30
IP	506&04	506SmeadHosp-CREATE	30
IP	506&13	506CREATE-SmeadHosp	30
IP	507&02	507SmeadHosp-Kynshm	60
IP	507&11	507Kynshm-SmeadHosp	60
IP	507&X0	507SmeadHosp-Kngswd	60
IP	507&X1	507Kngswd-SmeadHosp	60
IP	508&02	508SeaMills-Smead	60
IP	508&11	508Smead-SeaMills	60
IP	51&01	51Centre-HgrveDepot	20
IP	51&11	51HgrveDepot-Centre	20
IP	511&01	511Hengrove-Bedminst	72
IP	511&12	511Bedminster-Hengro	72
IP	512&11	Bedminster-circular	360
IP	512&X1	Broadmd-Bedminster	360
IP	512&X2	Bedminster-circular	120
IP	513&01	Brisli-Knowle	72
IP	513&12	Knowle-Brisli	72
IP	514&01	514BrisliT-Knowle	90
IP	514&12	514Knowle-BrisliT	72
IP	515&01	Stockwood-Hartcliffe	60
IP	515&11	Hartcliffe-Stockwood	60
IP	52&01	52Broadmd-HgrvePark	72
IP	52&11	52HgrvePark-Broadmd	90
IP	52&X11	52HgrvePark-Highrdg	360
IP	533&01	533Kynshm-Mngtsfld	60
IP	533&13	533Mngtsfld-Kynshm	60
IP	55&03	55Bristol-Nailsea	120
IP	55&11	55Nailsea-Bristol	120
IP	57&01	57Centre-Stockwood	60
IP	57&11	57Stockwood-Centre	90
IP	581&03	581ChpSod-Hnham	60
IP	581&11	581Hnham-ChpSod	51
IP	6&01	6BaldwinSt-Kingswod	20
IP	6&11	6Kingswod-BaldwinSt	20
IP	622&01	622Cribbs-ChpSod	90
IP	622&14	622ChippSod-Cribbs	90
IP	625&04	625UWEFren-SevBch	60
IP	625&12	625SevBch-UWEFren	60
IP	634&03	634Kingswood-Tormart	180
IP	634&11	634Tormarton-Kingswo	180
IP	635&03	635Centre-Chipham	120
IP	635&12	635Chipham-Centre	90
IP	67&01	Bristol-WestH	360
IP	672&04	672Broadmead-ChwVly	360
IP	672&13	672ChwVly-Broadmead	360
IP	672&X0	672Broadmead-ChwVly	360
IP	672&X1	672ChwVly-Broadmead	360
IP	689&03	689Centre-Yate	60
IP	689&11	689Yate-Centre	60
IP	7&01	7BldwnSt-StapleHill	20
IP	7&11	7StapleHill-BldwnSt	20
IP	70&01	7070BTM-UWEFrenchay	12

Time Period	Id	Route Description	Headway (mins)
PM	45&01	45Centre-LngwllGrn	20
PM	45&11	45LngllGrn-Centre	30
PM	462&02	462BTM-EmerGreen	30
PM	48&01	48RupertSt-EmGreen	15
PM	48&11	48EmGreen-RupertSt	15
PM	482&11	482ChippSod-Cribbs	60
PM	483&01	483Cribbs-ChpSod	60
PM	49&01	49RupertSt-EmGreen	15
PM	49&11	49EmGreen-RupertSt	20
PM	5&01	5RupertSt-Downend	30
PM	5&11	5Downend-RupertSt	30
PM	50&01	50Centre-HgrveDepot	20
PM	50&11	50HgrveDepot-Centre	30
PM	501&03	501Amouth-AbWood	60
PM	501&11	501AbWood-Amouth	60
PM	502&02	502Shirhmpton-UWEFC	60
PM	502&11	502UWEFC-Shirhmpton	60
PM	505&02	505SmeadHosp-BowAsh	30
PM	505&11	505BowAsh-SmeadHosp	30
PM	506&X0	506SmeadHosp-CREATE	30
PM	506&X1	506CREATE-SmeadHosp	30
PM	507&02	507SmeadHosp-Kynshm	60
PM	507&11	507Kynshm-SmeadHosp	60
PM	507&X0	507SmeadHosp-Kngswd	60
PM	507&X1	507Kngswd-SmeadHosp	60
PM	508&02	508SeaMills-Smead	60
PM	508&11	508Smead-SeaMills	60
PM	51&01	51Centre-HgrveDepot	20
PM	51&11	51HgrveDepot-Centre	30
PM	515&01	Stockwood-Hartcliffe	60
PM	515&11	Hartcliffe-Stockwood	60
PM	52&X01	52Broadmd-Highridge	60
PM	533&02	533Kynshm-Mngtsfld	60
PM	533&13	533Mngtsfld-Kynshm	60
PM	57&01	57Centre-Stockwood	30
PM	57&11	57Stockwood-Centre	60
PM	581&02	581ChpSod-Hnham	60
PM	581&14	581Hnham-ChpSod	60
PM	6&01	6BaldwinSt-Kingswod	30
PM	6&11	6Kingswod-BaldwinSt	30
PM	622&01	622Cribbs-ChpSod	60
PM	622&14	622ChippSod-Cribbs	60
PM	624&02	624BondSt-SevBch	60
PM	625&04	625UWEFren-SevBch	60
PM	625&15	625SevBch-UWEFren	60
PM	626&02	626Centre-Wotton	60
PM	635&03	635Centre-Chipham	60
PM	635&12	635Chipham-Centre	60
PM	672&04	672Broadmead-ChwVly	60
PM	689&03	689Centre-Yate	60
PM	689&12	689Yate-Centre	60
PM	7&01	7BldwnSt-StapleHill	15
PM	7&11	7StapleHill-BldwnSt	20
PM	70&01	7070BTM-UWEFrenchay	15
PM	70&11	70UWEFrenchay-BTM	15
PM	73&01	73Centre-Cribbs	15
PM	73&11	73Cribbs-Centre	15
PM	75&01	75Cribbs-Hengrove	10
PM	75&11	75Hengrove-Cribbs	12
PM	76&01	76Cribbs-Hengrove	12
PM	76&11	76Hengrove-Cribbs	12
PM	8&11	8TempleMeads-Cotham	15
PM	86&01	86Kgwood-Wotton-Unde	30
PM	86&13'	86Wotton-Under-Edge-	60
PM	9&11	9BTM-Redland	15
PM	90&01	90Broadmead-Hngrve	10
PM	90&11	90Hngrve-Broadmead	10
PM	902&11	902PortPR-Centre	12
PM	903&11	903LongAshPR-Centre	12
PM	904&11	904BrstonPR-Centre	12
PM	A1&04	A1BrisAir-Broadmead	10
PM	A1&13	A1Broadmead-BrisAir	10

Appendix A1: GBATS4 Bus Services by time period

Time Period	Id	Route Description	Headway (mins)
AM	X1&01	X1BrisBS-WSM	30
AM	X1&11	X1WSM-BrisBS	20
AM	X18&03	X18AztWest-Kgwood	60
AM	X18&X1	X18Emersgrn-AztWest	60
AM	X2&11	X2BrisBS-Portis	30
AM	X27&01	X27Yate-AnchorRd	60
AM	X27&12	X27AnchorRd-Yate	60
AM	X3&11	X3Portis-BrisBS	30
AM	X39&01	X39BristoBS-BathBS	12
AM	X39&11	X39BathBS-BristolBS	15
AM	X42&02	X42ChpSod-BrisBS	60
AM	X6&01	X6Bristol-Clevedon	30
AM	X6&11	X6Clevedon-Bristol	30
AM	X7&02	X7Clevedon-BTM	60
AM	X7&11	X7BTM-Clevedon	60
AM	X7&c1	X7Centre-Chepstow	30
AM	X7&c2	X7Chepstow-Centre	60
AM	X73&11	X73Cribbs-Centre	30
AM	X8&01	X8Bristol-Clevedon	60
AM	X8&X01	X8Bristol-Portishead	60
AM	X9&01	X9Bristol-Nailsea	30

Time Period	Id	Route Description	Headway (mins)
IP	70&11	70UWEFrenchay-BTM	12
IP	73&01	73Centre-Cribbs	10
IP	73&11	73Cribbs-Centre	10
IP	75&01	75Cribbs-Hengrove	10
IP	75&11	75Hengrove-Cribbs	10
IP	76&01	76Cribbs-Hengrove	10
IP	76&11	76Hengrove-Cribbs	10
IP	8&11	8TempleMeads-Cotham	12
IP	86&01'	86Kgwood-Wotton-Unde	120
IP	86&13'	86Wotton-Under-Edge-	120
IP	9&11	9BTM-Redland	12
IP	90&01	90Broadmead-Hngrve	10
IP	90&11	90Hngrve-Broadmead	10
IP	902&11	902PortPR-Centre	15
IP	903&11	903LongAshPR-Centre	12
IP	904&11	904BrstonPR-Centre	15
IP	904&X1	904Centre-BrstonPR	360
IP	A1&04	A1BrisAir-Broadmead	10
IP	A1&13	A1Broadmead-BrisAir	10
IP	A4&04	A4BrisAir-BathCntre	60
IP	A4&13	A4BathCntre-BrisAir	60
IP	NHS&1	CabtCrcus-MchaelsHsp	30
IP	NHS&2	BTM-StMichaelsHospit	30
IP	X1&01	X1BrisBS-WSM	20
IP	X1&11	X1WSM-BrisBS	20
IP	X18&12	X18Kgwood-AztWest	180
IP	X18&X0	X18AztWest-Emersgrn	360
IP	X2&11	X2BrisBS-Portis	30
IP	X25&02	X25Cribbs-Portishead	60
IP	X25&11	X25Portishead-Cribbs	60
IP	X27&01	X27Yate-AnchorRd	60
IP	X27&12	X27AnchorRd-Yate	60
IP	X3&11	X3Portis-BrisBS	30
IP	X39&01	X39BristoBS-BathBS	12
IP	X39&11	X39BathBS-BristolBS	12
IP	X42&11	X42BrisBS-NSChpSod	360
IP	X6&01	X6Bristol-Clevedon	30
IP	X6&11	X6Clevedon-Bristol	30
IP	X7&02	X7Clevedon-BTM	60
IP	X7&11	X7BTM-Clevedon	60
IP	X7&c1	X7Centre-Chepstow	60
IP	X7&c2	X7Chepstow-Centre	60
IP	X8&01	X8Bristol-Clevedon	60
IP	X8&X01	X8Bristol-Portishead	60
IP	X9&01	X9Bristol-Nailsea	360

Time Period	Id	Route Description	Headway (mins)
PM	A4&04	A4BrisAir-BathCntre	60
PM	A4&13	A4BathCntre-BrisAir	60
PM	NHS&1	CabtCrcus-MchaelsHsp	30
PM	NHS&2	BTM-StMichaelsHospit	30
PM	X1&02	X1BrisBS-WSM	20
PM	X1&11	X1WSM-BrisBS	30
PM	X18&01	X18AztWest-Kgwood	60
PM	X18&X0	X18AztWest-Emersgrn	60
PM	X18&X1	X18Emersgrn-AztWest	60
PM	X2&11	X2BrisBS-Portis	30
PM	X25&02	X25Cribbs-Portishead	60
PM	X25&11	X25Portishead-Cribbs	60
PM	X27&01	X27Yate-AnchorRd	60
PM	X27&12	X27AnchorRd-Yate	60
PM	X3&11	X3Portis-BrisBS	30
PM	X39&01	X39BristoBS-BathBS	15
PM	X39&11	X39BathBS-BristolBS	15
PM	X42&11	X42BrisBS-NSChpSod	60
PM	X54&03	X54Bristol-Nailsea	60
PM	X54&13	X54Nailsea-Redclife	60
PM	X6&01	X6Bristol-Clevedon	30
PM	X6&11	X6Clevedon-Bristol	30
PM	X7&02	X7Clevedon-BTM	60
PM	X7&11	X7BTM-Clevedon	60
PM	X7&c1	X7Centre-Chepstow	60
PM	X7&c2	X7Chepstow-Centre	60
PM	X73&01	X73Centre-Cribbs	30
PM	X8&01	X8Bristol-Clevedon	60
PM	X8&X01	X8Bristol-Portishead	60
PM	X9&01	X9Bristol-Nailsea	30

Appendix A2: GBATS4 Rail Services by time period

Time Period	Id	Route Description	Headway (mins)
AM	051a2s	Drby-Plym Chlt-Taun	30
AM	051a4n	Plym-Glas Taun-Chlt	60
AM	051a5n	Pain-Manc Taun-Chlt	60
AM	123a1n	Warm-GtMv Trow-Chlt	60
AM	123a2n	Pmth-CdfC Trow-Newp	60
AM	123a3n	From-CdfC Trow-Newp	60
AM	123a4s	BTM-Sals BTM-Trow	180
AM	123a5s	WoSH-Weym Chlt-Trow	120
AM	123a6s	Chlt-West Chlt-Trow	120
AM	123a7s	CdfC-Pmth Newp-Trow	60
AM	125a1e	Swan-Padd Newp-Lond	30
AM	125a2w	Padd-BTM Lond-BTM	60
AM	125a4w	Padd-BTM Lond-BTM	60
AM	125a5w	Padd-Swan Lond-Newp	30
AM	125a6e	Taun-Padd Taun-Lond	60
AM	125a7e	Plym-Padd Taun-Lond	60
AM	133a1s	Avnm-BTM Avnm-BTM	80
AM	133a2n	BTM-Avnm BTM-Avnm	40
AM	133a3s	SevB-BTM Svrn-BTM	80
AM	134a1n	Weym-Prkw Trow-Prkw	60
AM	134a2s	BTM-WsM BTM-WsM	120
AM	134a3s	Prkw-Taun Prkw-Taun	60
AM	134a4s	Prkw-BTM Prkw-BTM	60
AM	134a5n	ExSD-Prkw Taun-Prkw	60
AM	134a6n	WsM-CdfC WsM-Newp	60
AM	134a7s	Glos-Swin Yate-Swin	120
AM	135a1s	CdfC-Pain Newp-Taun	120

Time Period	Id	Route Description	Headway (mins)
IP	051a1n	BTM-Manc BTM-Chlt	90
IP	051a2s	Manc-BTM Chlt-BTM	90
IP	051a3s	Newc-Plym Chlt-Taun	120
IP	051a4s	Manc-Pain Chlt-Taun	360
IP	051a5n	Penz-Glas Taun-Chlt	52
IP	051a6n	Pain-Manc Taun-Chlt	360
IP	123a1n	Weym-Glos Trow-Yate	180
IP	123a2n	Pmth-CdfC Trow-Newp	60
IP	123a3n	Sals-BTM Trow-BTM	180
IP	123a4n	Pmth-CdfC Trow-Newp	360
IP	123a5n	Weym-BTM Trow-BTM	180
IP	123a6n	Sotn-GtMv Trow-Chlt	90
IP	123a7s	BTM-Sals BTM-Trow	180
IP	123a8s	CdfC-Pmth Newp-Trow	72
IP	123a9s	CdfC-Pmth Newp-Trow	360
IP	123b1s	Glos-Weym Yate-Trow	120
IP	125a1e	BTM-Padd BTM-Lond	30
IP	125a2e	Swan-Padd Newp-Lond	30
IP	125a3w	Padd-BTM Lond-BTM	33
IP	125a5w	Padd-Pain Lond-Taun	360
IP	125a6w	Padd-Swan Lond-Newp	30
IP	125a7e	Penz-Padd Taun-Lond	180
IP	125a8e	Pain-Padd Taun-Lond	360
IP	133a1s	Avnm-BTM Avnm-BTM	60
IP	133a3n	BTM-Avnm BTM-Avnm	120
IP	133a4n	BTM-SevB BTM-Svrn	120
IP	133a5n	BTM-Avnm BTM-Avnm	120
IP	133a5s	SevB-BTM Svrn-BTM	120
IP	134a1n	West-Prkw Trow-Prkw	360
IP	134a2n	West-Glos Trow-Yate	360
IP	134a3n	BTM-Glos BTM-Yate	180
IP	134a4s	Prkw-WsM Prkw-WsM	60
IP	134a5s	Prkw-Bath Prkw-Bath	180
IP	134a6s	GtMv-Brtn Chlt-Trow	360
IP	134a7s	GtMv-West Chlt-Trow	180
IP	134a8s	CdfC-Taun Newp-Taun	360
IP	134a9s	CdfC-Plym Newp-Taun	60
IP	134b1n	Taun-Prkw Taun-Prkw	180
IP	134b2n	Penz-CdfC Taun-Newp	72
IP	134b3n	WsM-Prkw WsM-Prkw	60
IP	134b4n	WsM-CdfC WsM-Newp	360

Time Period	Id	Route Description	Headway (mins)
PM	051a1n	BTM-Manc BTM-Chlt	60
PM	051a3s	Abdn-Penz Chlt-Taun	30
PM	051a4n	Plym-Leds Taun-Chlt	60
PM	123a1n	Pmth-CdfC Trow-Newp	60
PM	123a2n	Weym-Glos Trow-Yate	60
PM	123a4s	FAW-West FAW-Trow	120
PM	123a5s	CdfC-Pmth Newp-Trow	60
PM	123a6s	Glos-Weym Yate-Trow	60
PM	125a1e	BTM-Padd BTM-Lond	60
PM	125a2e	Swan-Padd Newp-Lond	30
PM	125a3w	Padd-BTM Lond-BTM	60
PM	125a4w	Padd-WsM Lond-WsM	60
PM	125a6w	Padd-Swan Lond-Newp	30
PM	125a7e	WsM-Padd WsM-Lond	60
PM	133a1s	Avnm-BTM Avnm-BTM	80
PM	133a2n	BTM-Avnm BTM-Avnm	80
PM	133a3n	BTM-SevB BTM-Svrn	80
PM	133a4s	SevB-BTM Svrn-BTM	80
PM	134a1n	Bath-Prkw Bath-Prkw	120
PM	134a3s	Prkw-WsM Prkw-WsM	60
PM	134a4s	Prkw-Warm Prkw-Trow	60
PM	134a5s	CdfC-Taun Newp-Taun	60
PM	134a6n	Taun-CdfC Taun-Newp	60
PM	134a8n	WsM-Prkw WsM-Prkw	60

Appendix B
Bus Journey Time Comparison

Appendix B1: Modelled AM Peak Bus Journey Time vs Timetabled Time

	Route ID	From	To	Headway	Number of services	Difference (Model vs Timetable)	Pass/Fail
Weston-super-Mare	1W&11	Weston-Super-Mare	Bristol Bus Station	60	1	-1%	Pass
	1W&01	Bristol Bus Station	Weston-Super-Mare	30	2	3%	Pass
	X1&11	Weston-Super-Mare	Bristol Bus Station	20	3	9%	Pass
	X1&01	Bristol Bus Station	Weston-Super-Mare	30	2	8%	Pass
	121&12	Weston-Super-Mare	Bristol Bus Station	60	1	9%	Pass
	121&01	Bristol Bus Station	Weston-Super-Mare	60	1	-4%	Pass
Portished	X2&11	Bristol Bus Station	Portishead	30	2	6%	Pass
	X3&11	Bristol Bus Station	Portishead	30	2	4%	Pass
	X6&01	Bristol Bus Station	Clevedon	30	2	2%	Pass
	X6&11	Clevedon	Bristol Bus Station	30	2	7%	Pass
	X7&11	Temple Meads	Clevedon	60	1	14%	Pass
	X8&01	Bristol Bus Station	Clevedon	60	1	-1%	Pass
	X8&X01	Bristol Bus Station	Portishead	60	1	-1%	Pass
Severn Beach	40&11	Cribbs Causeway	Union Street (BCC)	20	3	-3%	Pass
	40&01	Union Street (BCC)	Cribbs Causeway	20	3	6%	Pass
	41&01	Union Street (BCC)	Avonmouth	20	3	15%	Pass
	41&11	Avonmouth	Union Street (BCC)	20	3	3%	Pass
	501&11	Abbey Wood	Avonmouth	60	1	0%	Pass
	501&03	Avonmouth	Abbey Wood	60	1	9%	Pass
	502&02	Shirehampton	UWE Frenchay Campus	60	1	-3%	Pass
	502&11	UWE Frenchay Campus	Shirehampton	60	1	5%	Pass
	508&02	Sea Mills	Southmead	60	1	-2%	Pass
	508&11	Southmead	Sea Mills	60	1	-6%	Pass
Henbury	1&01	Broom Hill	Cribbs Causeway	12	5	4%	Pass
	1&11	Cribbs Causeway	Broom Hill	12	5	2%	Pass
	2&01	Stockwood	Cribbs Causeway	12	5	3%	Pass
	2&11	Cribbs Causeway	Cribbs Causeway	12	5	3%	Pass
	3A&01	The Centre (BCC)	Aztec West	30	2	-3%	Pass
	3A&11	Aztec West	The Centre (BCC)	15	4	-1%	Pass
	3X&01	The Centre (BCC)	Aztec West	60	1	14%	Pass
	40&01	Union Street (BCC)	Cribbs Causeway	20	3	6%	Pass
	40&11	Cribbs Causeway	Union Street (BCC)	20	3	-3%	Pass
	73&01	The Centre (BCC)	Cribbs Causeway	15	4	8%	Pass
	73&11	Cribbs Causeway	The Centre (BCC)	15	4	-6%	Pass
	X73&11	Cribbs Causeway	The Centre (BCC)	30	2	14%	Pass
	75&11	Hengrove	Cribbs Causeway	12	5	3%	Pass
	75&01	Cribbs Causeway	Hengrove	12	5	14%	Pass
	76&01	Cribbs Causeway	Hengrove	12	5	7%	Pass
	76&11	Hengrove	Cribbs Causeway	10	6	0%	Pass
	319&02	Cribbs Causeway	Bath Bus Station	60	1	8%	Pass
	319&11	Bath Bus Station	Cribbs Causeway	30	2	4%	Pass
	319&X0	Bristol Parkway	Bath Bus Station	60	1	4%	Pass
	622&14	Chipping Sodbury	Cribbs Causeway	60	1	8%	Pass
Bristol Parkway / Yate	73&01	The Centre (BCC)	Cribbs Causeway	15	4	8%	Pass
	73&11	Cribbs Causeway	The Centre (BCC)	15	4	-6%	Pass
	24&11	Horfield Common	Ashton Vale	20	3	3%	Pass
	24&01	Ashton Vale	Horfield Common	20	3	5%	Pass
	25&01	Ashton Vale	Horfield Common	20	3	2%	Pass
	25&11	Horfield Common	Ashton Vale	20	3	0%	Pass
	11&11	UWE Frenchay Campus	Bower Ashton Campus	20	3	1%	Pass
	11&02	Bower Ashton Campus	UWE Frenchay Campus	20	3	-6%	Pass
	12&01	The Centre (BCC)	UWE Frenchay Campus	30	2	1%	Pass
	12&12	UWE Frenchay Campus	The Centre (BCC)	30	2	-2%	Pass
	15&12	UWE Frenchay Campus	The Centre (BCC)	20	3	-2%	Pass
	15&01	The Centre (BCC)	UWE Frenchay Campus	30	2	-1%	Pass
	19&01	The Centre (BCC)	UWE Frenchay Campus	15	4	-3%	Pass
	19&11	UWE Frenchay Campus	The Centre (BCC)	15	4	-2%	Pass
	70&01	Temple Meads	UWE Frenchay Campus	15	4	0%	Pass
	70&11	UWE Frenchay Campus	Temple Meads	15	4	-7%	Pass
	502&11	UWE Frenchay Campus	Shirehampton	60	1	-7%	Pass
	502&02	Shirehampton	UWE Frenchay Campus	60	1	9%	Pass
	319&02	Cribbs Causeway	Bath Bus Station	60	1	9%	Pass

Appendix B1: Modelled AM Peak Bus Journey Time vs Timetabled Time

	Route ID	From	To	Headway	Number of services	Difference (Model vs Timetable)	Pass/Fail
	319&11	Bath Bus Station	Cribbs Causeway	30	2	10%	Pass
	319&X0	Bristol Parkway	Bath Bus Station	60	1	4%	Pass
	X27&12	Anchor Road (BCC)	Yate	60	1	5%	Pass
	327&11	Bristol Bus Station	Yate	60	1	-2%	Pass
	327&02	Yate	Bristol Bus Station	60	1	-2%	Pass
	342&02	Chipping Sodbury	Bristol Bus Station	30	2	2%	Pass
	342&11	Bristol Bus Station	Chipping Sodbury	30	2	10%	Pass
Keynsham / Bath Spa	178&11	Bath Bus Station	Bristol Bus Station	60	1	4%	Pass
	178&01	Bristol Bus Station	Bath Bus Station	60	1	4%	Pass
	349&11	Keynsham	The Horsefair (BCC)	30	2	13%	Pass
	338&11	Bath Bus Station	Bristol Bus Station	30	2	-5%	Pass
	338&01	Bristol Bus Station	Bath Bus Station	30	2	-2%	Pass
	A4&13	Bath City Centre	Bristol Airport	60	1	8%	Pass
	A4&04	Bristol Airport	Bath City Centre	60	1	6%	Pass
	X39&01	Bristol Bus Station	Bath Bus Station	12	5	9%	Pass
	X39&11	Bath Bus Station	Bristol Bus Station	15	4	8%	Pass
	319&11	Bath Bus Station	Cribbs Causeway	30	2	10%	Pass
	319&X0	Bristol Parkway	Bath Bus Station	60	1	4%	Pass
	332&01	Bristol Bus Station	Bath Bus Station	60	1	13%	Pass
	332&11	Bath Bus Station	Bristol Bus Station	60	1	9%	Pass
	42&11	Keynsham	The Centre (BCC)	20	3	-6%	Pass
	42&01	The Centre (BCC)	Keynsham	20	3	0%	Pass
Top 40% of services	16&X11	16UoBBS-TyndPark		6	10	-2%	Pass
	16&X02	16TyndPark-UoBBS		10	6	-2%	Pass
	76&11	76Hengrove-Cribbs		10	6	0%	Pass
	90&01	90Broadmead-Hngrve		10	6	-2%	Pass
	90&11	90Hngrve-Broadmead		10	6	-4%	Pass
	903&11	903LongAshPR-Centre		10	6	1%	Pass
	A1&04	A1BrisAir-Broadmead		10	6	9%	Pass
	A1&13	A1Broadmead-BrisAir		10	6	15%	Pass
	1&01	1BrmHill-Cribbs		12	5	4%	Pass
	1&11	1Cribbs-BrmHill		12	5	2%	Pass
	2&01	2Stockwood-Cribbs		12	5	3%	Pass
	2&11	2Cribbs-Stockwood		12	5	3%	Pass
	75&01	75Cribbs-Hengrove		12	5	14%	Pass
	75&11	75Hengrove-Cribbs		12	5	3%	Pass
	76&01	76Cribbs-Hengrove		12	5	7%	Pass
	8&11	8TempleMeads-Cotham		12	5	3%	Pass
	9&11	9BTM-Redland		12	5	-1%	Pass
	902&11	902PortPR-Centre		12	5	7%	Pass
	904&11	904BrstonPR-Centre		12	5	4%	Pass
	X39&01	X39BristoBS-BathBS		12	5	13%	Pass
	19&11	19UWEFC-Centre		15	4	-2%	Pass
	48&01	48RupertSt-EmGreen		15	4	3%	Pass
	48&11	48EmGreen-RupertSt		15	4	-4%	Pass
	49&01	49RupertSt-EmGreen		15	4	0%	Pass
	49&11	49EmGreen-RupertSt		15	4	-3%	Pass
	70&01	70BTM-UWEFrenchay		15	4	0%	Pass
	70&11	70UWEFrenchay-BTM		15	4	-7%	Pass
	73&01	73Centre-Cribbs		15	4	8%	Pass
	73&11	73Cribbs-Centre		15	4	-6%	Pass
	X39&11	X39BathBS-BristolBS		15	4	8%	Pass
	11&02	11BowerAshton-UWEFC		20	3	-6%	Pass

Appendix B2: Modelled IP Bus Journey Time vs Timetabled Time

	Route ID	From	To	Headway	Number of services	Difference (Model vs Timetable)	Pass/Fail
Weston-super-Mare	1W&11	Weston-Super-Mare	Bristol Bus Station	60	1	-4%	Pass
	1W&01	Bristol Bus Station	Weston-Super-Mare	60	1	0%	Pass
	X1&11	Weston-Super-Mare	Bristol Bus Station	20	3	8%	Pass
	X1&01	Bristol Bus Station	Weston-Super-Mare	20	3	9%	Pass
	121&12	Weston-Super-Mare	Bristol Bus Station	120	1	1%	Pass
	121&01	Bristol Bus Station	Weston-Super-Mare	120	1	-6%	Pass
Portishead	X2&11	Bristol Bus Station	Portishead	30	2	4%	Pass
	X3&11	Bristol Bus Station	Portishead	30	2	6%	Pass
	X6&01	Bristol Bus Station	Clevedon	30	2	2%	Pass
	X6&11	Clevedon	Bristol Bus Station	30	2	9%	Pass
	X7&11	Temple Meads	Clevedon	60	1	20%	Fail
	X7&02	Clevedon	Temple Meads	60	1	-1%	Pass
	X8&01	Bristol Bus Station	Clevedon	60	1	-3%	Pass
	X8&X01	Bristol Bus Station	Portishead	60	1	-4%	Pass
Severn Beach	40&11	Cribbs Causeway	Union Street (BCC)	20	3	-2%	Pass
	40&01	Union Street (BCC)	Cribbs Causeway	20	3	6%	Pass
	41&01	Union Street (BCC)	Avonmouth	20	3	9%	Pass
	41&11	Avonmouth	Union Street (BCC)	20	3	8%	Pass
	501&11	Abbey Wood	Avonmouth	60	1	1%	Pass
	502&02	Shirehampton	UWE Frenchay Campus	60	1	-4%	Pass
	502&11	UWE Frenchay Campus	Shirehampton	60	1	3%	Pass
	508&02	Sea Mills	Southmead	60	1	-5%	Pass
	508&11	Southmead	Sea Mills	60	1	-4%	Pass
Henbury	1&01	Broom Hill	Cribbs Causeway	10	6	-6%	Pass
	1&11	Cribbs Causeway	Broom Hill	10	6	1%	Pass
	2&01	Stockwood	Cribbs Causeway	10	6	-3%	Pass
	2&11	Cribbs Causeway	Cribbs Causeway	10	6	-5%	Pass
	3&01	The Centre (BCC)	Cribbs Causeway	16	4	7%	Pass
	3&11	Cribbs Causeway	The Centre (BCC)	15	4	2%	Pass
	3A&01	The Centre (BCC)	Aztec West	360	0	-3%	Pass
	40&01	Union Street (BCC)	Cribbs Causeway	20	3	6%	Pass
	40&11	Cribbs Causeway	Union Street (BCC)	20	3	-2%	Pass
	73&01	The Centre (BCC)	Cribbs Causeway	10	6	-4%	Pass
	73&11	Cribbs Causeway	The Centre (BCC)	10	6	-6%	Pass
	75&11	Hengrove	Cribbs Causeway	10	6	10%	Pass
	75&01	Cribbs Causeway	Hengrove	10	6	1%	Pass
	76&01	Cribbs Causeway	Hengrove	10	6	6%	Pass
	76&11	Hengrove	Cribbs Causeway	10	6	-3%	Pass
	319&02	Cribbs Causeway	Bath Bus Station	30	2	5%	Pass
	319&11	Bath Bus Station	Cribbs Causeway	30	2	2%	Pass
	622&14	Chipping Sodbury	Cribbs Causeway	90	1	6%	Pass
	X25&02	Cribbs Causeway	Portishead	60	1	2%	Pass
	309&01	Bristol Bus Station	Thornbury	33	2	-7%	Pass
	309&11	Thornbury	Bristol Bus Station	30	2	-1%	Pass
	625&04	UWE Frenchay Campus	Severn Beach	60	1	6%	Pass
	625&12	Severn Beach	UWE Frenchay Campus	60	1	1%	Pass
Bristol Parkway / Yate	73&01	The Centre (BCC)	Cribbs Causeway	10	6	-4%	Pass
	73&11	Cribbs Causeway	The Centre (BCC)	10	6	-6%	Pass
	24&11	Horfield Common	Ashton Vale	20	3	3%	Pass
	24&01	Ashton Vale	Horfield Common	20	3	-2%	Pass
	25&01	Ashton Vale	Horfield Common	20	3	-2%	Pass
	25&11	Horfield Common	Ashton Vale	20	3	6%	Pass
	11&11	UWE Frenchay Campus	Bower Ashton Campus	21	3	1%	Pass
	11&02	Bower Ashton Campus	UWE Frenchay Campus	21	3	-1%	Pass
	12&01	The Centre (BCC)	UWE Frenchay Campus	20	3	7%	Pass
	12&12	UWE Frenchay Campus	The Centre (BCC)	20	3	1%	Pass
	15&12	UWE Frenchay Campus	The Centre (BCC)	20	3	0%	Pass
	15&01	The Centre (BCC)	UWE Frenchay Campus	20	3	3%	Pass
	19&01	The Centre (BCC)	UWE Frenchay Campus	12	5	7%	Pass
	19&11	UWE Frenchay Campus	The Centre (BCC)	12	5	4%	Pass
	70&01	Temple Meads	UWE Frenchay Campus	12	5	1%	Pass
	70&11	UWE Frenchay Campus	Temple Meads	12	5	-3%	Pass
	501&11	Abbey Wood	Avonmouth	60	1	1%	Pass
	502&11	UWE Frenchay Campus	Shirehampton	60	1	3%	Pass
	502&02	Shirehampton	UWE Frenchay Campus	60	1	3%	Pass
	625&04	UWE Frenchay Campus	Severn Beach	60	1	6%	Pass

Appendix B2: Modelled IP Bus Journey Time vs Timetabled Time

	Route ID	From	To	Headway	Number of services	Difference (Model vs Timetable)	Pass/Fail
	625&12	Severn Beach	UWE Frenchay Campus	60	1	1%	Pass
	319&02	Cribbs Causeway	Bath Bus Station	30	2	6%	Pass
	319&11	Bath Bus Station	Cribbs Causeway	30	2	2%	Pass
	X27&12	Anchor Road (BCC)	Yate	60	1	9%	Pass
	327&11	Bristol Bus Station	Yate	60	1	10%	Pass
	327&02	Yate	Bristol Bus Station	60	1	-1%	Pass
	342&02	Chipping Sodbury	Bristol Bus Station	30	2	7%	Pass
	342&11	Bristol Bus Station	Chipping Sodbury	33	2	15%	Pass
Keynsham / Bath Spa	178&11	Bath Bus Station	Bristol Bus Station	60	1	-1%	Pass
	178&01	Bristol Bus Station	Bath Bus Station	60	1	6%	Pass
	349&11	Keynsham	The Horsefair (BCC)	30	2	0%	Pass
	338&11	Bath Bus Station	Bristol Bus Station	30	2	-5%	Pass
	338&01	Bristol Bus Station	Bath Bus Station	30	2	-8%	Pass
	A4&13	Bath City Centre	Bristol Airport	60	1	-1%	Pass
	A4&04	Bristol Airport	Bath City Centre	60	1	-4%	Pass
	X39&01	Bristol Bus Station	Bath Bus Station	12	5	2%	Pass
	X39&11	Bath Bus Station	Bristol Bus Station	12	5	10%	Pass
	319&11	Bath Bus Station	Cribbs Causeway	30	2	2%	Pass
	332&01	Bristol Bus Station	Bath Bus Station	60	1	13%	Pass
	332&11	Bath Bus Station	Bristol Bus Station	60	1	5%	Pass
	42&11	Keynsham	The Centre (BCC)	20	3	-2%	Pass
	42&01	The Centre (BCC)	Keynsham	20	3	-1%	Pass
Top 40% of services	1&01	1BrmHill-Cribbs		10	6	-6%	Pass
	1&11	1Cribbs-BrmHill		10	6	1%	Pass
	2&01	2Stockwood-Cribbs		10	6	-3%	Pass
	2&11	2Cribbs-Stockwood		10	6	-5%	Pass
	73&01	73Centre-Cribbs		10	6	-4%	Pass
	73&11	73Cribbs-Centre		10	6	-6%	Pass
	75&01	75Cribbs-Hengrove		10	6	1%	Pass
	75&11	75Hengrove-Cribbs		10	6	10%	Pass
	76&01	76Cribbs-Hengrove		10	6	6%	Pass
	76&11	76Hengrove-Cribbs		10	6	-3%	Pass
	90&01	90Broadmead-Hngrve		10	6	-2%	Pass
	90&11	90Hngrve-Broadmead		10	6	-1%	Pass
	A1&04	A1BrisAir-Broadmead		10	6	7%	Pass
	A1&13	A1Broadmead-BrisAir		10	6	5%	Pass
	19&01	19Centre-UWEFC		12	5	7%	Pass
	19&11	19UWEFC-Centre		12	5	4%	Pass
	70&01	7070BTM-UWEFrenchay		12	5	1%	Pass
	70&11	70UWEFrenchay-BTM		12	5	-3%	Pass
	8&11	8TempleMeads-Cotham		12	5	1%	Pass
	9&11	9BTM-Redland		12	5	1%	Pass
	903&11	903LongAshPR-Centre		12	5	7%	Pass
	X39&01	X39BristoBS-BathBS		12	5	2%	Pass
	X39&11	X39BathBS-BristolBS		12	5	10%	Pass
	16&02	16Centre-UoBBS		13	5	6%	Pass
	49&11	49EmGreen-RupertSt		14	4	0%	Pass
	16&11	16UoBBS-Centre		13	5	4%	Pass
	3&11	3Cribbs-Centre		15	4	2%	Pass
	48&01	48RupertSt-EmGreen		15	4	5%	Pass
	48&11	48EmGreen-RupertSt		15	4	0%	Pass
	49&01	49RupertSt-EmGreen		15	4	-3%	Pass
	902&11	902PortPR-Centre		15	4	12%	Pass
	904&11	904BrstonPR-Centre		15	4	10%	Pass
	3&01	3Centre-Cribbs		16	4	7%	Pass
	3&11	3Centre-Cribbs		15	4	0%	Pass

Appendix B3: Modelled PM Peak Bus Journey Time vs Timetabled Time

	Route ID	From	To	Headway	Number of services	Difference (Model vs Timetable)	Pass/Fail
Weston-super-Mare	1W&11	Weston-Super-Mare	Bristol Bus Station	30	2	-1%	Pass
	1W&01	Bristol Bus Station	Weston-Super-Mare	60	1	14%	Pass
	X1&11	Weston-Super-Mare	Bristol Bus Station	30	2	6%	Pass
	X1&02	Bristol Bus Station	Weston-Super-Mare	20	3	4%	Pass
Portishead	X2&11	Bristol Bus Station	Portishead	30	2	6%	Pass
	X3&11	Bristol Bus Station	Portishead	30	2	4%	Pass
	X6&01	Bristol Bus Station	Clevedon	30	2	7%	Pass
	X6&11	Clevedon	Bristol Bus Station	30	2	10%	Pass
	X7&11	Temple Meads	Clevedon	60	1	15%	Pass
	X7&02	Clevedon	Temple Meads	60	1	0%	Pass
	X8&01	Bristol Bus Station	Clevedon	60	1	2%	Pass
	X8&X01	Bristol Bus Station	Portishead	60	1	1%	Pass
Severn Beach	40&11	Cribbs Causeway	Union Street (BCC)	20	3	3%	Pass
	40&01	Union Street (BCC)	Cribbs Causeway	20	3	2%	Pass
	41&01	Union Street (BCC)	Avonmouth	20	3	6%	Pass
	41&11	Avonmouth	Union Street (BCC)	20	3	8%	Pass
	501&11	Abbey Wood	Avonmouth	60	1	4%	Pass
	501&03	Avonmouth	Abbey Wood	60	1	-3%	Pass
	502&02	Shirehampton	UWE Frenchay Campus	60	1	-2%	Pass
	502&11	UWE Frenchay Campus	Shirehampton	60	1	-1%	Pass
Henbury	1&01	Broom Hill	Cribbs Causeway	12	5	3%	Pass
	1&11	Cribbs Causeway	Broom Hill	12	5	-7%	Pass
	2&01	Stockwood	Cribbs Causeway	12	5	0%	Pass
	2&11	Cribbs Causeway	Cribbs Causeway	12	5	7%	Pass
	3A&01	The Centre (BCC)	Aztec West	30	2	0%	Pass
	3A&11	Aztec West	The Centre (BCC)	30	2	5%	Pass
	3B&01	The Centre (BCC)	Bradley Stoke	60	1	0%	Pass
	3C&11	Aztec West	Clifton	60	1	1%	Pass
	40&01	Union Street (BCC)	Cribbs Causeway	20	3	2%	Pass
	40&11	Cribbs Causeway	Union Street (BCC)	20	3	3%	Pass
	73&01	The Centre (BCC)	Cribbs Causeway	15	4	0%	Pass
	73&11	Cribbs Causeway	The Centre (BCC)	15	4	-3%	Pass
	X73&01	The Centre (BCC)	Cribbs Causeway	30	2	-1%	Pass
	75&11	Hengrove	Cribbs Causeway	12	5	-3%	Pass
	75&01	Cribbs Causeway	Hengrove	10	6	-5%	Pass
	76&01	Cribbs Causeway	Hengrove	12	5	9%	Pass
	76&11	Hengrove	Cribbs Causeway	12	5	1%	Pass
	319&02	Cribbs Causeway	Bath Bus Station	30	2	10%	Pass
	319&11	Bath Bus Station	Cribbs Causeway	30	2	3%	Pass
	X25&02	Cribbs Causeway	Portishead	60	1	9%	Pass
	309&01	Bristol Bus Station	Thornbury	60	1	14%	Pass
	309&11	Thornbury	Bristol Bus Station	30	2	-3%	Pass
	625&15	Severn Beach	UWE Frenchay Campus	60	1	7%	Pass
	625&04	UWE Frenchay Campus	Severn Beach	60	1	-3%	Pass
Bristol Parkway / Yate	73&01	The Centre (BCC)	Cribbs Causeway	15	4	0%	Pass
	73&11	Cribbs Causeway	The Centre (BCC)	15	4	-3%	Pass
	X73&01	The Centre (BCC)	Cribbs Causeway	30	2	-1%	Pass
	24&11	Horfield Common	Ashton Vale	20	3	2%	Pass
	24&01	Ashton Vale	Horfield Common	20	3	8%	Pass
	25&01	Ashton Vale	Horfield Common	20	3	1%	Pass
	25&11	Horfield Common	Ashton Vale	20	3	-8%	Pass
	11&11	UWE Frenchay Campus	Bower Ashton Campus	30	2	6%	Pass
	11&02	Bower Ashton Campus	UWE Frenchay Campus	20	3	-2%	Pass
	12&01	The Centre (BCC)	UWE Frenchay Campus	30	2	2%	Pass
	12&12	UWE Frenchay Campus	The Centre (BCC)	30	2	-1%	Pass
	15&12	UWE Frenchay Campus	The Centre (BCC)	20	3	-3%	Pass
	15&01	The Centre (BCC)	UWE Frenchay Campus	20	3	-1%	Pass
	19&01	The Centre (BCC)	UWE Frenchay Campus	15	4	9%	Pass
	19&11	UWE Frenchay Campus	The Centre (BCC)	15	4	-2%	Pass
	70&01	Temple Meads	UWE Frenchay Campus	15	4	-2%	Pass
	70&11	UWE Frenchay Campus	Temple Meads	15	4	-8%	Pass
	501&11	Abbey Wood	Avonmouth	60	1	4%	Pass
	501&03	Avonmouth	Abbey Wood	60	1	-3%	Pass
	502&11	UWE Frenchay Campus	Shirehampton	60	1	-1%	Pass

Appendix B3: Modelled PM Peak Bus Journey Time vs Timetabled Time

	Route ID	From	To	Headway	Number of services	Difference (Model vs Timetable)	Pass/Fail
	502&02	Shirehampton	UWE Frenchay Campus	60	1	-2%	Pass
	625&15	Severn Beach	UWE Frenchay Campus	60	1	7%	Pass
	625&04	UWE Frenchay Campus	Severn Beach	60	1	-3%	Pass
	319&02	Cribbs Causeway	Bath Bus Station	30	2	10%	Pass
	319&11	Bath Bus Station	Cribbs Causeway	30	2	3%	Pass
	X27&12	Anchor Road (BCC)	Yate	60	1	-8%	Pass
	327&11	Bristol Bus Station	Yate	60	1	6%	Pass
	327&02	Yate	Bristol Bus Station	60	1	-9%	Pass
	342&02	Chipping Sodbury	Bristol Bus Station	30	2	7%	Pass
	342&11	Bristol Bus Station	Chipping Sodbury	30	2	0%	Pass
Keynsham / Bath Spa	178&11	Bath Bus Station	Bristol Bus Station	60	1	5%	Pass
	178&01	Bristol Bus Station	Bath Bus Station	60	1	6%	Pass
	349&11	Keynsham	The Horsefair (BCC)	30	2	18%	Fail
	338&11	Bath Bus Station	Bristol Bus Station	30	2	-7%	Pass
	338&01	Bristol Bus Station	Bath Bus Station	30	2	-3%	Pass
	A4&13	Bath City Centre	Bristol Airport	60	1	6%	Pass
	A4&04	Bristol Airport	Bath City Centre	60	1	4%	Pass
	X39&01	Bristol Bus Station	Bath Bus Station	15	4	13%	Pass
	X39&11	Bath Bus Station	Bristol Bus Station	15	4	-5%	Pass
	319&11	Bath Bus Station	Cribbs Causeway	30	2	3%	Pass
	319&02	Bristol Parkway	Bath Bus Station	30	2	7%	Pass
	332&01	Bristol Bus Station	Bath Bus Station	60	1	14%	Pass
	332&11	Bath Bus Station	Bristol Bus Station	60	1	7%	Pass
	42&11	Keynsham	The Centre (BCC)	20	3	1%	Pass
	42&01	The Centre (BCC)	Keynsham	20	3	-2%	Pass
Top 40% of services	16&X02	16TyndPark-UoBBS		8	7.5	11%	Pass
	16&X11	16UoBBS-TyndPark		8	7.5	-2%	Pass
	75&01	75Cribbs-Hengrove		10	6	-5%	Pass
	90&01	90Broadmead-Hngrve		10	6	-3%	Pass
	90&11	90Hngrve-Broadmead		10	6	-9%	Pass
	A1&04	A1BrisAir-Broadmead		10	6	3%	Pass
	A1&13	A1Broadmead-BrisAir		10	6	4%	Pass
	1&01	1BrmHill-Cribbs		12	5	3%	Pass
	1&11	1Cribbs-BrmHill		12	5	-7%	Pass
	2&01	2Stockwood-Cribbs		12	5	0%	Pass
	2&11	2Cribbs-Stockwood		12	5	7%	Pass
	75&11	75Hengrove-Cribbs		12	5	-3%	Pass
	76&01	76Cribbs-Hengrove		12	5	9%	Pass
	76&11	76Hengrove-Cribbs		12	5	1%	Pass
	902&11	902PortPR-Centre		12	5	8%	Pass
	903&11	903LongAshPR-Centre		12	5	-1%	Pass
	904&11	904BrstonPR-Centre		12	5	0%	Pass
	19&01	19Centre-UWEFC		15	4	9%	Pass
	19&11	19UWEFC-Centre		15	4	-2%	Pass
	48&01	48RupertSt-EmGreen		15	4	8%	Pass
	49&01	49RupertSt-EmGreen		15	4	1%	Pass
	7&01	7BldwnSt-StapleHill		15	4	-5%	Pass
	70&01	7070BTM-UWEFrenchay		15	4	-2%	Pass
	73&01	73Centre-Cribbs		15	4	0%	Pass
	73&11	73Cribbs-Centre		15	4	-3%	Pass
	8&11	8TempleMeads-Cotham		15	4	6%	Pass
	9&11	9BTM-Redland		15	4	2%	Pass
	X39&01	X39BristoBS-BathBS		15	4	13%	Pass
	X39&11	X39BathBS-BristolBS		15	4	-5%	Pass
	11&02	11BowerAshton-UWEFC		20	3	-2%	Pass
	15&01	15Centre-UWEFC		20	3	-1%	Pass
	15&12	15UWEFC-Centre		20	3	-3%	Pass

Bristol City Council Clean Air Plan Full Business Case

Transport Modelling Methodology Report (T3)

FBC-23 | H

February 2021

Bristol City Council

Bristol City Council Clean Air Plan Full Business Case

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1	23.05.2018	Revision A	KW	KW	JB	BL
2	31.08.2018	Revision B	KW	KW	CB	BL
3	29.01.2019	Revision C	CB	CB	KW	HO
4	05.09.2019	Revision D	KW	JB	CB	HO
5	23.10.2019	Revision E	KW	CB	CB	HO
6	03.04.2020	Revision F	KW	CB	CB	HO
7	22.01.2021	Revision G	JM	CB	CB	HO
8	17.02.2021	Revision H	KW	CB	CB	HO

Contents

Acronyms and Abbreviations

AADT	Annual average daily traffic
ANPR	Automatic Number Plate Recognition
ATC	Automatic traffic count
AQMA	Air Quality Management Area
BCC	Bristol City Council
CAP	Clean Air Plan
CAZ	Clean Air Zone
CO_2	Carbon Dioxide
Defra	Department for Environment, Food & Rural Affairs
DfT	Department for Transport
EFT	Emission Factor Toolkit
GBATS	Greater Bristol Area Transport Study
HGV	Heavy Goods Vehicle
IMD	Indices of Multiple Deprivation
JAQU	Joint Air Quality Unit
LGV	Light Goods Vehicle
NO_2	Nitrogen Dioxide
NTM	National Transport Model
NTEM	National Trip End Model
OBC	Outline Business Case
FBC	Final Business Case
PT	Public Transport
(Web)TAG	Transport Analysis Guidance
VDM	Variable Demand Model
VRN	Vehicle Registration Number

1. Introduction

1.1 Background

Poor air quality is the largest known environmental risk to public health in the UK[1]. Investing in cleaner air and doing more to tackle air pollution are priorities for the EU and UK governments, as well as for Bristol City Council (BCC). The Mayor of Bristol has often cited Bristol's 'moral and legal duty' to improve air quality in the city and the administration recognises that achieving improved air quality is not solely a transport issue. Notwithstanding the Council's work on a Clean Air Zone, efforts have been made to make citizens more aware of – and take personal responsibility for – various sources of air pollution, from traffic fumes to solid fuel burning. The Mayor has articulated a 'call to action' for local people, businesses and organisations to consider how small changes can make a significant difference in cutting toxic fumes across the city. BCC has monitored and endeavoured to address air quality in Bristol for decades and declared its first Air Quality Management Area in 2001. Despite this, Bristol has ongoing exceedances of the legal limits for Nitrogen Dioxide (NO_2) and these are predicted to continue until around 2027 without intervention.

The added context is that of the COVID-19 pandemic. Recent research suggests that poor air quality may be correlated with higher death / infection rates from COVID-19. This is further compounded by growing evidence that suggests that those from black, Asian and minority ethnic communities are more at risk of catching and dying from the virus and the fact that individuals from these communities are more likely to live in areas where air quality is poor. The challenge of maintaining public health and supporting economic recovery while also achieving legal air quality levels after lockdown restrictions are lifted will remain live and intersecting issues for the foreseeable future.

The UK Government continue to transpose European Union law into its Environment Bill[2] , to ensure that certain standards of air quality continue to be met, by setting air quality assessment levels (AQALs) on the concentrations of specific air pollutants. It's very unlikely that these AQALs will differ to EU Limit Values prescribed by the European Union's Air Quality Directive and transcribed in the UK's Air Quality Standards Regulation 2010. Therefore, these Limit Values will remain in enforcement post-Brexit. In common with many EU member states, the EU Limit Value for annual mean nitrogen dioxide (NO_2) is breached in the UK and there are on-going breaches of the NO_2 limit value in Bristol. The UK government is taking steps to remedy this breach in as short a time as possible, with the aim of reducing the harmful impacts on public health. Within this objective, the Government has published a UK Air Quality Plan and a Clean Air Zone Framework, both originally published in 2017 (noting there have been subsequent revisions). The latter document provides the expected approach for local authorities when implementing and operating a Clean Air Zone (CAZ). The following business cases have been submitted to JAQU for the Clean Air Plan; Strategic Outline Case (April 2018), and an Outline Business Case (November 2019 and updated between April and June 2020).

1.2 Purpose of this report

This report sets out the transport modelling methodology which outlines the approach taken to model the transport impacts, including base and forecast years, baseline assumptions and scheme effects. It also sets out how the Euro standards have been calculated and forecast, together with how the traffic modelling outputs will feed into the air quality modelling.

Versions of this report were published for the OBC in October 2019 and April 2020, which supported the draft economic case that was also published at this time.

[1] Public Health England (2014) Estimating local mortality burdens associated with particular air pollution. https://www.gov.uk/government/publications/estimating-local-mortality-burdens-associated-with-particulate-air-pollution

[2] Environment Bill 2019-21 https://services.parliament.uk/bills/2019-21/environment.html

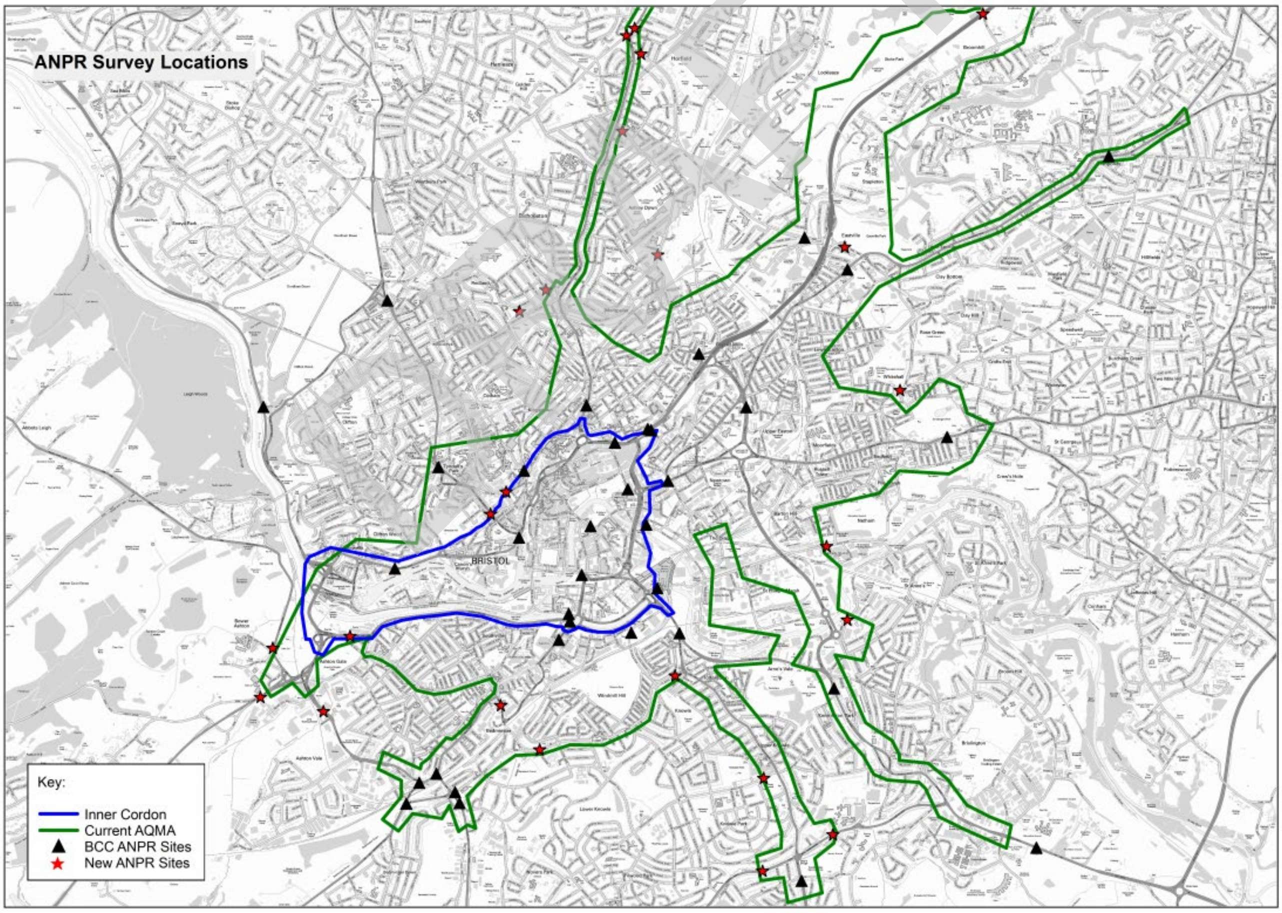
2. Data Collection and Use

2.1 Automatic Number Plate Recognition

Permanent Automatic Number Plate Recognition (ANPR) camera data is available in and around Bristol City Centre and has been obtained for 2015 and 2017. In addition to these sites, surveys of another 24 ANPR sites were commissioned in 2017 to enhance the data collected at the permanent sites. Figure 2-1 shows the location of both the permanent and commissioned ANPR sites.

The 2017 ANPR surveys were undertaken in July 2017 due to the programme timescales of the Feasibility Study at that time. Data from the permanent cameras has been obtained for June and July 2017 in order to assess whether there are any substantial differences in fleet composition between a neutral month (June) and a summer month (July). This comparison showed that there were no material differences in compliance rates by vehicle type between the June and July datasets at the BCC permanent camera locations. Hence the dataset subsequently used in the analysis was the full July 2017 data, including both the BCC permanent sites and the 24 additional ANPR locations since this gave the greatest geographical coverage.

Figure 2-1: ANPR Survey Locations



The data collected has been used to determine the compliance/non-compliance splits of the current fleet when compared to the CAZ framework criteria; namely that non-compliant vehicles are those that do not meet the required Euro standards for a CAZ (i.e. petrol must be at least Euro 4 and diesel must be at least Euro 6). The registration data from the ANPR surveys have been cross referenced with data purchased from Carweb to gain information on vehicle type, fuel type and Euro standard. Both the base year and baseline (future year) splits have been determined from the 2017 ANPR data, adjusted to the assessment year using the fleet projection tool in the Emission Factor Toolkit for compliance splits and TAG projections for changes in fuel type splits. Splits have been applied to the model matrices for each user class (Cars, Taxis, LGVs, Coaches and HGVs).

The GBATS transport model does not have a separate taxi or coach user classes. Therefore, the ANPR data has been used to split the taxi fleet from the car matrices and the coaches from the HGV matrices, by applying global factors for each time period.

The data collected has also been used to determine the fuel type splits and Euro standard fleet mix for the base year and assessment year models. Therefore, in addition to splitting each user class by compliance within the transport model, this data has been used to add more detail to the modelled outputs via post processing to yield emissions standards inputs into the Air Quality Model.

Compliance segmentation of highway model trip matrices has been considered on a geographical basis, based on a review of compliance by area and trip pattern e.g. trips through or to the city centre. Hence the combined 2017 ANPR data has also been used to identify the relationship between fleet composition and movements through the city, by matching registration number plates between cameras and identifying the vehicle details.

Further details are provided in FBC-24 ANPR Analysis and Application technical note in Appendix E of the FBC.

2.2 Bus Fleet

Jacobs and BCC have held conversations with First bus, the main local operator, about the fleet composition by service for the base year, baseline and options to be assessed.

The bus fleet composition is handled outside the transport model via post processing of model outputs. This has enabled vehicle details for particular routes to be accounted for in both the current and future fleet.

2.3 Stated Preference Surveys

Stated preference surveys have been undertaken to determine local behavioural responses to the implementation of a CAZ. This provides Bristol based proportions for the responses to a CAZ by petrol and diesel non-compliant cars.

The main part of the survey are two stated preference exercises, the first asks the respondent to consider their most recent trip through the zone and how they would have responded from the following choices:

- Paid the charge and travelled as before;
- Made the same journey but changed mode;
- Not have made the journey at all;
- Made the same journey purpose but changed the destination;
- Made the same journey but changed route to avoid the zone; or,
- Made the same journey but switched to another compliant vehicle in their household (this option will only be shown if the respondent has indicated in an earlier question that such a vehicle exists).

Each respondent was asked to make this choice for one of two subgroups of 4 different charge levels.

The second exercise asks respondents the longer-term choice of whether they would continue to pay the charge to travel in the zone or would pay upgrade the vehicle to a compliant one for a given hypothetical cost.

When completed, the survey data has undergone a cleaning process to identify and discard nonsensical questionnaires.

Statistical models have been fitted to the data and then combined in order to allow predictions to be made on behavioural changes to feed into the highway transport model. Specifically, of the non-compliant car user class that travels in the zone it has allowed the proportions to be established as follows:

- Travel as is (and pay the charge);
- Still travel as a non-compliant vehicle but reroute or change destination (to avoid the charge);
- Be moved to the compliant car user class (due to replacing their non-compliant vehicle with a compliant one); and,
- Be removed from the highway matrix entirely (due to no longer making the car journey).

The survey also asks questions about respondents' existing vehicle replacement plans to inform both the likely average upgrade cost and the base change in vehicle fleet compliance rate regardless of the introduction of a Charging Zone.

The structure, implementation and outcomes of the survey are provided fully in FBC-28 Stated Preference Survey Report.

3. Base Year Model

3.1 2013 Model

In 2013, BCC commissioned CH2M (now Jacobs) to update the existing GBATS model, primarily to assess the MetroWest scheme. The updated model is called the GBATS4 Metro Model (GBATS4M). The GBATS4M model consists of:

- A Highway Assignment Model representing vehicle-based movements across the Greater Bristol area for a 2013 autumn weekday morning peak hour (08:00-09:00), an average inter-peak hour (10:00-16:00) and an evening peak hour (17:00-18:00);
- A Public Transport (PT) Assignment Model representing bus and rail-based movements across the same area and time periods; and
- A five-stage multi-modal incremental Variable Demand Model (VDM) that forecasts changes in trip frequency and choice of main mode, time period of travel, destination, and sub-mode choice, in response to changes in generalised costs across the 12-hour period (07:00 – 19:00).

3.1.1 Highway Model

The GBATS4M highway model included an update of the trips to/from the city centre with roadside interview data. The model has been validated using the guidance, measures and criteria recommended in TAG M3.1. The following comparisons between modelled and observed data have been reported in the METROWEST Highway Model Local Model Validation Report:

- Total flows for cordons and screenlines, for light and all vehicles;
- Traffic Flows on individual links, for light and all vehicles; and
- Journey times (both cruise and net) for a range of key routes.

The analysis shows that the three models meet the acceptability guidelines:

- Regarding matrix estimation changes;
- For traffic flows on links across the total cordon and screenlines and at the individual calibration, and independent validation sites; and
- For journey times.

All three models (AM, inter-peak and PM) achieve acceptable levels of convergence and are stable based on delay/cost. Full details of the highway model update are detailed in the METROWEST Highway Model Local Model Validation Report.

The light and heavy goods vehicles had not previously been validated in short screenlines, using grouped counts. This has been checked as part of this study and reported in OBC-25 LGV and HGV Validation Technical Note in Appendix E of the FBC.

3.1.2 Public Transport Model

The GBATS4M PT model is closely integrated with the GBATS4M Highway model. The two models use different software packages (EMME and SATURN, respectively) but are identical in terms of road network structure, and zone system. The bus routes and frequencies in the PT model are used in the Highway model. The validation process has been carried out in-line with current guidelines as set-out in the TAG M3.2. This states that validation should involve checks of:

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

Count data from a variety of sources has been compared to modelled flows in all represented time-periods. This has demonstrated that in the majority of cases the resulting validation has been good. Full details can be found in the METROWEST Public Transport Model Local Model Validation Report.

3.1.3 Variable Demand Model

The GBATS4M variable demand model is a five-stage multi-modal incremental model that calculates trip frequency, main mode choice, time period choice, destination choice and sub mode choice with regards to changes in generalised cost for both the highway and PT models. The variable demand model follows the current TAG guidance with respect to the structure of model, parameters used and realism tests, which demonstrate that it is fit for purpose to test the impact of proposed future year schemes. Full details of the demand model design methodology and calibration are outlined in the METROWEST Demand Model Report.

3.2 2015 Model

The air quality model base year is 2015 since the 2017 data was not available at the time the model was developed, and in 2016 there was a significant amount of disruption from roadworks in the city (related to the Metrobus scheme) which prevented some monitoring data from being collected and altered the typical travel patterns across the city.

As the transport model has a base year of 2013, a 2015 traffic model has been developed to support this by interpolating from the 2013 and 2021 models. It was therefore pragmatic to undertake disaggregation of the traffic model by vehicle compliance / fuel type in the 2015 model rather than 2013. The validation of the 2015 fleet composition will be reported within the T4 Transport Modelling Forecast Report appended to the FBC.

3.2.1 Matrix Compliance / Fuel Splits

The base year highway model has 6 user classes: Car Non-business (Low Income), Car Non-business (Medium Income), Car Non-business (High Income), Car Business, LGV and HGV. These have been split into 16 user classes using the following methodology:

- Split the Car user classes into Car and Taxi user classes;
- Split the HGV user class into HGV and Coach user classes; and
- Split Car, Taxi, LGV, HGV and Coach matrices into compliant and non-compliant using the time period splits.

Before the compliance / fuel splits were applied to the matrices, the car and HGV user classes were split to produce Taxi and Coach user classes respectively. Compliance splits have been calculated from the 2017 ANPR data worked back to 2015 using the 2015 vs 2017 relative differences in the EFT national Euro standard splits and applied to the 2015 matrices for each time period. Car fuel splits have been calculated from ANPR data, adjusted by TAG changes between 2015 and 2017.

For further details and splits used please refer to FBC-24 ANPR Analysis and Application technical note in Appendix E of the FBC.

4. Baseline Model

4.1 Opening Year

The opening date of the CAZ scheme will be towards the end of 2021 in line with the most recent direction received on 20 August 2020, which currently states the commencement date 29 October 2021.

4.2 Compliance Year

Technical work undertaken for the Strategic Outline Case[3] indicated compliance was likely to be achieved at most locations in the year of opening. This analysis was based on the response rates provided in 'Table 2 – Behavioural responses to charging Clean Air Zones' within the JAQU Evidence package which forecasts a large proportion of drivers will replace their vehicles, as shown in Figure 5.1 below. The analysis undertaken assumed this response would be achieved in the same year as implementation, but in reality, it is unlikely to be an immediate response. The long-term nature of this key response and the assessment of the potential to achieve compliance in the opening year indicated the need to assess the impact of the CAZ in 2023 rather than 2021.

4.3 Uncertainty Log

Appendix A shows the uncertainty log for the 2021 to 2036 forecast traffic models currently held. The uncertainty log was developed in 2015 therefore details for an up-to-date uncertainty log have been collated. This covers both development and scheme assumptions. The baseline model (2023) has the most recent scheme assumptions for the assessment year modelled within it, based on the Near Certain and More than Likely entries in the uncertainty log.

4.4 Street Space Schemes

In addition to the schemes mentioned in the uncertainty log, the Street Space schemes have also been included in the Baseline scenario.

The Street Space schemes have been/are being implemented to open up road space usually reserved for parking and movement of general traffic to public transport, cyclists and pedestrians to:

- Enable better social distancing, especially in local shopping areas;
- Encourage people to travel by bike or walk; and
- Reduce air pollution.

BCC is monitoring the impacts of the changes and will liaise with local residents, businesses and ward councillors before making any changes permanent. However, the schemes are expected to be permanent, as BCC have advised:

"The administration is committed to the Street Space schemes some of which have been a part of the council's transport strategy for a number of years and would likely have been implemented in the fullness of time without the pandemic having happened. Where problems have emerged changes have been made but the main elements of the schemes retained. We are confident that the schemes as a whole work for the City's transport network and will be retained long term having captured the benefits. The council are fully committed to not only enable social distancing but also to make the city more accessible for all as part of our liveable neighbourhoods aspirations. There is more chance of the schemes being retained than there is of them being removed so they should be included in the modelling as part of the base line."

[3] https://www.cleanairforbristol.org/bristols-clean-air-plan/

Changes to the old city have been made sooner than planned because of coronavirus (COVID-19) in part to:

- Allow for social distancing; and
- Enable businesses to make use of the outdoor space.

BCC provided Jacobs with the Bristol Street Space Schemes details. The overview of these schemes is shown in Figure 4-1 and Figure 4-2 below and a summary of the individual schemes included are shown in Table 4-1. More detailed general arrangement plans were provided to Jacobs for modelling purposes for the larger schemes highlighted.

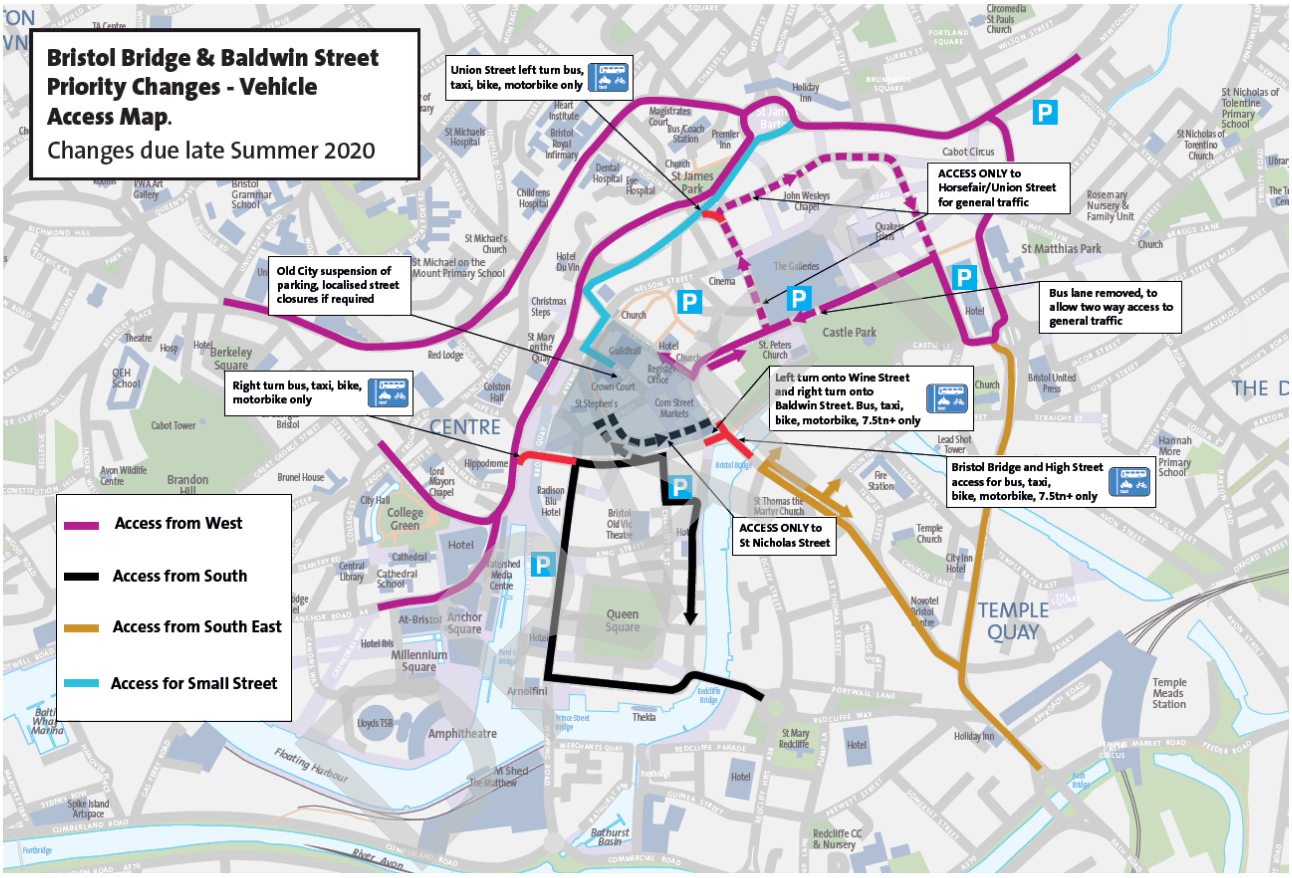


Figure 4-1: Street Space Schemes - Map 1

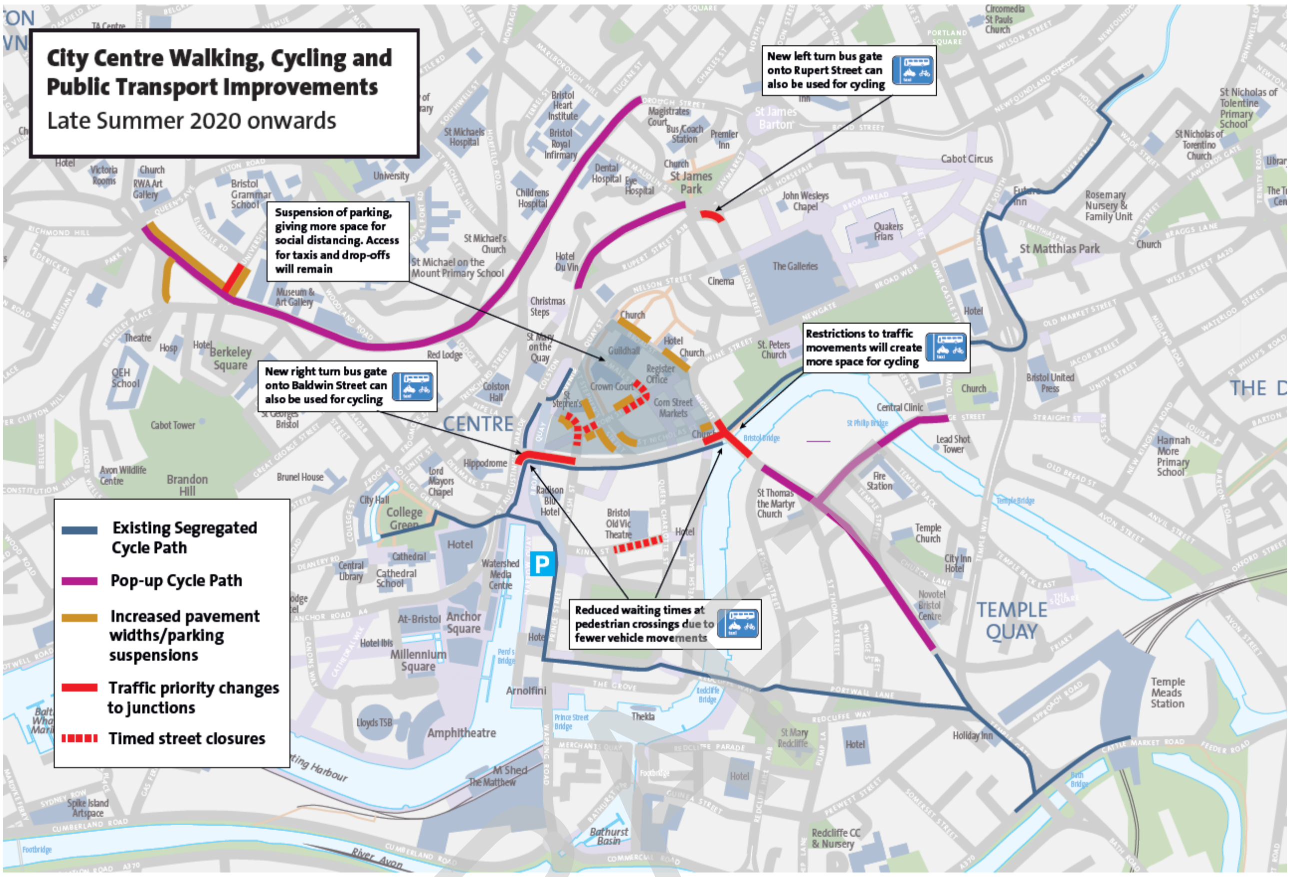


Figure 4-2: Street Space Schemes - Map 2

Table 4-1: Street Space Scheme Summary

Ref No.	Data Source	Description of Street Space Scheme	Location	Modelled
1	E20016-08 C101 Park Row-Upper Maudlin Street - DRAFT.pdf and E20016-08 C102 Park Row-Upper Maudlin Street - DRAFT.pdf	Park Row / Upper Maudlin Street / Marlborough Street cycle lanes. With-flow segregated cycle route, may be a TTRO	Park Row / Upper Maudlin Street / Marlborough Street	Yes
Baldwin Street priority changes and Bristol Bridge closure				
2	Road Closure Map 2 - August 2020 v6.pdf	Union Street left turn bus, taxi, motorbike only	Union Street turn onto Rupert Street	Yes
2.1	Road Closure Map 2 - August 2020 v6.pdf	Access only to Horsefair/Union Street for general traffic	Union Street / Horsefair	Yes
2.2	Road Closure Map 2 - August 2020 v6.pdf	Bus lane removed, to allow two-way access to general traffic	Newgate	Yes
2.3	Road Closure Map 2 - August 2020 v6.pdf	Left turn onto Wine Street and right on to Baldwin Street. Bus, taxi, bike and motorbike, 7.5tn+ only	Baldwin Street / Wine Street	Yes
2.4	Road Closure Map 3 - Transport Improvements v6	Restrictions to traffic movements will create space for cycling	Baldwin Street / Wine Street / High Street / Bristol Bridge	Yes
2.5	Road Closure Map 3 - Transport Improvements v6	New right turn bus gate onto Baldwin Street can also be used for cycling	Baldwin Street / St Augustine's Parade	Yes
2.6	Road Closure Map 2 - August 2020 v6.pdf	Bristol Bridge and High Street access for bus, taxi, bike and motorbike, 7.5tn+ only	Bristol Bridge and High Street	Yes
2.7	Road Closure Map 3 - Transport Improvements v6	Reduced waiting times at pedestrian crossings due to fewer vehicle movements	Baldwin Street / Wine Street / High Street and	Yes

Ref No.	Data Source	Description of Street Space Scheme	Location	Modelled
			Baldwin Street / St Augustine's Parade	
2.8	Road Closure Map 2 - August 2020 v6.pdf	Right Turn bus, taxi, bike, motorbike only	Baldwin Street / St Augustine's Parade	Yes
City Centre Walking, Cycling and Public Transport Improvements				
3	Road Closure Map 3 - Transport Improvements v6	Suspension of parking, giving more space for social distancing. Access for taxis and drop offs remain	Old City area	No - Old city not in model
3.1	Road Closure Map 2 - August 2020 v6.pdf	Access only to St Nicolas Street	St Nicolas Street	No - Old city not in model
3.2	Road Closure Map 3 - Transport Improvements v6	New left turn bus gate into Rupert St can also be used for cycling	Horsefair into Rupert St	Yes
3.3	Road Closure Map 2 - August 2020 v6.pdf	Old City suspension of parking, localised street closures if required.	Old City area	No - Old city not in model
3.4	Road Closure Map 3 - Transport Improvements v6	Timed street closures in the old city area	Old City area	No - Old city not in model
3.5	Road Closure Map 3 - Transport Improvements v7	Increased pavements and suspension of parking in various locations	Old City area and the Triangle	No - Old city not in model
3.6	Road Closure Map 3 - Transport Improvements v6	Red line on University Road suggesting traffic priority changes	University Road	Yes
3.7	Road Closure Map 3 - Transport Improvements v6	Timed street closures on Kings Street	Kings Street	Yes
4	EATF Team	Bi-directional cycle lane on Victoria Street	Victoria Street Cycle Lane	No – too detailed for model
5	EATF Team	Bi-directional /uni-directional on Lewins Mead and uni-directional on Stokes Croft	Lewins Mead and Stokes Croft	No – incorporated in Ref No. 6
6	EATF Team	Removal of general traffic lane on Lewins Mead / Haymarket – from Christmas Street junction to St James Barton roundabout	Lewins Mead / Haymarket	Yes
7	EATF Team	Footway widening and uni directional cycle lane	Clifton Triangle	No – too detailed for model
8	EATF Team	Pavement widening at pinch points	Bedminster Parade	No – too small for model
9	EATF Team	Pavement widening at pinch points. Potential closure being progressed	St Marks Rd	No – too detailed for model
10	EATF Team	Cycle route (using space claimed by temporary barriers)	North St	No – to detailed for model
11	EATF Team	Closure north of York St roundabout; northern arm of York St / James St roundabout	Mina Rd	No – too uncertain
12	EATF Team	Pedestrian crossing	Merchants Bridge	No -– too small for model
13	EATF Team	Point closure - (road closure).	Grenville Rd / Upton Rd	No - too uncertain
14	EATF Team	Point closure - (road closure).	Rosemary lane in Easton	No - not in model
15	EATF Team	Point closure - (road closure).	Beaufort Rd / Victoria Ave- Beckswith and Avonvale	No - too uncertain
16	EATF Team	Point closure - (road closure).	Woodland Rd	Yes
17	EATF Team	Point closure - (road closure).	Dean Lane, Southville	Yes

Some of the schemes are not suitable for modelling as they are too detailed for inclusion in the SATURN model or deemed too small or uncertain. This has been indicated in the table above.

Five of the road closure schemes are not modelled because the Old City is not included in the model, as the Old City comprises of minor roads used for local access. Although some of these schemes include street closure and reduction in space the impact would be minimal.

4.5 Model Constraints

A growth model has been developed within the Demand Model. This creates highway and public transport future year Reference demand matrices using the production and attraction trip end totals for the new development and a gravity model to distribute these new developments using base year travel costs, then converting to origin and destination format. These new trips are then added to the base year matrices. Three-dimensional matrix balancing to build full Reference case matrices is undertaken, retaining the base year trip length distribution and control to the National Trip End model (NTEM, Tempro V7.2) OD growth for West of England and external zones.

These Reference case matrices are then run through the variable demand model until convergence is achieved within the limits specified by the DfT. Demand responses considered in the model are:

- Trip frequency
- Main model choice (car vs PT)
- Time period choice
- Destination choice
- Sub-mode choice (bus vs rail and car vs P&R).

Hence there is no land use – transport interaction (LUTI) component of the model.

Light and heavy goods vehicle growth is based on forecasts produced by the National Transport Model (NTM) as advised by TAG. Goods vehicles are not subject to change via the demand model.

4.6 Model Travel Costs

This section details the model parameter changes that were implemented in the future year VDM models. In general, these changes were implemented in line with TAG advised parameter change, using the TAG Data Book July 2020 (v1.13.1). The TAG parameter changes were applied relative to a 2021 reference year since the 2021 modelled flows have been checked and corrected to observed data (see Section 8) as agreed with JAQU at a FBC scoping meeting on 16th December 2020. Further details are provided below.

4.6.1 Value of Time

Table 4.2 details the value of time assumptions, which are in 2013 prices.

Table 4-2: Future Year Value of Time by demand segment

Demand Segment	2021	2023	2031
VOT HBW (p/min) - Low Inc	8.09	8.26	9.43
VOT HBW (p/min) - Med Inc	11.96	12.23	13.95
VOT HBW (p/min) - High Inc	17.83	18.22	20.78
VOT OTH (p/min) - Low Inc	10.47	10.70	12.20
VOT OTH (p/min) - Med Inc	12.76	13.04	14.87
VOT OTH (p/min) - High Inc	15.42	15.76	17.98
VOT EMP - Car (p/min)	50.11	51.21	58.40
VOT EMP - Bus (p/min)	30.79	31.46	35.88
VOT EMP - Rail (p/min)	59.18	60.48	68.98

4.6.2 Fuel Costs

Table 4-3: Future Year Value of Time by demand segment

Demand Segment	2021	2023	2031
Fuel cost - Non-work (p/litre)	54.70	53.20	45.62
Fuel cost - Business (p/litre)	43.76	42.56	36.49
Non Fuel Cost Parameter a1 (p/km)	5.20	5.15	4.61
Non Fuel Cost Parameter b1 (p/hr)	143.73	143.73	143.73

4.6.3 Parking Costs

The model contains parking charges in Bristol's Central Parking Zone (CPZ) and the Resident Parking Schemes (RPS).

The CPZ parking charges are included in the base and future year modelling. These charges are assumed to increase only in line with inflation; as a result, modelled values do not change between base and modelled years.

The RPS parking charges are applied in future year modelling to cover schemes implemented since October 2013. An approximate average 'RPS' charge of £1.50 (based on £1 per hour charge with a stay of 3 hours applicable to 50% of car trips) is applied to model zones falling within the boundaries of these RPS's. As with the CPZ, RPS charges are assumed to increase only in line with inflation; as a result, values do not change between 2021 and 2031.

4.6.4 Public Transport Fares

PT fares have been assumed to increase in the future years modelled.

Bus fares have been assumed to increase by 1.72% per year in real terms, based on the change in average fares between 2005 and 2020 of 29.23%, as reported for England in the Department for Transport (DfT) Local Bus Fares Index.

Rail fares have been assumed to increase by 0.88% per year in real terms, based on the change in average fares across all operators between 2004 and 2020 of 15.06%, as reported in the Office of Rail and Road (ORR) Rail Fares Index (January 2020) Statistical Release.

Table 4-4 gives the modelled PT fares.

Table 4-4: Public Transport Fare Assumptions

Fare	2021	2023	2031
Bus fare (p/km)	30.5	31.6	36.2
Rail fare (p/km)	16.9	17.3	18.5

4.7 Matrix Compliance / Fuel Type Splits

The outturn baseline highway model from the variable demand model has 6 user classes: Car Non-business (Low Income), Car Non-business (Medium Income), Car Non-business (High Income), Car Business, LGV and HGV. These have been split into 16 user classes using the following methodology, as per the base year model:

- Split the Car user classes into Car and Taxi user classes;
- Split the HGV user class into HGV and Coach user classes; and
- Split Car, Taxi, LGV, HGV and Coach matrices into compliant and non-compliant using the time period splits.

The fleet projection tool within the EFT version 9.1b has been used to project the euro standard splits, and associated compliance splits, from the 2017 ANPR data to the Baseline year of 2021. The EFT v9.1b is a 'non-standard' EFT update which has been produced for local authorities (LAs) developing NO_2 plans only. This version of EFT contains fleet figures which have resulted from a recent Department for Transport (DfT) project to develop new passenger car fleet projections in light of emerging evidence regarding changes in consumer purchasing behaviour. JAQU's assessment is that the fleet projections in EFT v9.1 represent the best evidence currently available at a national level regarding the future of the fleet. For this reason, JAQU recommends that, v9.1 is used by NO2 plan LAs. Therefore, all testing since the OBC testing has been undertaken using the fuel splits directly from EFT 9.1b as advised by JAQU.

For further details and splits used please refer to FBC-24 ANPR Analysis and Application technical note in Appendix E of the FBC.

5. Option Modelling

5.1 Options

The Small CAZ D option is reported here and includes following:

- Small Area Class D (charging non-compliant cars, buses, coaches, taxis, HGVs and LGVs);
- Fast Track Measures:
  - Closure of Cumberland Road inbound to general traffic; and
  - Holding back traffic to the city centre through the use of existing signals.

A scrappage scheme was previously modelled. A revised financial assistance scheme is currently being considered however any financial assistance would be considered to be mitigation in relation to the above schemes rather than abatement, and hence has not been included in this assessment.

This section of the report outlines the methodology in determining the charge applied, the response rate calculations and the way in which the options have been modelled.

5.2 Primary Behavioural Responses

Figure 5-1 shows Behavioural responses to charging Clean Air Zones' from the JAQU Evidence Package. The results from the stated preference surveys will determine the local proportions for each of the four primary responses for non-compliant cars to the implementation of the CAZ, which will replace the percentages shown for cars in Figure 5-1. An overview of the stated preference surveys are outlined in section 2.3 of this report and the structure, implementation and outcomes of the survey are provided fully in FBC-28 Stated Preference Survey Report.

For non-compliant light goods vehicle, responses for 'vans' from the stated preference surveys were used. For coaches and HGVs, the proportions will be used from 'Table 2 – Behavioural responses to charging Clean Air Zones' within the JAQU Evidence package. Bus and Taxi responses will be based on talks with Bristol City Council and the service providers.

Proportions of non-compliant vehicle trips which react to the zone								
	Petrol Cars	Diesel Cars	Petrol LGVs	Diesel LGVs	RHGVs	AHGVs	Buses	Coaches
Pay charge – Continue into zone	7.1%	7.1%	20.3%	20.3%	8.7%	8.7%	0.0%	15.6%
Avoid Zone – Trips removed, modelled elsewhere	21.4%	21.4%	10.0%	10.0%	4.3%	4.3%	0.0%	0.0%
Cancel journey – trips removed completely	7.1%	7.1%	6.0%	6.0%	4.3%	4.3%	6.4%	12.5%
Upgrade Vehicle – trips replaced with compliant trips	64.3%	64.3%	63.8%	63.8%	82.6%	82.6%	93.6%	71.9%

Note: RHGVs = Rigid HGVs; and AHGVs = Articulated HGVs

Figure 5-1: 'Table 2 - Behavioural responses to charging Clean Air Zones' from JAQU Evidence Package

For a charging CAZ, the primary responses will be modelled using the GBATS4M SATURN highway model with the following methodology:

- Pay Charge – no change to the highway model;

- Avoid Zone (diversion) – a charge is applied to each inbound link to replicate the percentage change of non-compliant cars, LGVs and HGV's within the CAZ;
- Cancel journey / change mode / change destination – modelled by reducing the number of trips made by non-compliant vehicles to/from and within the CAZ area, to replicate the required percentage change from the baseline case; and
- Replace Vehicle – an adjustment to the link flows by extracting select cordon link flows for the non-compliant trips and switching the required proportion of replace vehicles from the non-compliant matrices to the compliant link flows.

Further details of the calculation of the behavioural responses is provided in FBC-26 Bristol Clean Air Plan: Primary Behavioural Response Calculation Methodology in Appendix E of the FBC.

5.3 Secondary Behavioural Responses

5.3.1 Charging CAZ

In addition to the primary behavioural responses, JAQU have made some further assumptions on secondary responses for a charging CAZ for cars which will be adopted in analysis. JAQU's assumptions from paragraph 3.3 of the Evidence Package are as follows:

- The 'upgrade vehicle' response will result in 75% replacing their non-compliant vehicle to a second-hand compliant vehicle;
- 25% will scrap their vehicle and buy a new compliant one of the same fuel type; and
- For those replacing with a second-hand vehicle, 75% will switch from diesel and petrol while the remainder will keep the same fuel type.

5.4 CAZ Response Rates

5.4.1 Upgrade Costs

In order to determine the primary response rates over a range of CAZ charges from the stated preference surveys, an upgrade cost is required for cars. The methodology for determining LGV response rates also requires an estimation of an upgrade cost. The upgrade costs of other vehicle types (HGVs, Taxi, Bus and Coaches) were not used to calculate the primary response rates; rather, the primary response rates for these vehicle types were determined by other information collated. The methodology for calculating the upgrade costs for all vehicle type is discussed fully in FBC-26 Bristol Clean Air Plan: Primary Behavioural Response Calculation Methodology in Appendix E of the FBC and is summarised as follows:

- Cars – The cost of a new car was calculated by determining the most popular car models. A national list was obtained from the SMMT website, which is comparable with the most popular car models identified from the ANPR data. New car prices for Petrol and Diesel models of the list of popular cars were extracted from the Parkers database;
- LGVs and HGVs – The cost of a new LGV, rigid HGV and artic HGV have been calculated from the Publication by Road Haulage Association on the LGV and HGV operating costs, 2018;
- Depreciation Rates – A non-compliant vehicle will not always be replaced with a new compliant vehicle; therefore, depreciation rates were used to calculate the value of vehicles by age. Depreciation rates from the National data inputs for Local Economic Models, provided by JAQU for this project have been used, since no locally derived depreciation values are available at the time the analysis was undertaken; and
- Average upgrade cost by vehicle type – Upgrade costs for each vehicle type and Euro Standard (and fuel type for cars) were calculated using the depreciated vehicle values. To derive an average upgrade cost by vehicle type, the upgrade costs by vehicle type and Euro Standard were weighted by trip frequency. The trip frequency

of each vehicle type was calculated from the ANPR survey data for Bristol, split by Euro standard. It was necessary to also account for 'secondary' behavioural responses within these calculations, as discussed above.

5.4.2 Proposed charge rates

The methodology for determining the proposed charge rates for all vehicle types is discussed fully in FBC-26 Bristol Clean Air Plan: Primary Behavioural Response Calculation Methodology in Appendix E of the FBC and Table 5-1 shows the final proposed charges. The charges were initially set for Cars, taxis and LGVs so that the responses of avoid zone, change mode / cancel journey and replace vehicle combined roughly equated to the combined JAQU CAZ responses. These charges were found to be insufficient to bring about compliance and so testing with higher charges was undertaken. Above a certain level there are diminishing returns to further increases and so the final proposed charges arrived at were at this point. Above a certain level there are diminishing returns to further increases and so the final proposed charges arrived at were at this point. Modelling also suggests that lowering the charges would lead to diminished air quality benefits.

Table 5-1: Bristol CAZ Proposed Charges

Charge Class	Daily Charge
Cars	£9.00
Taxis	£9.00
LGVs	£9.00
HGVs	£100.00
Buses	£100.00
Coaches	£100.00

5.4.3 Calculated Response Rates for Small CAZ D

The methodology for calculating the primary response rates for Small CAZ D is discussed fully in FBC-26 Bristol Clean Air Plan: Primary Behavioural Response Calculation Methodology in Appendix E of the FBC and is summarised as follows:

- Cars – The upgrade cost has been used to determine a range of primary responses for different charge rates using the stated preference survey responses for non-compliant cars from the Small zone area;
- LGVs – The primary response rates are calculated from the stated preference survey responses which were identified as a 'van'. Again, the upgrade cost is used to determine a range of primary responses for different charge rates from the Small zone area;
- HGVs – The primary behavioural responses rates for HGVs were taken from 'Table 2 – Behavioural responses to charging Clean Air Zones' in the Evidence Package, provided by JAQU. These response rates were used in the absence of any local data on HGV behavioural responses;
- Taxis – The taxi response rate is based on Bristol enforcing compliance for Taxis through their licensing agreements with taxi operators;
- Coaches – The initial response rates for coaches were taken from 'Table 2 – Behavioural responses to charging Clean Air Zones' in the Evidence Package, provided by JAQU; and
- Buses – The response rates for buses were determined through discussions between Bristol and bus operators.

An adjustment for foreign vehicles has been applied to the responses rates calculated from the methodology set out above, as foreign vehicles cannot be reliably charged (their details are not captured in the Driver and Vehicle Licensing Agency (DVLA) database in order to determine if the vehicle is compliant and so enforcement can only occur through a manual process with limited powers). The final response rates will assume a 'worst case', i.e. that these vehicles continue to drive within the zone but do not pay the charge. In reality it is unlikely that this will be the case for all foreign vehicles.

Table 5-2 shows the final primary behavioural response rates by vehicle type produced using the methodology set out above and the charge rates in Table 5-1.

Table 5-2: Final Primary Behavioural Response Rates for Small CAZ D

Response	Cars Low Income	Cars Medium Income	Cars High Income	Cars Employers Business	Taxis	LGVs	HGVs	Buses	Coaches
Pay Charge	4.3%	10.4%	5.4%	6.8%	4.1%	15.9%	8.8%	0.0%	17.8%
Avoid Zone	15.6%	19.0%	15.7%	7.7%	0.0%	19.2%	4.3%	0.0%	0.0%
Cancel Journey / Change Mode	39.8%	20.4%	14.2%	30.7%	0.0%	2.6%	4.3%	6.4%	11.4%
Replace Vehicle	40.4%	50.3%	64.6%	54.8%	95.9%	62.2%	82.6%	93.6%	70.8%

5.5 Traffic Management Measures

The identified traffic management measures to improve air quality have been modelled where included within Small CAZ D. This section discusses the methodology used to model these, which are covered by the Fast Track measures.

5.5.1 Cumberland Road

The closure of Cumberland Road inbound to general traffic was modelled within the SATURN highway model and run through the VDM to allow the demand model to determine the traffic response to this physical measure of removing highway capacity.

5.5.2 Holding Back Traffic from City Centre

The modelling of holding back traffic to the city centre was achieved through the use of adjusting existing signal timings to reduce the capacity to that of the baseline flows at each entry point. This restricted the re-routing of trips from Cumberland Road, therefore ensuring overall trips into the city centre remain at the reduced level.

6. HGV Adjustment Factors

Light and heavy goods vehicles were not originally validated using short screenlines and grouped counts in 2013, therefore an additional technical note has been produced to report this. For full details refer to FBC-25 LGV/HGV Validation Report. The key conclusions from this report are as follows:

- LGVs are generally well calibrated/validated on both the short screenline level and an individual link level screenlines and cordons;
- HGVs do not pass the TAG guidance for GEH statistics, but are close for the link flow difference criteria for the short screenlines and pass when each link is looked at individually;
- For both light and heavy goods vehicles, where TAG guidance is not met, the modelled flows are under assigned in some locations, over assigned in others; and
- The middle cordon relates closely to the medium CAZ boundary and the inner cordon relates closely to the small CAZ boundary. The calibration/validation of HGVs for the inner cordon is deemed more important than the middle cordon due the location of the compliance exceedances within Bristol. The HGV fit along the inner cordon is better than the middle cordon.

It was agreed with JAQU that HGV flow adjustments would be made on links with significant differences in modelled flows compared to observed counts, via post-processing. These adjustments would be carried through to future years for both the baseline and options. It should be noted that no HGV adjustment factors were applied to locations identified as critical in the air quality modelling hence there is very little effect on the results.

7. Church Road Adjustment

7.1 Introduction

Air Quality modelling undertaken and reported in AQ3, and appended to the OBC, has identified Church Road as having the highest exceedance of NO_2 for the Hybrid Option (details of this option are provided in the Option Assessment Report). Further investigation of available data has been undertaken for this location due to the high modelled concentrations and since the location is outside the scheme area, to help identify whether specific measures are required for this corridor.

Further analysis of the data at this location has shown that the 2015 base modelling results have overestimated the concentrations recorded at the monitoring site by approximately 25%. Traffic flows in the 2015 base year model were compared against a nearby DfT 2015 AADT estimate which has shown that the modelled flows could be significantly higher.

Traffic flows in the GBATS model were validated at the nearby locations, near to Lawrence Hill station to the west and along the A420 further to the east, but not on the section of Church Road next to St George Park, which is the location reported as having the highest NO_2 level. The GBATS validation at these other locations has been checked and has shown a good fit to the observed data.

Additional analysis was conducted using available count data in order to identify potential reasons for such a discrepancy in traffic flows and to establish the best estimate for AADT at this location.

Full details of this analysis of the data is discussed in the Church Road Traffic Flow Adjustment technical note, shown in Appendix B.

7.2 Adjustment Factors

The adjustment factors identified have been applied to Church Road traffic flows in order to improve the accuracy of the Air Quality modelling for this location. SCOOT data was considered a more reliable estimate of observed flows since it was recorded over a longer period compared to the MCC count data collected by DfT for the duration of one day.

The SCOOT data was available for 2019 and the base year of GBATS model is 2015. To adjust the count data to the same year as the model, factors were derived using the DfT traffic flow estimates on the section of Church Road near St George Park.

Two-way and directional adjustment factors were calculated and are shown in Table 6-1 below. Based on the differences in the comparison by direction, the directional adjustment factors have been applied. Table 6-2 shows the Church Road AADT flows before and after applying these adjustment factors.

Table 6-1: Church Road Adjustment Factors

DfT Expansion Method: AADT				
Location	Church Road (near St George Park)		GBATS Model - SCOOT Data X13160	Adjustment factors
Source Year	SCOOT Data X13160 2015 (est)	GBATS Model 2015	% Diff	
Inbound (WB)	9,260	12,476	35%	0.74
Outbound (EB)	10,502	15,423	47%	0.68
Total	19,762	27,899	41%	0.71

These adjustments have been applied to the Church Road flows from the transport model (between Blackswarth Road and A431 Summerhill Road by St George Park) to create an adjusted dataset for input to the EFT.

Table 6-2: Church Road AADT Flows - Before and After Adjustment

Direction	Church Road	
	Before Adjustment	After Adjustment
Inbound (westbound)	12,581	9,310
Outbound (eastbound)	15,567	10,586

8. Traffic Flow and Speed Adjustments

8.1 Introduction

The T-IRP has raised concerns about the age of the base transport model (reference rows 17 and 20 of the T-IRP review comments). It was agreed with JAQU that rebasing the base model would be a prohibitive task within the timescales prescribed in the direction received on the 20 August 2020 and therefore traffic data collected in October and November 2019 at locations on the network with critical compliance issues will be compared to the 2021 baseline transport model. Any notable differences will be corrected with adjustment factors. This was initially undertaken as a sensitivity test in Spring 2020 and then agreed with JAQU during a FBC scoping meeting on 16th December 2020 that it would be applied in the Core Scenario results for the FBC.

8.2 Traffic Flows

Automatic Traffic Count (ATC) data was collected in November 2019, which was then adjusted as follows to be comparable to the 2021 Baseline model.

- Normalised to October 2019; and
- Adjusted to 2021 using TEMPRO V7.2.

8.3 Traffic Speeds

The Analytical Assurance Statement (AAS) stated that the transport model link speeds would be checked using TrafficMaster data along links with critical compliance issues. Any notable differences will be corrected with adjustment factors, which will made in parallel to the traffic flow adjustments.

TrafficMaster data was extracted for October 2019 along links which have critical compliance issues.

8.4 Critical Link Factors

The three key critical locations for Air Quality are as follows and have been assessed for both flows and speeds:

- Marlborough St (B4051);
- Rupert St (A38); and
- Baldwin St (B4053).

Table 7-1 shows the adjustment factors for these critical links in terms of flows and speeds, which were then applied to the outturn AADT flows and speeds for the Small CAZ D option.

Table 7-1: Adjustment Factors

Critical Link	Traffic Flows		Speeds
	LV Factor	HGV Factor	Factor
Marlborough St (B4051) Northbound	0.56	4.50	0.60
Marlborough St (B4051) Southbound	0.88	2.92	1.19
Rupert St (A38) Westbound	0.77	0.78	0.57
Baldwin St (B4053) Eastbound	0.64	0.46	1.02
Baldwin St (B4053) Westbound	0.85	0.82	0.78

To some extent the factors will balance each other in terms of Air Quality impacts, for example if the traffic count factor decreases flows and the traffic speed factor also decreases speeds and vice versa.

9. Interim Years

The Evidence Package guidance states that projection for all years between the base year and the compliance year should be included, via interpolation methods. This is to show a clear pathway to compliance in the shortest time possible. However, where infrastructure changes are expected to have a significant impact on air quality there may be a need to model additional interim years. In the case of Bristol, the opening of the South Bristol Link road in 2017 is an infrastructure scheme that would fall into this category since it has altered the routing of vehicles in south Bristol.

We have focussed our analysis on the year of implementation (2021) and subsequent years. The 2021 model includes the South Bristol Link Road and hence will include the effects of this scheme on both the traffic and air quality results. Additional modelling of interim years would provide a more detailed understanding of the air quality projections over the next few years but will not assist in identifying the scheme most likely to achieve compliance in the shortest timescales possible. We therefore have not assessed interim years between 2015 and 2021.

10. Assessment Year Plus Ten

JAQU have advised emissions of the baseline and each options assessment (NO_2, particulate matter and CO_2) should also be calculated for 10 years after the year of implementation. This is needed to compare the long-term costs and benefits of options that are equally effective in terms of achieving compliance in the shortest time possible.

To produce traffic flows for the assessment year+10 (2031), a new demand model forecast year of 2031 was used to create baseline 2031 matrices and link flows, which were re-assigned before extracting data for the Air Quality Model. For modelling the Small CAZ D option, the same methodology applies to 2031 as described above for 2021.

Also, 2023 has been modelled as the expected compliance year based on OBC modelling as reported in FBC-19 Air Quality Modelling Report (AQ3) submitted to JAQU in April 2020.

11. Links to Air Quality Model

11.1 Base/Baseline Data Use

Link based data from the base and baseline highway assignment model has been output for Cars, Taxis, LGVs, Coaches and HGVs split by Euro standards compliance and / or fuel type as required into a spreadsheet. The highway model outputs also include buses (not split by compliance) and net speeds by link. Buses are split into compliant / non-compliant during post processing of highway model outputs before being input to the EFT.

The peak hourly flows (AM, IP and PM) have been converted into AADT using global factors derived from local ATC data. Percentages of cars (by fuel type), taxis, LGVs, HGVs (rigid and artic) and buses and coaches have been calculated from the flow data for each link from the highway model.

The disaggregation of the link-based data has been undertaken via post processing before input into the Air Quality model. This has been achieved using the following methodology:

- Buses split using information provided by First Bus, using Euro Standard of vehicle by service, which can then be applied to links;
- Cars and LGVs split by fuel type derived from the ANPR data;
- HGVs split by rigid and artic from the ANPR data;
- Motorcycles excluded due to limited information;
- Two separate EFT's used, split by compliance populated from the transport model; and
- Within each EFT, Euro Standard splits for the assessment year are overwritten with values derived from ANPR data projected to the modelled year.

The base and baseline year splits have been derived from the 2017 ANPR data, adjusted to the assessment years. For full details please refer to FBC-24 ANPR Analysis and Application technical note in Appendix E of the FBC.

11.2 Option Data Use

After the primary behavioural responses were modelled for each option in accordance with the methodology outlined in section 5.2 and the secondary behavioural responses of what type of car the replacement will be option in accordance with the methodology outlined in section 5.3, a similar approach to above for processing the option transport model data was used. There are separate EFT input tables split by compliance and/or banned vehicles containing the required link-based data.

Appendix A. Uncertainty Log

UA	Site Description	Address	Policy Area	Ward	Planning Status	Development Status	Certainty	Hectares	2014 - 2036									
									Office Floor space (sq m)	Office no. jobs	Industry Floor Space (sq m)	Industry no. jobs	Retail Floor space (sq m)	Retail no. jobs	Schools Floor space (sq m)	Schools no. students	Other Floor space (sq m)	Other no. jobs
B&NES		Manvers Street, Bath	Bath	Abbey	Future Allocation	None	RF		9000	750	0	0	0	0	0	0	0	0
B&NES		Avon Street, Bath	Bath	Abbey	Future Allocation	None	RF		18000	1500	0	0	0	0	0	0	0	0
B&NES		South Quays, Bath	Bath	Widcombe	Future Allocation	None	RF		16000	1333	0	0	0	0	0	0	0	0
B&NES		South Quays II, Bath	Bath	Widcombe	Future Allocation	None	RF		17500	1458	0	0	0	0	0	0	0	0
B&NES		Green Park, Bath	Bath	Widcombe	Future Allocation	None	RF		15000	1667	0	0	20000	1000	0	0	0	0
B&NES		Bath City Centre	Bath	Abbey	Future Allocation	None	H		0	0	0	0	0	0	0	0	0	0
B&NES		Bath Press, Bath	Bath	Westmoreland	Future Allocation	None	RF		3000	250	0	0	0	0	0	0	0	0
B&NES		Roseberry Place, Bath	Bath	Westmoreland	Planning Application	None	RF		5000	417	0	0	0	0	0	0	0	0
B&NES		Former MoD Foxhill	Bath	Odd Down	Pre-Planning Application	None	ML		0	0	0	0	0	0	0	200	0	0
B&NES		Somerdale, Keynsham	Keynsham	Keynsham North	Planning Status	Partly under construction	ML		10000	833	0	0	0	0	0	0	0	0
BCC	Extensions to the existing regional Distribution Centre (Use Class B8)	Accolade Park Kings Weston Lane Avonmouth Bristol BS11 9FG	Avonmouth and Bristol Port	Avonmouth	Permitted	Not Started	NC	15.00	0	0	9092	123	0	0	0	0	0	0
BCC		Accolade Park Kings Weston Lane Avonmouth Bristol BS11 9FG	Avonmouth and Bristol Port	Avonmouth	Permitted	Not Started	NC	15.00	0	0	-702	-10	0	0	0	0	0	0
BCC	New industrial buildings associated with outline planning application for redevelopment to provide new office campus, research, development and manufacturing building, new staff facilitie	Airbus UK Golf Course Lane Bristol BS99 7AR	Northern Arc	Southmead	Permitted	Not Started	NC	10.66	0	0	6388	160	0	0	0	0	0	0
BCC	Redevelopment to provide new office campus, research, development and manufacturing building, new staff facilities revised parking and access to A38.	Airbus UK Golf Course Lane Bristol BS99 7AR	Northern Arc	Southmead	Permitted	Not Started	NC	10.66	0	0	0	0	0	0	0	0	0	0
BCC	Residential development of up to 80 dwellings, including the demolition of Lewis House and change of use of Phoenix House to 3 no. 2-bed and 3 no. 1-bed flats. (Major application)	Anderson And Leese Building Brentry Hospital Brentry Lane Bristol BS10 6NB	Northern Arc	Henbury	Permitted	Not Started	NC	2.07	0	0	0	0	0	0	0	0	-900	-9
BCC	Ground floor and 1st floor classroom block extension to existing school,	Ashley Down Primary School Arthur Milton Street Bristol BS7 9JT	Rest of Bristol	Bishopston	Permitted	Under Construction	NC	1.08	0	0	0	0	0	0	2307	210	0	0
BCC	Proposed change of use of the existing hangar from Use Class B2 (General Industrial) to Use Class B8 (Storage or Distribution),	BAE Systems West Way Bristol BS99 7AR	Northern Arc	Southmead	Permitted	Not Started	NC	3.36	0	0	35585	483	0	0	0	0	0	0
BCC		BAE Systems West Way Bristol BS99 7AR	Northern Arc	Southmead	Permitted	Not Started	NC	-3.36	0	0	-35585	-483	0	0	0	0	0	0

UA	Site Description	Address	Policy Area	Ward	Planning Status	Development Status	Certainty	Hectares	2014 - 2036 Office Floor space (sq m)	Office no. jobs	Industry Floor Space (sq m)	Industry no. jobs	Retail Floor space (sq m)	Retail no. jobs	Schools Floor space (sq m)	Schools no. students	Other Floor space (sq m)	Other no. jobs
BCC	Alterations to Unit A including its partial demolition, insertion of mezzanine floor and re-cladding together with the erection of unit for class D2 (gym)	Bath Road Retail Park Bath Road Brislington Bristol BS4 3LP	South Bristol	Brislington West	Permitted	Not Started	NC	1.35	0	0	0	0	1742	78	0	0	1958	18
BCC		Bath Road Retail Park Bath Road Brislington Bristol BS4 3LP	South Bristol	Brislington West	Permitted	Not Started	NC	-1.35	0	0	0	0	-2831	-127	0	0	0	0
BCC	Proposed new teaching block, reception extension	Begbrook Primary School Begbrook Drive Bristol BS16 1HG	Rest of Bristol	Frome Vale	Permitted	Not Started	NC	2.17	0	0	0	0	0	0	804	210	0	0
BCC	Housing with mixed-uses. A proportion of mixed-use development including business use	Blackberry Hill Hospital, Manor Road, Fishponds	Rest of Bristol	Frome Vale	Allocated	Not started	RF	9.11	0	0	0	0	500	22	0	0	0	0
BCC	New pool hall extension to include: 25m pool; learner pool; changing area and ancillary spaces to the rear of the existing academy and a proposed extension of the existing fitness gym.	Bristol Brunel Academy Speedwell Road Bristol BS15 1NU	Rest of Bristol	Hillfields	Permitted	Not Started	NC	1.36	0	0	0	0	0	0	1441	0	0	0
BCC	Demolition of the laundry building, former nurses accommodation, physiotherapy and William Lloyd unit, along with modern accretions to other listed buildings on the site and erection of a range of buildings from two to seven storeys and conversion of the remaining buildings to provide 190 residential units and 2,442 metres square commercial floorspace comprising A1, A2, A3, A4, B1 and D2	Bristol General Hospital Guinea Street Bristol BS1 6SY	Bristol City Centre	Cabot	Permitted	Not Started	NC	1.54	0	0	0	0	1628	73	0	0	814	8
BCC		Bristol General Hospital Guinea Street Bristol BS1 6SY	Bristol City Centre	Cabot	Permitted	Not Started	NC	1.54	0	0	0	0	0	0	0	0	-17911	-169
BCC	Industrial development within Use Classes B2 and B8.	Cabot Park Plots P1, P7B and P8 Poplar Way East Lawrence Weston Bristol	Avonmouth and Bristol Port	Avonmouth	Permitted	Not Started	NC	4.04	0	0	14552	197	0	0	0	0	0	0
BCC	Extension to rear of main hospital building; extension to curtilage former stable block;	Cossham Hospital Lodge Road Bristol BS15 1LF	Rest of Bristol	Hillfields	Permitted	Under Construction	NC	1.62	0	0	0	0	0	0	0	0	1144	11
BCC		Cossham Hospital Lodge Road Bristol BS15 1LF	Rest of Bristol	Hillfields	Permitted	Under Construction	NC	-1.62	0	0	0	0	0	0	0	0	-1509	-14
BCC	Outline application for the demolition of the existing building and redevelopment of the site for 7380 square metres of B1 office use	Diamonite Industrial Park Goodneston Road Bristol BS16 3JX	Rest of Bristol	Hillfields	Permitted	Not Started	NC	1.08	7380	523	0	0	0	0	0	0	0	0

									2014 - 2036									
UA	**Site Description**	**Address**	**Policy Area**	**Ward**	**Planning Status**	**Development Status**	**Certainty**	**Hectares**	**Office Floor space (sq m)**	**Office no. jobs**	**Industry Floor Space (sq m)**	**Industry no. jobs**	**Retail Floor space (sq m)**	**Retail no. jobs**	**Schools Floor space (sq m)**	**Schools no. students**	**Other Floor space (sq m)**	**Other no. jobs**
BCC		Diamonite Industrial Park Goodneston Road Bristol BS16 3JX	Rest of Bristol	Hillfields	Permitted	Not Started	NC	-1.08	-1800	-128	-5900	-148	0	0	0	0	0	0
BCC	Outline planning application for a 10 year masterplan of the campus for the future development of the faculty buildings, amenities and environs.	Faculty Of Art Media And Design University Of The West Of England Bristol Kennel Lodge Road Bristol BS3 2JT	South Bristol	Southville	Permitted	Not Started	NC	2.94	0	0	0	0	0	0	0	0	8453	80
BCC		Faculty Of Art Media And Design University Of The West Of England Bristol Kennel Lodge Road Bristol BS3 2JT	South Bristol	Southville	Permitted	Not Started	NC	-2.94	0	0	0	0	0	0	0	0	-6534	-62
BCC	Reserved Matters for 5,601 sqm employment space	Filwood Park Hengrove Way Bristol	South Bristol	Filwood	Permitted	Not Started	NC	1.97	5601	397	0	0	0	0	0	0	0	0
BCC	Mixed use development, including the creation of a new park, erection of up to 150 no. residential units, 8000 sqm of employment floorspace (Use Class B1/B2)	Filwood Park Hengrove Way Bristol	South Bristol	Filwood	Permitted	Not Started	NC	5.10	1200	85	1200	30	0	0	0	0	0	0
BCC	Re-development to provide a mixed use scheme comprising business (B1), 398 no. residential apartments (C3), retail units (A1), professional services (A2), food and drink uses (A3, A4 & A5), creche (D1), health and leisure club (D2) and a micro brewery (Sui Generis)	Finzel's Reach (former Bristol Brewery) Counterslip Bristol BS1 6BX	Bristol City Centre	Lawrence Hill	Permitted	Not Started	NC	1.79	25963	1839	1587	40	3750	168	0	0	2760	26
BCC	Construction of a transit store of approximately 8500sq.m.	Former BP Site Avonmouth Docks St Andrews Road Avonmouth Bristol BS11 9DQ	Avonmouth and Bristol Port	Avonmouth	Permitted	Not Started	NC	5.40	0	0	8500	101	0	0	0	0	0	0
BCC	Construction of a transit store of approximately 10,130 sq.m.	Former Coal Yard Royal Edward Dock Bristol BS11 9BT	Avonmouth and Bristol Port	Avonmouth	Permitted	Not Started	NC	1.74	0	0	10130	120	0	0	0	0	0	0
BCC	Redevelopment of part of existing industrial site for a Bio-fuel, renewable energy plant	Former Columbian Chemicals (Sevalco) Severn Road Avonmouth Bristol BS11 0YU	Avonmouth and Bristol Port	Avonmouth	Permitted	Not Started	NC	4.30	0	0	2807	70	0	0	0	0	0	0
BCC	Housing, Commercial, Other	Former Diesel Depot / Arena site, Bath Road	Bristol City Centre	Windmill Hill	Allocated	Not started	RF	4.05	6100	432	0	0	4000	179	0	0	26400	249

									2014 - 2036										
UA	**Site Description**	**Address**	**Policy Area**	**Ward**	**Planning Status**	**Development Status**	**Certainty**	**Hectares**	**Office Floor space (sq m)**	**Office no. jobs**	**Industry Floor Space (sq m)**	**Industry no. jobs**	**Retail Floor space (sq m)**	**Retail no. jobs**	**Schools Floor space (sq m)**	**Schools no. students**	**Other Floor space (sq m)**	**Other no. jobs**
BCC	Redevelopment of the site to provide a building comprising 2,650 sq m (gross) of employment floorspace (class B1/B2/B8) and/or class D1 floorspace with associated parking, 41 no. senior living units with ancillary accommodation (Class C2) with associated parking, a 45 bed care home with associated parking, 13 no. houses and 29 no. one and two bedroom flats	Former Parnalls Works corner of Filwood Road and Goodneston Road Fishponds Bristol BS16 3JX	Rest of Bristol	Hillfields	Permitted	Not Started	NC	1.80	1325	94	1325	33	0	0	0	0	380	4
BCC	mixed use development within two buildings (A and B) comprising ground floor commercial use (A1, A2, A3, A4, A5, B1, D1 or D2) with residential units (total 107) and office/studio space (B1) above.	Former Post Office Sorting Depot Cattle Market Road Bristol BS1 1BX	Bristol City Centre	Lawrence Hill	Permitted	Not Started	NC	1.12	12198	864	0	0	1594	71	0	0	797	8
BCC	The construction and operation of a Resource Recovery Centre, including a Material Recycling facility, an Energy-from-Waste and Bottom Ash facility, associated Office Visitor Centre	Former Sevalco Site (North) Severn Road Avonmouth Bristol BS11 0YU	Avonmouth and Bristol Port	Avonmouth	Permitted	Not Started	NC	8.54	0	0	26383	660	0	0	0	0	0	0
BCC	The modernisation of the County Cricket ground to include demolition of existing Mound & Jessop stands & associated toilet blocks, provision of 7500 permanent seats incorporating bar, toilet block facilities & 351 surface car parking spaces, a 147 dwelling apartment building incorporating 111 basement car parking spaces, a 217msq club shop, 150msq of office space	Gloucestershire County Cricket Club Nevil Road Bristol BS7 9EJ	Rest of Bristol	Bishopston	Permitted	Under Construction	NC	4.73	150	11	0	0	467	21	0	0	2000	19
BCC	Removal of four temporary classrooms and replacement with four permanent classrooms and ancillary accommodation.	Henleaze Junior School Park Grove Bristol BS9 4LG	Rest of Bristol	Henleaze	Permitted	Not Started	NC	4.39	0	0	0	0	0	0	0	0	630	6
BCC		Henleaze Junior School Park Grove Bristol BS9 4LG	Rest of Bristol	Henleaze	Permitted	Not Started	NC	-4.39	0	0	0	0	0	0	0	0	-272	-3
BCC	New office development associated with: Demolition of existing factory buildings (use class B1 and B2) and erection of new office building (use class B1)	Imperial Tobacco Ltd Winterstoke Road Bristol BS3 2LJ	South Bristol	Bedminster	Permitted	Under Construction	NC	1.93	9717	688	0	0	0	0	0	0	0	0
BCC		Imperial Tobacco Ltd Winterstoke Road Bristol BS3 2LJ	South Bristol	Bedminster	Permitted	Under Construction	NC	-1.93	0	0	-13670	-342	0	0	0	0	0	0

UA	Site Description	Address	Policy Area	Ward	Planning Status	Development Status	Certainty	Hectares	2014 - 2036									
									Office Floor space (sq m)	Office no. jobs	Industry Floor Space (sq m)	Industry no. jobs	Retail Floor space (sq m)	Retail no. jobs	Schools Floor space (sq m)	Schools no. students	Other Floor space (sq m)	Other no. jobs
BCC	Change of use of part of the building to a nursery; erection of new, rear elevation; construction of an all-weather sports pitch;	Imperial Tobacco Ltd Winterstoke Road Bristol BS3 2LJ	South Bristol	Bedminster	Permitted	Not Started	NC	-1.26	-2785	-197	0	0	0	0	0	0	0	0
BCC	Change of use from a business and conference centre, including a restaurant, function room facilities	Kings Weston House Kings Weston Lane Lawrence Weston Bristol BS11 0UR	Northern Arc	Kingsweston	Permitted	Not Started	NC	1.33	0	0	0	0	0	0	0	0	425	4
BCC	Change of use from a business and conference centre, including a restaurant, function room facilities	Kings Weston House Kings Weston Lane Lawrence Weston Bristol BS11 0UR	Northern Arc	Kingsweston	Permitted	Not Started	NC	-1.33	-425	-30	0	0	0	0	0	0	0	0
BCC	a mixed use development totaling 406 residential apartments, 17 live/work units,	'Lakeshore' (Former Office Block To Wills Factory) Hengrove Way Bristol BS14 0HR	South Bristol	Hartcliffe	Permitted	Not Started	NC	4.67	1611	114	0	0	0	0	0	0	0	0
BCC	Mixed use development comprising residential units, offices, leisure, retail and food and drink uses, education, cultural and crèche facilities,	Land At Canons Marsh (incl. car park & Brandons Yard) Anchor Road City Centre Bristol	Bristol City Centre	Cabot	Permitted	Under Construction	NC	1.39	8632	611	0	0	436	20	0	0	0	0
BCC	Subdivision of existing industrial unit and construction of 3 no. industrial buildings (flexible B1(c), B2 and B8 Use Classes).	Land At Chittening Industrial Estate Bristol BS11 0YB	Avonmouth and Bristol Port	Avonmouth	Permitted	Under Construction	NC	3.75	0	0	14524	363	0	0	0	0	0	0
BCC		Land At Chittening Industrial Estate Bristol BS11 0YB	Avonmouth and Bristol Port	Avonmouth	Permitted	Under Construction	NC	-3.75	0	0	-16722	-418	0	0	0	0	0	0
BCC	Housing, community use and retail	Land at former Lawrence Weston Campus of City of Bristol College, Lawrence Weston	Northern Arc	Kingsweston	Allocated	Not started	RF	2.45	0	0	0	0	1800	81	0	0	1200	11
BCC	industrial redevelopment, comprising B1(b), B1(c) and B8 uses. (Major application)	Land At Rockingham Park Smoke Lane Bristol	Avonmouth and Bristol Port	Avonmouth	Permitted	Not Started	NC	5.99	5945	421	8918	121	0	0	0	0	0	0
BCC	mixed use scheme including residential, retail, office, community workspace, hotel and leisure uses (Classes C1, C2, C3, A1, A2, A3, B1, D1, D2)	Land At Wapping Wharf Wapping Road Bristol	Bristol City Centre	Cabot	Permitted	Not Started	NC	2.68	1350	96	0	0	2096	94	0	0	3048	29
BCC	Outline application for an employment development within Use Classes B1 (Light Industrial), B2 (General Industrial) and B8 (Storage and Distribution)	Land North Of SCA Factory South Side Of Deep Pit Road Bristol	Rest of Bristol	Hillfields	Permitted	Not Started	NC	1.24	3729	264	0	0	0	0	0	0	0	0

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BCC	Outline application for mixed use redevelopment of land to comprise a maximum of 32,442 sq m of floorspace; up to 21,892 sq m residential floorspace (a maximum of 250 separate units); up to 8,400sq m of commercial floorspace (B1 Class); up to 2,000sq m of commercial floorspace (A1, A2, A3, A4 or A5); a doctors surgery of up to 150 sq m (D1);	Land Surrounding Dove Lane St Pauls Bristol	Bristol City Centre	Ashley	Permitted	Not Started	NC	1.72	8400	595	0	0	2000	89	0	0	150	1
BCC	Community use (including school) and housing with business. The site should provide 2,000 to 3,000m² of business and / or community facilities.	Marksbury Road College Site	South Bristol	Windmill Hill	Allocated	Not started	RF	2.34	900	64	0	0	150	7	2900	480	1100	10
BCC	New build and classroon extension	May Park Primary School Coombe Road Bristol BS5 6LE	Rest of Bristol	Eastville	Permitted	Under Construction	NC	2.93	0	0	0	0	0	0	4288	60	0	0
BCC		May Park Primary School Coombe Road Bristol BS5 6LE	Rest of Bristol	Eastville	Permitted	Under Construction	NC	-2.93	0	0	0	0	0	0	-400	0	0	0
BCC	Proposed extension and refurbishment	Millpond Primary School Baptist Street Bristol BS5 0YR	Inner East	Lawrence Hill	Permitted	Under Construction	NC	1.61	0	0	0	0	0	0	103	0	0	0
BCC	Extension to the western elevation of the store	Morrisons 692-716 Fishponds Road Fishponds Bristol BS16 3UE	Rest of Bristol	Frome Vale	Permitted	Not Started	NC	2.57	0	0	0	0	728	33	0	0	0	0
BCC	Refurbishment of wing of secondary school and new build extension to create primary school	Orchard School Filton Road Bristol BS7 0XZ	Northern Arc	Horfield	Permitted	Under Construction	NC	10.98	0	0	0	0	0	0	0	210	240	2
BCC	Outline application for the retention of Endemol buildings, demolition of other existing buildings and erection of new buildings of 2-7 storeys built on top of new undercroft car park to provide employment floor space (B1); Retail floor space (A1, A3 & A4); up to 11 live/work units; and up to 210 residential units (C3); with revised vehicular access off Bath Road. (Major application)	Paintworks Phase III site, Bath Road	South Bristol	Brislington West	Permitted	Not Started	NC	2.40	11060	783	0	0	1280	57	0	0	6674	63
BCC		Paintworks Phase III site, Bath Road	South Bristol	Brislington West	Permitted	Not Started	NC	-2.40	0	0	-10200	-255	0	0	0	0	0	0
BCC	Outline planning application - Erection of Public House.	Plot 1 - Phase 6 Imperial Park South Side Of Main Access Wills Way Bristol	South Bristol	Hartcliffe	Permitted	Not Started	NC	1.08	0	0	0	0	1200	54	0	0	0	0

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BCC	Outline planning application - Erection of business units (Use Class B1	Plot 3 - Phase 6 Imperial Park South Side Wills Way Bristol	South Bristol	Hartcliffe	Permitted	Not Started	NC	1.44	2400	170	0	0	0	0	0	0	0	0
BCC	Proposed Bristol Resource Recovery Centre	Plot M2 (Merebank) Kings Weston Lane Avonmouth Bristol BS11 8AQ	Avonmouth and Bristol Port	Avonmouth	Permitted	Under Construction	NC	7.32	0	0	27524	374	0	0	0	0	0	0
BCC	Redevelopment of the former Rhodia chemical works to provide a chilled distribution unit (Use Class B8) and an ancillary service centre (Use Class B2)	Portside (Former Rhodia Works) St Andrews Road Avonmouth Bristol BS11 9YF	Avonmouth and Bristol Port	Avonmouth	Permitted	Under Construction	NC	17.15	0	0	57195	1430	0	0	0	0	0	0
BCC	Mixed use development comprising 4 hectares of residential development to be built at a minimum density of 30 dwellings per hectare and 0.3 hectares of employment land for class B1 (business) use.	Riverwood International Packaging Ltd Filwood Road Bristol BS16 3SB	Rest of Bristol	Hillfields	Permitted	Not Started	NC	4.36	1500	106	0	0	0	0	0	0	0	0
BCC		Riverwood International Packaging Ltd Filwood Road Bristol BS16 3SB	Rest of Bristol	Hillfields	Permitted	Not Started	NC	-4.36	0	0	-26577	-361	0	0	0	0	0	0
BCC	mixed use comprising around 145 residential units (Use Class C3), around 5000sqm of employment floorspace (Use Classes B1(b) (c), B8) and around 600 sqm of retail floorspace (Use Classes A1/A2/A3).	Sainsburys Winterstoke Road Bristol BS3 2NS	South Bristol	Bedminster	Permitted	Not Started	NC	4.05	2500	177	2500	48	8367	374	0	0	0	0
BCC		Sainsburys Winterstoke Road Bristol BS3 2NS	South Bristol	Bedminster	Permitted	Not Started	NC	-4.05	0	0	0	0	-8367	-374	0	0	0	0
BCC	Erection of a steel clad portal framed building.	Sims Metal Royal Edward Dock Bristol BS11 9BT	Avonmouth and Bristol Port	Avonmouth	Permitted	Not Started	NC	1.30	0	0	945	13	0	0	0	0	0	0
BCC	Construct a single storey social centre.	Southmead Community Sport Pen Park Sports Pavilion Jarratts Road Bristol BS10 6WF	Northern Arc	Southmead	Permitted	Not Started	NC	5.91	0	0	0	0	0	0	0	0	360	3
BCC	construct the new acute North Bristol and Community hospital	Southmead Hospital Southmead Road Bristol BS10 5NB	Northern Arc	Horfield	Permitted	Under Construction	NC	18.40	0	0	0	0	0	0	0	0	145515	1374
BCC		Southmead Hospital Southmead Road Bristol BS10 5NB	Northern Arc	Horfield	Permitted	Under Construction	NC	-18.40	0	0	0	0	0	0	0	0	-70452	-665
BCC	Housing with mixed-uses	St Matthias Campus, College Road, Fishponds.	Rest of Bristol	Frome Vale	Allocated	Not started	RF	5.62	0	0	0	0	0	0	0	0	927	9
BCC		St Matthias Campus, College Road, Fishponds.	Rest of Bristol	Frome Vale	Allocated	Not started	RF	-5.62	0	0	0	0	0	0	0	0	-5469	-52
BCC	Proposed single storey extension.	Stax Trade Centre Passage Road Henbury Bristol BS10 7JB	Northern Arc	Henbury	Permitted	Not Started	NC	1.38	0	0	653	16	0	0	0	0	0	0

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BCC	Provide a new 18,000 seated (18,500 Capacity) stadium and ancillary accommodation, hotel (84 rooms), 99 student flats (546 rooms), restaurant, convenience store, offices	The Memorial Stadium Filton Avenue Bristol BS7 0AQ	Rest of Bristol	Bishopston	Permitted	Not Started	NC	3.90	1548	110	0	0	370	17	0	0	12633	119
BCC		The Memorial Stadium Filton Avenue Bristol BS7 0AQ	Rest of Bristol	Bishopston	Permitted	Not Started	NC	-3.90	0	0	0	0	0	0	0	0	-3500	-33
BCC	Redevelopment of land fronting St. Michaels Hill and Tyndalls Avenue to provide academic/educational facilities (Use Class D1)	University Of Bristol Site St Michaels Hill & Tyndall Avenue Bristol BS2 8BH	Bristol City Centre	Cabot	Permitted		NC	1.26	0	0	0	0	0	0	0	0	21163	200
BCC		University Of Bristol Site St Michaels Hill & Tyndall Avenue Bristol BS2 8BH	Bristol City Centre	Cabot	Permitted		NC	-1.26	0	0	0	0	0	0	0	0	-9200	-87
BCC	Employment & Other (hotel)	Bristol and Exeter Yard (TCN) site	Bristol City Centre	Lawrence Hill	Allocated	Not started	RF	1.11	1000	71	0	0	0	0	0	0	3000	71
BCC	Potential Future Development site Avonmouth (Industrial)	Former GKN Aerospace, Atlantic Road	Avonmouth and Bristol Port	Avonmouth	Allocated	Not started	RF	4.86	0	0	29000	394	0	0	0	0	0	0
BCC	Potential Future Development site Avonmouth (Industrial)	Former Texaco Oil Depot	Avonmouth and Bristol Port	Avonmouth	Allocated	Not started	RF	3.73	0	0	22300	303	0	0	0	0	0	0
BCC	Housing with mixed-uses.	Glenside Campus, Blackberry Hill, Fishponds	Rest of Bristol	Frome Vale	Allocated	Not started	RF	6.83	0	0	0	0	500	22	0	0	0	0
BCC	Housing, offices and open space in the form of a large high quality park	Hengrove Park	South Bristol	Hengrove	Allocated	Not started	RF	49.84	30000	2125	0	0	0	0	0	0	0	0
BCC	Community use, open space, business and housing.	Knowle West Health Park, Downton Road	South Bristol	Filwood	Allocated	Not started	RF	4.48	0	0	5200	130	0	0	0	0	0	0
BCC	Housing, Offices	Land and buildings south of Brunel Lock Road, including A-Bond Warehouse	Bristol City Centre	Cabot	Allocated	Not started	RF	3.15	9600	680	0	0	0	0	0	0	0	0
BCC		Land and buildings south of Brunel Lock Road, including A-Bond Warehouse	Bristol City Centre	Cabot	Allocated	Not started	RF	3.15	0	0	-17100	-192	0	0	0	0	0	0
BCC	Housing and light industry	Land at and adjacent to Malago House, Bedminster Road, Bedminster	South Bristol	Bedminster	Allocated	Not started	RF	2.84	0	0	6000	150	0	0	0	0	0	0
BCC	Housing, business, community use and small-scale retail	Land at former Elizabeth Shaw Factory, Greenbank Road, Easton	Inner East	Easton	Allocated	Not started	RF	1.96	0	0	0	0	800	36	700	0	0	0
BCC	Housing and business	Land at Novers Hill, adjacent to industrial units	South Bristol	Filwood	Allocated	Not started	RF	2.18	7200	510	0	0	0	0	0	0	0	0
BCC	Housing and light industry	Morley / Ashley / Southey Street Works, St Werburgh's	Inner East	Ashley	Allocated	Not started	RF	1.61	0	0	4600	115	0	0	0	0	0	0
BCC	Community use (school)	Open Space to rear of Abingdon Road and Honiton Road, Mayfield Park, nr Fishponds	Rest of Bristol	Hillfields	Allocated	Not started	RF	1.59	0	0	0	0	0	0	2900	450	0	0

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BCC	Housing - Business uses	Part of Henacre Open Space, Lawrence Weston	Northern Arc	Avonmouth	Allocated	Not started	RF	3.69	2100	149	0	0	0	0	0	0	0	0
BCC	Employment, residential, other	Plot 6 Temple Quay, The Friary	Bristol City Centre	Lawrence Hill	Allocated	Not started	RF	1.47	4800	340	0	0	1200	54	0	0	600	14
BCC	Housing and business	Site of former City of Bristol College (Hartcliffe Campus), Hawkfield Road, Hartcliffe	South Bristol	Whitchurch Park	Allocated	Not started	RF	8.48	10800	765	0	0	0	0	0	0	0	0
NSC	Erection of 4no two storey office buildings with associated car parking and landscaping.	Plot 6, Servert Road, Gordano Gate, Portishead	Town	Portishead East	Full	Part built - only one block complete, rest not started	NC	1.09	4,400	367	0	0	0	0	0	0	0	0
NSC	Application to extend time limit for 08/P/1914/O (Outline planning application for the erection of an employment development comprising of a B1 office use including demolition of existing premises)	A.P. Burt Paper Mill site, Portishead	Town	Portishead East	Outline	Not Started	NC	1.7	0	0	-9,300	-70	0	0	0	0	0	0
NSC	Application to extend time limit for 08/P/1914/O (Outline planning application for the erection of an employment development comprising of a B1 office use including demolition of existing premises)	A.P. Burt Paper Mill site, Portishead	Town	Portishead East	Outline	Not Started	NC	1.7	8,000	400	0	0	0	0	0	0	0	0
NSC	Outline planning permission for the erection of a new furniture store, petrol filling station and associated parking.	Land off Wyndham Way, Gordano Gate, Portishead	Town	Portishead East	Outline	Not Started	NC	1.43	0	0	0	0	5,190	38	0	0	0	0
NSC	Reserved matters for external appearance, siting, design, means of access and landscaping for the erection of 3 commercial office blocks (B1)	Long Ashton Research Station, Weston Road, Long Ashton	Service Village	Wraxall and Long Ashton	Reserved Matters	Two office blocks complete, one not started	NC	1.16	2,494	208	0	0	0	0	0	0	0	0
NSC	Reserved matters for 66no dwellings with live/work units.	Oxford Plasma Technology, North End Road, Yatton	Service Village	Yatton	Reserved Matters	Not Started	ML	1.46	0	0	-18,288	-270	0	0	0	0	0	0
NSC	Erection of an extension to existing building to create additional warehouse space.	Unit A, Kenn Business Park, Barns Ground, Kenn	Countryside	Yatton	Full	Not Started	NC	1.03	0	0	635	8	0	0	0	0	0	0
NSC	Outline application for B1, B2, B8, C1, A1, A2, A3, A4, A5 development with associated works with all matters reserved for subsequent approval apart from access.	Land north of Somerset Avenue and land off West Wick Roundabout, South Worle, Weston-super-Mare	Town	Weston-super-Mare South Worle	Outline	Two reserved matters application received and building work has commenced.	NC	6.4	6800	360	4200	120	0	0	0	0	850	20
NSC	Erection of (B1) office comprising central core, office floor space, parking and landscaping.	Former Weston Gateway Caravan Park, Land off Somerset Avenue, West Wick, Weston-super-Mare	Town	Weston-super-Mare South Worle	Reserved Matters	Under Construction	NC	0.55	3,719	300	0	0	0	0	0	0	0	0

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NSC	Reserved matters application pursuant to outline application 11/P/0672/O for erection of public house/restaurant	Plot G, Weston Gateway Business Park, Somerset Avenue, Weston-super-Mare	Town	Weston-super-Mare South Worle	Reserved Matters	Not Started	NC	0.5	0	0	0	0	0	0	0	0	796	40
NSC	Erection of 13no. B1(a) and B1(b) office buildings	Land off Wolvershill Road, Summer Lane, West Wick, Weston super Mare	Town	Weston-super-Mare South Worle, Banwell and Winscombe, Kewstoke	Reserved Matters	Not Started	NC	3.48	17,158	1430	0	0	0	0	0	0	0	0
NSC	Application to extend time limit for implemtation of plannning permission 07/P/2156/F (Erection of two storey office (Class B1))	Land off Scot Elm Drive, West Wick Business Park, Weston super Mare	Town	Weston-super-Mare South Worle	Full	Not Started	NC	0.5	676	56	0	0	0	0	0	0	0	0
NSC	Proposed new office development, associated car parking and landscaping	Land at Scot Elm Drive, West Wick, Weston-super-Mare	Town	Weston-super-Mare South Worle	Full	Not Started	NC	2.17	10,951	913	0	0	0	0	0	0	0	0
NSC	Change of use from boarding kennels and cattery to B1/B8 mixed use.	Land at Chelvey Boarding Kennels, Brockley Lane, Brockley	Countryside	Backwell	Full	Not Started	NC	2.2	100	8	630	8	0	0	0	0	0	0
NSC	Outline application the formation of a Business Park and an Industrial Quarter.	Weston Park, Weston Airfield, Winterstoke Road, Weston-super-Mare	Town	Weston-super-Mare East, Hutton and Locking	Outline	Two reserved matters application received and building work has commenced.	NC	29.5	49322	4,110	27500	578	0	0	0	0	9975	250
NSC	Erection of an office building pursuant of Outline Permission 07/P/1950/O	Plot A3, Weston Park, Weston Airfield, Winterstoke Road, Weston-super-Mare	Town	Hutton and Locking, Weston-super-Mare East, Weston-super-Mare South	Full	Under Construction	NC	0.58	2,180	182	0	0	0	0	0	0	0	0
NSC	Reserved Matters for the erection of a public house/restaurant and hotel.	Weston Park, Land at Former Weston Airfield, Off Locking Moor Road, Weston-super-Mare	Town	Weston-super-Mare East	Reserved Matters	Not Started	NC	0.7	0	0	0	0	0	0	0	0	3532	72
NSC	Outline application for the development of a business park comprising B1, B2 and B8	Land to the west of Kenn Road, bound by former railway, the M5 and Colehouse Lane, Kenn	Countryside	Yatton	Outline	Not Started	ML	9.48	Unknown	Unknown	Unknown	Unknown	0	0	0	0	0	0
NSC	Variation of condition 50 of outline permission 05/P/1198/O to read: The new buils B1/Office space shall be limited to a total floorspace of 24,000sqm over a footprint area of 11,000sqm.	Barrow Hospital, Barrow Gurney, Somerset	Countryside	Backwell	Full	Not Started	H	38.3	24,000	2000	0	0	0	0	0	0	0	0
NSC	Erection of foodstore, customer parking, service access and associated development	Land off Serbert Way, Portishead	Town	Portishead East	Full	Under Construction	NC	1.9	0	0	0	0	4,568	270	0	0	0	0

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NSC	Part 1: Full application for the erection of a hotel (C1 hotel use) with restaurant (A3 restaurant and cafe use) and public house (A4 drinking establishment use) and erection of a multi-storey car park with 381 spaces; Part 2: Outline application with all matters except access reserved for subsequent approval for the demolition of existing buildings and replacement with a new multi-use retail and leisure complex comprising a multiplex cinema; a health and fitness suite and bowling centre (D2 assembly and leisure), restaurants (A3 Restaurant and cafe use) and retail units (A1 retail use)	Dolphin Square, Oxford Street, Weston-super-Mare	Town	Weston-super-Mare Central	Full	Not Started	NC		0	0	0	0	10191	536	0	0	4444	111
SGC	Land at Barnhill Quarry	Land at Barnhill Road, Chipping Sodbury	Yate/Chipping Sodbury	Chipping Sodbury	Planning permission	Under construction	NC	3.99	0	0	0	0	1960	160	0	0	0	0
SGC	Land at North Yate	Land north of Brimsham Park, Yate	Yate/Chipping Sodbury	Yate North	Site allocated	Identified within development plan	RF	9	0	0	Not known	2300	0	0	0	0	0	0
SGC	Hollywood Tower Estate	Hollywood Tower Estate, Cribbs Causeway	Elsewhere	Almondsbury	Planning permission	Approved development proposals	NC	54.68	0	0	0	0	0	0	0	0	23694	130
SGC	Hortham Nursery	Hortham Nursery, Hortham Lane, Almondsbury	Elsewhere	Almondsbury	Planning permission	Under construction	NC	2.76	0	0	0	0	0	0	0	0	1686	0
SGC	Alomondsbury Garden Centre	Almondsbury Garden Centre, Over Lane, Almondsbury	Elsewhere	Almondsbury	Planning permission	Approved development proposals	NC	-2.47	0	0	0	0	-3350	0	0	0	0	0
SGC	Alomondsbury Garden Centre	Almondsbury Garden Centre, Over Lane, Almondsbury	Elsewhere	Almondsbury	Planning permission	Approved development proposals	NC	2.47	0	0	0	0	4150	10	0	0	0	0
SGC	Whale Wharf Business Park	Whale Wharf Business Park, Whale Wharf Lane, Littleton upon Severn	Elsewhere	Severn	Planning permission	Approved development proposals	NC	-7.55	0	0	-3460	0	0	0	0	0	0	0
SGC	Whale Wharf Business Park	Whale Wharf Business Park, Whale Wharf Lane, Littleton upon Severn	Elsewhere	Severn	Planning permission	Approved development proposals	NC	7.55	0	0	0	0	0	0	0	0	3460	10
SGC	The Ridings Federation, Winterbourne	The Ridings Federation, High Street, Winterbourne	Elsewhere	Winterbourne	Planning permission	Approved development proposals	NC	-5.3	0	0	0	0	0	0	Not Known	Not Known	0	0
SGC	The Ridings Federation, Winterbourne	The Ridings Federation, High Street, Winterbourne	Elsewhere	Winterbourne	Planning permission	Under construction	NC	5.3	0	0	0	0	0	0	11175	Not Known	0	0
SGC	Oaklands, Almondsbury	Oaklands, Oaklands Lane, Almondsbury	Elsewhere	Almondsbury	Planning permission	Approved development proposals	NC	-4.05	-1383	0	0	0	0	0	0	0	0	0
SGC	Oaklands, Almondsbury	Oaklands, Oaklands Lane, Almondsbury	Elsewhere	Almondsbury	Planning permission	Approved development proposals	NC	4.05	0	0	0	0	0	0	0	0	1383	20

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SGC	Springfield Lake Nursery	Springfield Lake Nursery, Brewery Hill, Upton Cheyney	Elsewhere	Bitton	Planning permission	Approved development proposals	NC	-6.16	0	0	0	0	0	0	0	0	-26078	-20
SGC	Springfield Lake Nursery	Springfield Lake Nursery, Brewery Hill, Upton Cheyney	Elsewhere	Bitton	Planning permission	Approved development proposals	NC	6.16	0	0	0	0	0	0	0	0	30290	20
SGC	Willow Farm	Willow Farm, Severn Road, Severnside	Severnside	Almondsbury	Planning permission	Under construction	NC	4.29	0	0	0	0	0	0	0	0	2205	3
SGC	Portal West Distribution Park	Portal West Distribution Park, Pilning	Severnside	Pilning and Severn Beach	Planning permission	Approved development proposals	NC	25.52	0	0	102080	1276	0	0	0	0	0	0
SGC	Severnside	Land at Severnside	Severnside	Pilning and Severn Beach	Planning permission	Approved development proposals	NC	139	0	0	Not known	10000	0	0	0	0	0	0
SGC	Plot 8020. G Park	Plot 8020, G Park, Western Approach, Severnside	Severnside	Pilning and Severn Beach	Planning permission	Approved development proposals	NC	6.21	0	0	23372	296	0	0	0	0	0	0
SGC	Plots 6030 and 6040, Western Approach	Plots 6030 and 6040, Western Approach, Severnside	Severnside	Pilning and Severn Beach	Planning permission	Approved development proposals	NC	2.64	0	0	9228	119	0	0	0	0	0	0
SGC	Land at Ellinghurst Farm, Pilning	Land at Ellinghurst Farm, Pilning	Severnside	Pilning and Severn Beach	Planning permission	Approved development proposals	NC	11.67	0	0	36166	478	0	0	0	0	0	0
SGC	Land at Severnside Works	Land at Severnside Works, Severn Road, Hallen	Severnside	Pilning and Severn Beach	Planning permission	Approved development proposals	NC	11.8	0	0	0	0	0	0	0	0	15595	55
SGC	Avalon Works	Avalon Works, Severn Road, Hallen	Severnside	Pilning and Severn Beach	Planning permission	Approved development proposals	NC	31.96	0	0	119660	1500	0	0	0	0	0	0
SGC	Plots 900, 950 and 960 Western Sector, Aztec West	Plots 900, 950 and 960, Aztec West, Almondsbury	North Fringe of Bristol	Patchway	Planning permission	Approved development proposals	NC	4.34	25443	1339	0	0	0	0	0	0	0	0
SGC	Land off Catbrain Lane, Cribbs Causeway	Land off Catbrain Lane, Cribbs Causeway	North Fringe of Bristol	Patchway	Lapsed planning permission	Not started	NC	1.14	6180	350	0	0	0	0	0	0	0	0
SGC	UWE	University of the West of England, Stoke Gifford	North Fringe of Bristol	Frenchay and Stoke Park	Planning permission	Approved development proposals	NC	2.58	0	0	0	0	0	0	Not known	Not known	0	0
SGC	Vantage Park	Vantage Park, Old Gloucester Road, Bradley Stoke	North Fringe of Bristol	Bradley Stoke South	Planning permission	Approved development proposals	NC	-1.67	0	0	0	0	0	0	0	0	Not known	-5
SGC	Vantage Park	Vantage Park, Old Gloucester Road, Bradley Stoke	North Fringe of Bristol	Bradley Stoke South	Planning permission	Approved development proposals	NC	1.67	0	0	0	0	0	0	0	0	Not known	10
SGC	Northern part of Filton Airfield	Northfield, Filton	North Fringe of Bristol	Patchway	Planning permission	Approved development proposals	NC	12.95	0	0	64622	3300	0	0	0	0	0	0
SGC	Rodney Works, Filton	Rodney Works, Gloucester Road North, Filton	North Fringe of Bristol	Filton	Planning permission	Approved development proposals	NC	4.02	0	0	20427	0	0	0	0	0	0	0
SGC	1550 Park Avenue, Aztec West	1551 Park Avenue, Aztec West, Almondsbury	North Fringe of Bristol	Patchway	Planning permission	Approved development proposals	NC	-1.32	0	0	-4834	0	0	0	0	0	0	0
SGC	1550 Park Avenue, Aztec West	1552 Park Avenue, Aztec West, Almondsbury	North Fringe of Bristol	Patchway	Planning permission	Approved development proposals	NC	1.32	7636	420	0	0	0	0	0	0	0	0
SGC	Carlton Lodge, Patchway	Carlton Lodge, Gloucester Road, Patchway	North Fringe of Bristol	Patchway	Planning permission	Under construction	NC	1.38	0	0	0	0	0	0	0	0	5970	212
SGC	Land to West of Merlin Road	Land to West of Merlin Road, Cribbs Causeway	North Fringe of Bristol	Patchway	Planning permission	Approved development proposals	NC	5.17	0	0	0	0	0	0	0	0	3600	258
SGC	Rolls Royce East Works	Rolls Royce, Gloucester Road, Filton	North Fringe of Bristol	Filton	Planning permission	Approved development proposals	NC	26.62	0	0	0	0	0	0	0	0	90058	2336

									2014 - 2036									
UA	Site Description	Address	Policy Area	Ward	Planning Status	Development Status	Certainty	Hectares	Office Floor space (sq m)	Office no. jobs	Industry Floor Space (sq m)	Industry no. jobs	Retail Floor space (sq m)	Retail no. jobs	Schools Floor space (sq m)	Schools no. students	Other Floor space (sq m)	Other no. jobs
SGC	Plot 1700 Aztec West	Plot 1700 Aztec West, Almondsbury	North Fringe of Bristol	Patchway	Planning permission	Approved development proposals	NC	-2.17	0	0	-6565	-200	0	0	0	0	0	0
SGC	Plot 1700 Aztec West	Plot 1700 Aztec West, Almondsbury	North Fringe of Bristol	Patchway	Planning permission	Approved development proposals	NC	2.17	15060	610	0	0	0	0	0	0	0	0
SGC	Former Mushroom Farm, Cribbs Causeway	Former Mushroom Farm, Cribbs Causeway, Almondsbury	North Fringe of Bristol	Patchway	Planning permission	Approved development proposals	NC	1.85	0	0	2714	0	0	0	0	0	0	0
SGC	Filton Triangle	Filton Triangle, Stoke Gifford	North Fringe of Bristol	Stoke Gifford	Planning permission	Under construction	NC	17.48	0	0	11216	170	0	0	0	0	0	0
SGC	Abbeywood Retail Park	Abbeywood Retail Park, Station Road, Filton	North Fringe of Bristol	Frenchay and Stoke Park	Planning permission	Under construction	NC	3.63	0	0	0	0	8209	400	0	0	0	0
SGC	CPNN	Cribbs Patchway New Neighbourhood, Filton	North Fringe of Bristol	Filton	Site allocated	Identified within development plan	ML	50	0	0	Not known	6500	0	0	0	0	0	0
SGC	Wallscourt Primary School	Wallscourt Primary School, Longdown Avenue, Filton	North Fringe of Bristol	Frenchay and Stoke Park	Planning permission	Under cosntruction	NC	2.03	0	0	0	0	0	0	2755	410	0	0
SGC	BTE Academy	BTE Academy, New Road, Stoke Gifford	North Fringe of Bristol	Frenchay and Stoke Park	Planning permission	Under cosntruction	NC	1.11	0	0	0	0	0	0	4358	440	0	0
SGC	Land off Longdown Ave, Stoke Gifford	Land off Longdown Ave, Stoke Gifford	North Fringe of Bristol	Frenchay and Stoke Park	Planning permission	Approved development proposals	NC	8.32	0	0	0	0	0	0	0	0	6347	212
SGC	Harlequin Office Park	Harlequin Office Park, Folly Brook Road, Emersons Green	East Fringe of Bristol	Emersons Green	Planning permission	Approved development proposals	NC	1.76	9150	915	0	0	0	0	0	0	0	0
SGC	Emersons Green East, "SPark"	Science Park, Emersons Green	East Fringe of Bristol	Emersons Green/Boyd Valley	Planning permission	Approved development proposals	NC	16.87	0	0	38491	2200	0	0	0	0	0	0
SGC	National Composites Centre, Emersons Green	National Composites Centre, Feynman Way Central, Emersons Green	East Fringe of Bristol	Emersons Green	Planning permission	Approved development proposals	NC	3.92	0	0	9972	100	0	0	0	0	0	0
SGC	Emersons Green Development Area C	Emersons Green East, Emersons Green	East Fringe of Bristol	Emersons Green/Boyd Valley	Site allocated	Identified within development plan	RF	20	0	0	85000	2500	0	0	0	0	0	0
SGC	Emersons Green Safeguarded land	Emersons Green East, Emersons Green	East Fringe of Bristol	Emersons Green/Boyd Valley	Site allocated	Identified within development plan	RF	5	0	0	20400	600	0	0	0	0	0	0
SGC	Bristol Water Depot, Soundwell	Bristol Water Depot, Soundwell Road, Soundwell	East Fringe of Bristol	Kings Chase	Planning permission	Approved development proposals	NC	-1.83	0	0	0	0	0	0	0	0	Not known	-40
SGC	Land between Avon Ring Road and Folly Brook Road, Emersons Green	Land between Avon Ring Road and Folly Brook Road, Emersons Green	East Fringe of Bristol	Emersons Green	Planning permission	Approved development proposals	NC	2.34	0	0	0	0	0	0	0	0	8346	130
SGC	Ansteys Road	Land at Ansteys Road, Hanham	East Fringe of Bristol	Hanham	Planning permission awaiting signing of S106 Agreement	Not started	NC	-3.23	0	0	Not known	Not known	0	0	0	0	0	0
SGC	Ansteys Road	Land at Ansteys Road, Hanham	East Fringe of Bristol	Hanham	Planning permission awaiting signing of S106 Agreement	Not started	NC	3.23	0	0	0	0	2918	200	0	0	0	0

UA	Area	Policy Area	Ward	Planning Status	Dev't Status	Certainty	Dwelling Totals 2013-2036	Dwelling Totals 2013-2021	Dwelling Totals 2022-2026	Dwelling Totals 2027-2031	Dwelling Totals 2032-2036
BCC	Former Courage Brewery Counterslip Redcliff Bristol	City Centre	Lawrence Hill	Permitted	Under Construction	NC	203	203	0	0	0
BCC	Hewlett Packard (Land Adjacent To Romney House) Romney Avenue Bristol BS7 9ST (6B)	Northern Arc	Lockleaze	Permitted	Under Construction	NC	141	141	0	0	0
BCC	Former Imperial Tobacco Office Building Hengrove Way Bristol BS14 0HR	South Bristol	Hartcliffe	Permitted	Under Construction	NC	152	152	0	0	0
BCC	ND10 The Zone Anvil Street Bristol BS2 0LT	City Centre	Lawrence Hill	Permitted	Under construction	NC	109	109	0	0	0
BCC	Land Bounded By Redcliff Street, St Thomas Street And Three Queens Lane, Redcliffe Bristol	City Centre	Lawrence Hill	Permitted	Not started	NC	568	568	0	0	0
BCC	Globe House Eugene Street St Pauls Bristol BS5 0TN	Inner East	Lawrence Hill	Permitted	Not started	NC	51	51	0	0	0
BCC	Pring & St Hill Ltd Malago Road Bristol BS3 4JH	South Bristol	Southville	Permitted	Not started	NC	183	183	0	0	0
BCC	80 Stokes Croft Bristol BS1 3QY	City Centre	Ashley	Permitted	Not started	NC	79	79	0	0	0
BCC	Ashton Vale And Former Alderman Moore Allotments Off Ashton Road (B3128) Bristol	South Bristol	Bedminster	Permitted	Not started	NC	137	137	0	0	0
BCC	Paintworks Bristol BS4 3EH	South Bristol	Brislington West	Permitted	Not started	NC	221	221	0	0	0
BCC	Sainsburys Winterstoke Road Bristol BS3 2NS	South Bristol	Bedminster	Permitted	Not started	NC	145	145	0	0	0
BCC	Former Parnalls Works Filwood Road Bristol BS16 3JX	Rest of Bristol	Hillfields	Permitted	Not started	NC	83	83	0	0	0
BCC	Former Post Office Sorting Depot Cattle Market Road Bristol BS1 1BX	City Centre	Lawrence Hill	Permitted	Not started	NC	107	107	0	0	0
BCC	Plot ND9 Temple Quay 2 Avon Street Bristol	City Centre	Lawrence Hill	Permitted	Not started	NC	173	173	0	0	0
BCC	Huller House/South Warehouse, Redcliff Backs.	City Centre	Lawrence Hill	Permitted	Not started	NC	55	55	0	0	0
BCC	Warehouse Adjacent To Trewlawney House, Surrey Street And Including 31-32 Portland Square St Pauls Bristol	City Centre	Ashley	Permitted	Not started	NC	59	59	0	0	0
BCC	Plot ND6 Temple Quay North Temple Gate Bristol	City Centre	Lawrence Hill	Permitted	Not started	NC	60	60	0	0	0
BCC	Graphic Packaging Ltd Filwood Road Bristol BS16 3SB	Rest of Bristol	Hillfields	Permitted	Not started	NC	208	208	0	0	0
BCC	Playing Field Brook Road Speedwell Bristol	Rest of Bristol	Eastville	Permitted	Not started	NC	80	80	0	0	0
BCC	Riverview House 171 - 178 Coronation Road Bristol BS3 1RF	South Bristol	Southville	Permitted	Not started	NC	78	78	0	0	0
BCC	Land At Canons Marsh Anchor Road Bristol	City Centre	Cabot	Permitted	Under construction	NC	170	170	0	0	0
BCC	Land Surrounding Dove Lane St Pauls Bristol	City Centre	Ashley	Permitted	Not started	NC	250	250	0	0	0
BCC	Anderson And Leese Building Brentry Hospital Brentry Lane Bristol BS10 6NB	Northern Arc	Henbury	Permitted	Not started	NC	80	80	0	0	0
BCC	Gloucestershire County Cricket Club Nevil Road Bristol BS7 9EJ	Rest of Bristol	Bishopston	Permitted	Under construction	NC	147	147	0	0	0
BCC	Wapping Wharf/Princes Wharf, City Docks. (Other Phases)	City Centre	Cabot	Permitted	Not started	NC	431	431	0	0	0
BCC	Land At Wapping Wharf Wapping Road Bristol	City Centre	Cabot	Permitted	Not started	NC	194	194	0	0	0
BCC	Filwood Park Hengrove Way Bristol	South Bristol	Filwood	Permitted	Not started	NC	150	150	0	0	0
BCC	Diamonite Industrial Park Goodneston Road Bristol BS16 3JX	Rest of Bristol	Hillfields	Permitted	Not started	NC	50	50	0	0	0
BCC	Bristol General Hospital Guinea Street Bristol BS1 6SY	City Centre	Cabot	Permitted	Not started	NC	190	190	0	0	0
BCC	The Memorial Stadium Filton Avenue Bristol	Rest of Bristol	Bishopston	Permitted	Not Started	NC	65	65	0	0	0
BCC	8-10 Colston Avenue Bristol BS1 4ST	City Centre	Cabot	Permitted	Not Started	NC	56	56	0	0	0
BCC	Former Bristol Magistrates' Court Nelson Street City Centre Bristol BS1 2PY	City Centre	Cabot	Permitted	Not Started	NC	81	81	0	0	0
BCC	St Stephens House Colston Avenue Bristol	City Centre	Cabot	Permitted	Under Construction	NC	52	52	0	0	0
BCC	13-21 Baldwin Street Bristol BS1 1NA	City Centre	Cabot	Permitted	Not Started	NC	87	87	0	0	0
BCC	10 Anchor Road Bristol BS1 5TT	City Centre	Cabot	Permitted	Not Started	NC	68	68	0	0	0

UA	Area	Policy Area	Ward	Planning Status	Dev't Status	Certainty	Dwelling Totals 2013-2036	Dwelling Totals 2013-2021	Dwelling Totals 2022-2026	Dwelling Totals 2027-2031	Dwelling Totals 2032-2036
BCC	Pro-Cathedral Park Place Clifton Bristol BS8 1JR	City Centre	Clifton East	Permitted	Under Construction	NC	117	117	0	0	0
BCC	Bristol Entertainment Centre Frogmore Street Bristol BS1 5NA	City Centre	Cabot	Permitted	Not Started	NC	84	84	0	0	0
BCC	Henacre Open Space, Lawrence Weston	Northern Arc	Avonmouth	Allocated	Not started	RF	150	0	150	0	0
BCC	Land at Lawrence Weston Campus of City of Bristol College, Lawrence Weston	Northern Arc	Kingsweston	Allocated	Not started	RF	80	80	0	0	0
BCC	Former Dunmail Primary School, Southmead	Northern Arc	Southmead	Allocated	Not started	RF	140	140	0	0	0
BCC	Bonnington Walk former allotments site, Lockleaze	Northern Arc	Lockleaze	Allocated	Not started	RF	170	170	0	0	0
BCC	Romney House and Lockleaze School, Lockleaze	Northern Arc	Lockleaze	Allocated	Not started	RF	250	0	250	0	0
BCC	BT Depot, Filton Road, Horfield	Northern Arc	Horfield	Allocated	Not started	RF	60	0	60	0	0
BCC	Blackberry Hill Hospital, Manor Road, Fishponds	Rest of Bristol	Frome Vale	Allocated	Not started	RF	300	300	0	0	0
BCC	Glenside Campus, Blackberry Hill, Fishponds	Rest of Bristol	Frome Vale	Allocated	Not started	RF	300	0	300	0	0
BCC	St Matthias Campus, College Road, Fishponds	Rest of Bristol	Frome Vale	Allocated	Not started	RF	300	300	0	0	0
BCC	Morley / Ashley / Southey Street Works, St Werburgh's	Inner East	Ashley	Allocated	Not started	RF	100	0	100	0	0
BCC	Former Elizabeth Shaw chocolate factory, Greenbank	Inner East	Easton	Allocated	Not started	RF	236	0	236	0	0
BCC	Land at and adjacent to Malago House Bedminster Road, Bedminster	South Bristol	Bedminster	Allocated	Not started	RF	90	0	90	0	0
BCC	Land at Novers Hill, east of Hartcliffe Way and west of Novers Lane / Novers Hill	South Bristol	Filwood	Allocated	Not started	RF	440	0	440	0	0
BCC	Land adjoining Hartcliffe Way and Hengrove Way, Inn's Court.	South Bristol	Filwood	Allocated	Not started	RF	430	0	430	0	0
BCC	Marksbury Road College Site	South Bristol	Windmill Hill	Allocated	Not started	RF	85	85	0	0	0
BCC	Land adjoining Airport Road between Creswicke Road and to the east of Ilminster Avenue.	South Bristol	Filwood	Allocated	Not started	RF	100	0	100	0	0
BCC	Land at Novers Hill, adjacent to industrial units.	South Bristol	Filwood	Allocated	Not started	RF	50	0	50	0	0
BCC	Former Florence Brown school, west of Leinster Avenue	South Bristol	Filwood	Allocated	Not started	RF	85	0	85	0	0
BCC	Open spaces either side of Inns Court Drive	South Bristol	Filwood	Allocated	Not started	RF	70	0	70	0	0
BCC	Land adjoining Airport Road between Creswicke Road and to the east of Ilminster Avenue.	South Bristol	Knowle	Allocated	Not started	RF	50	0	50	0	0
BCC	Broad Plain House and associated land, Broadbury Road	South Bristol	Filwood	Allocated	Not started	RF	50	0	50	0	0
BCC	Kingswear and Torpoint	South Bristol	Windmill Hill	Allocated	Not started	RF	119	0	119	0	0
BCC	Land at Broom Hill, Brislington	South Bristol	Brislington East	Allocated	Not started	RF	300	300	0	0	0
BCC	Government Offices, Flowers Hill, Brislington	South Bristol	Brislington West	Allocated	Not started	RF	100	0	100	0	0
BCC	493-499 Bath Road, Kensington Park, nr Arno's Vale	South Bristol	Brislington West	Allocated	Not started	RF	85	0	85	0	0
BCC	Site of former City of Bristol College (Hartcliffe Campus), Hawkfield Road, Hartcliffe	South Bristol	Whitchurch Park	Allocated	Not started	RF	300	0	300	0	0
BCC	Hengrove Park	South Bristol	Hengrove	Allocated	Not started	RF	1000	0	1000	0	0
BCC	Former New Fosseway School, Hengrove	South Bristol	Hengrove	Allocated	Not started	RF	175	175	0	0	0
BCC	Newfoundland Way	City Centre	Lawrence Hill	Allocated	Not started	RF	100	0	100	0	0
BCC	Redcliffe Way	City Centre	Lawrence Hill	Allocated	Not started	RF	140	0	140	0	0
BCC	Central Ambulance Station	City Centre	Cabot	Allocated	Not started	RF	100	100	0	0	0
BCC	The Horsefair / Callowhill Court	City Centre	Cabot	Allocated	Not started	RF	200	200	0	0	0
BCC	McArthur's Warehouse, Gasferry Road	City Centre	Cabot	Allocated	Not started	RF	80	0	80	0	0
BCC	Purifier House West, Anchor Road	City Centre	Cabot	Allocated	Not started	RF	50	0	50	0	0
BCC	Land and buildings south of Brunel Lock Road, including A-Bond Warehouse	City Centre	Cabot	Allocated	Not started	RF	100	0	100	0	0
BCC	Fire Station, Temple Back	City Centre	Lawrence Hill	Allocated	Not started	RF	140	0	140	0	0
BCC	Lakota Nightclub / Former Coroner's Court, Upper York Street / Backfields	City Centre	Ashley	Allocated	Not started	RF	60	0	60	0	0

UA	Area	Policy Area	Ward	Planning Status	Dev't Status	Certainty	Dwelling Totals 2013-2036	Dwelling Totals 2013-2021	Dwelling Totals 2022-2026	Dwelling Totals 2027-2031	Dwelling Totals 2032-2036
BCC	The Carriage Works & Westmoreland House	City Centre	Ashley	Allocated	Not started	RF	100	0	100	0	0
BCC	Plot 3 Temple Quay	City Centre	Lawrence Hill	Allocated	Not started	RF	50	50	0	0	0
BCC	Plot ND5 Temple Quay North	City Centre	Lawrence Hill	Allocated	Not started	RF	147	0	147	0	0
BCC	Temple Circus, Temple Street	City Centre	Lawrence Hill	Allocated	Not started	RF	50	0	50	0	0
BCC	Templegate Peugeot	City Centre	Lawrence Hill	Allocated	Not started	RF	60	60	0	0	0
BCC	Plot 6 Temple Quay	City Centre	Lawrence Hill	Allocated	Not started	RF	80	0	80	0	0
BCC	Former Diesel Depot Site	City Centre	Windmill Hill	Allocated	Not started	RF	70	70	0	0	0
BCC	Silverthorne Lane	City Centre	Lawrence Hill	Allocated	Not started	RF	1200	0	1200	0	0
B&NES	BWR: B3, B4, B10, B10a, B10b, B7, B8	Bath	Kingsmead	Full Permission	Under Construction	UC	93	93			
B&NES	BWR: B17	Bath	Westmoreland	Full Permission	Under Construction	NC	55	55			
B&NES	BWR: B1 & B2	Bath	Westmoreland	Full Permission	Under Construction	NC	26	26			
B&NES	BWR: B6, B12	Bath	Westmoreland	Full Permission	Under Construction	NC	38	38			
B&NES	BWR: B11, B13,B15a, B15b	Bath	Westmoreland	Full Permission	Under Construction	NC	259	259			
B&NES	BWR: B10c	Bath	Westmoreland	Full Permission	Under Construction	NC	11	11			
B&NES	BWR: B5	Bath	Westmoreland	Outline Permission	Not Started	NC	45	45			
B&NES	BWR: B16	Bath	Westmoreland	Outline Permission	Not Started	NC	53	53			
B&NES	BWR: OPA.1 Unsecured Land	Bath	Westmoreland	Outline Permission	Not Started	ML	1460	492	605	363	
B&NES	BWR: North Bank	Bath	Kingsmead	Alllocated Site	Not Started	RF	286		286		
B&NES	BWR:East	Bath	Kingsmead	Allocated Site	Not Started	RF	300		300		
B&NES	MoD Ensleigh 1	Bath	Lansdown	Full Permission	Not Started	NC	40		40		
B&NES	MoD Ensleigh 2	Bath	Lansdown	Full Permission	Not Started	NC	240	157	83		
B&NES	MoD Ensleigh 3	Bath	Lansdown	Allocated Site	Not Started	RF	120		120		
B&NES	MoD Foxhill	Bath	Combe Down	Full Application Submitted	Not Started	NC	700	380	320		
B&NES	MoD Warminster Road	Bath	Bathwick	Full Application Submitted	Not Started	NC	150	150			
B&NES	Lambridge Harvester	Bath	Lambridge	Full Permission	Not Started	ML	50	50			
B&NES	R/O 89-123 Englishcombe Lane	Bath	Odd Down	Allocated Site	Not Started	NC	50	50			
B&NES	Hope House	Bath	Lansdown	Full Application Submitted	Not Started	NC	50	50			
B&NES	Brougham Hayes	Bath	Widcombe	Full Permisison	Not Started	NC	50	50			
B&NES	Hartwells Garage	Bath	Newbridge	Application Imminent	Not Started	RF	80	80			
B&NES	Roseberry Place	Bath	Twerton	Application Imminent	Not Started	NC	170	170			
B&NES	Avon Street Car and Coach Park	Bath	Abbey	None	Not Started	RF	120		120		
B&NES	Cattlemrket	Bath	Abbey	None	Not Started	RF	50		50		
B&NES	Manvers Street	Bath	Abbey	None	Not Started	RF	100		100		
B&NES	Royal United Hospital	Bath	Newbridge	None	Not Started	RF	100		100		
B&NES	Bath Press	Bath	Westmoreland	Application Imminent	Not Started	ML	200	200			
B&NES	Twerton Park	Bath	Twerton	None	Not Started	H	150			150	
B&NES	Odd Down/Southstoke	Bath	Bathavon South	Allocated Site	Not Started	NC	300	300			

UA	Area	Policy Area	Ward	Planning Status	Dev't Status	Certainty	Dwelling Totals 2013-2036	Dwelling Totals 2013-2021	Dwelling Totals 2022-2026	Dwelling Totals 2027-2031	Dwelling Totals 2032-2036
B&NES	SW Keynsham 1	Keynsham	Keynsham South	Full Permission	Under Construction	NC	285	285			
B&NES	SW Keynsham 2	Keynsham	Keynsham South	Full Application Submitted	Not Started	NC	266	266			
B&NES	Somerdale	Keynsham	Keynsham North	Part Outline/Part Full Permission	Not Started	NC	700	350	350		
B&NES	Riverside	Keynsham	Keynsham South	None	Not Started	ML	90	90			
B&NES	East of Keynsham	Keynsham	Keynsham East	Allocated Site	Not Started	NC	250	250			
B&NES	East of Keynsham (Safeguarded Green Belt)	Keynsham	Keynsham East	Safegurded Land	Not Started	RF	250		250		
B&NES	SW Keynsham 3	Keynsham	Keynsham South	Allocated Site	Not Started	NC	150	150			
B&NES	Cautletts Close	Somer Valley	MSN Redfield	Full Permission	Under Construction	NC	109	109			
B&NES	Alcan	Somer Valley	Westfield	Full Permission	Under Construction	NC	169	169			
B&NES	Radstock Railway Land	Somer Valley	Radstock	Part Outline/Part Full Permission	Not Started	NC	190	190			
B&NES	Fosseway South	Somer Valley	MSN Redfield	Outline Permission	Not Started	NC	165	165			
B&NES	Monger Lane	Somer Valley	MSN North	Outline Permission	Not Started	NC	135	135			
B&NES	Knobsury Lane	Somer Valley	Radstock	Outline Permission	Not Started	NC	53	53			
B&NES	Paulton House	Somer Valley	Paulton	Prior Approval Change of Use	Not Started	NC	58	58			
B&NES	R/O St Peters Factory	Somer Valley	Westfield	Pre app Submitted	Not Started	NC	90	90			
B&NES	Welton Bibby Baron	Somer Valley	MSN North	Allocated Site	Not Started	RF	150	150			
B&NES	Polestar	Somer Valley	Paulton	Part Outline/Part Full Permission	Under Construction	NC	528	528			
B&NES	Wellow Lane	Somer Valley	Peasedown	Full Permission	Complete	NC	89	89			
B&NES	Greenlands Road	Somer Valley	Peasedown	Outline Permission	Not Started	NC	89	89			
B&NES	Temple Inn Lane	Rural	Temple Cloud	Outline Application Submitted	Not Started	ML	70	70			
SGC	Charlton Hayes, Patchway	North Fringe of Bristol	Patchway	Planning Permission	Site under construction	NC	2067	2067	0	0	0
SGC	Wallscourt Farm, Filton	North Fringe of Bristol	Frenchay and Stoke Park	Planning Permission	Site under construction	NC	283	283	0	0	0
SGC	Sea Stores, Kennedy Way, Yate	Yate/Chipping Sodbury	Yate Central	Planning Permission	Site under construction	NC	53	53	0	0	0
SGC	Coopers Site, Westerleigh Road, Yate	Yate/Chipping Sodbury	Yate Central	Planning Permission	Site under construction	NC	53	53	0	0	0
SGC	Land at Harry Stoke, Stoke Gifford	North Fringe of Bristol	Frenchay and Stoke Park/Stoke Gifford/Winterbourne	Planning Permission	Site under construction	NC	1200	1116	84	0	0
SGC	Hanham Hall Hospital, Whittucks Road, Hanham	East Fringe of Bristol	Hanham	Planning Permission	Site under construction	NC	158	158	0	0	0

UA	Area	Policy Area	Ward	Planning Status	Dev't Status	Certainty	Dwelling Totals 2013-2036	Dwelling Totals 2013-2021	Dwelling Totals 2022-2026	Dwelling Totals 2027-2031	Dwelling Totals 2032-2036
SGC	Emersons Green	East Fringe of Bristol	Boyd Valley/Emersons Green	Planning Permission	Site not started	NC	2300	2300	0	0	0
SGC	Waterworks Site, Soundwell Road, Kingswood	East Fringe of Bristol	Kingschase	Planning Permission	Site not started	NC	75	50	25	0	0
SGC	Kingswood Trading Eatate, Elmtree Way, Kingswood	East Fringe of Bristol	Kingschase	Planning Permission	Site not started	NC	57	57	0	0	0
SGC	The Meads, Frampton Cotterell	Elsewhere	Frampton Cotterell	Planning Permission	Site under construction	NC	27	27	0	0	0
SGC	Mount Pleasant Farm, Longwell Green	East Fringe of Bristol	Longwell Green	Planning Permission	Site not started	NC	70	70	0	0	0
SGC	Land at Barnhill, Chipping Sodbury	Yate/Chipping Sodbury	Chipping Sodbury	Planning Permission	Site not started	NC	170	170	0	0	0
SGC	Land north of Park Farm, Thornbury	Thornbury	Thornbury North	Planning Permission	Site not started	NC	500	500	0	0	0
SGC	North Yate New Neighbourhood	Yate/Chipping Sodbury	Yate North	Planning Permission	Site not started	NC	**3000**	1674	1026	300	0
SGC	Former Coopers Works, Westerleigh Road, Yate	Yate/Chipping Sodbury	Yate Central	Planning Permission	Site under construction	NC	92	92	0	0	0
SGC	Morton Way North, Thornbury	Thornbury	Thornbury North	Planning application submitted	Site not started	NC	300	300	0	0	0
SGC	East of Coldharbour Lane, Stoke Gifford	North Fringe of Bristol	Frencahay and Stoke Park	Site allocated in Local Plan and submission of planning application expected	Site not started	NC	650	650	0	0	0
SGC	South of Douglas Road, Kingswood	East Fringe of Bristol	Woodstock	Planning Permission awaiting signing of S106 Agreement	Site not started	NC	334	334	0	0	0
SGC	Emersons Green	East Fringe of Bristol	Boyd Valley	Site Allocated in Local Plan	Site not started	RF	500	450	50	0	0
SGC	Cribbs Patchway New Neighbourhood	North Fringe of Bristol	Patchway	Site allocated in Core Strategy	Site not started	NC	5700	2996	2704	0	0
SGC	New Neighbourhood, Harry Stoke	North Fringe of Bristol	Winterbourne/Stoke Gifford/Frenchay and Stoke Park	Site allocated in Core Strategy	Site not started	NC	2000	1020	980	0	0
SGC	Frenchay Hospital, Park Road, Frenchay	North Fringe of Bristol	Frecnchay and Stoke Park	Planning application submitted	Site not started	NC	490	490	0	0	0
SGC	Former Intier Site, Bath Road, Bitton	Elsewhere	Bitton	Submission of planning application imminent	Site not started	ML	140	140	0	0	0
SGC	Rodford Primary School, Yate	Yate/Chipping Sodbury	Dodington	Submission of planning application imminent	Site not started	ML	63	63	0	0	0

UA	Area	Policy Area	Ward	Planning Status	Dev't Status	Certainty	Dwelling Totals 2013-2036	Dwelling Totals 2013-2021	Dwelling Totals 2022-2026	Dwelling Totals 2027-2031	Dwelling Totals 2032-2036
SGC	The Heath/Newton House, Cadbury Heath	Elsewhere	Parkwall	Submission of planning application imminent	Site not started	ML	60	60	0	0	0
NSC	Oxford Plasma Technology, North End Road, yatton	Other (Remaining) areas	Yatton	Full Planning consent	Not started	ML	66	66			
NSC	Barrow Hospital	Other (Remaining) areas	Backwell	Outline planning subject to legal	Not started	ML	215	215			
NSC	Block Q, Newfoundland Way, East Quay, Portishead	Portishead	Portishead Central	Full Planning consent	Not started	NC	94	94			
NSC	Block D, Dockside, Portishead	Portishead	Portishead Central	Full Planning consent	Under construction	NC	124	124			
NSC	Block G Dockisde	Portishead	Portishead Central	Full Planning consent	Under construction	NC	110	110			
NSC	East Dock, Dockside	Portishead	Portishead Central	Full Planning consent	Not started	NC	13	13			
NSC	Land at 176 High Street, Portishead	Portishead	Portishead South & North Weston	Full Planning consent	Under construction	NC	58	58			
NSC	Severn Paper Mill, Portishead	Portishead	Portishead East	Outline planning consent	Not started	NC	135	135			
NSC	Weston Gateway Caravan Park, WSM	Weston-super-Mare	Weston-super-Mare South Worle	Full Planning consent	Under construction	NC	193	193			
NSC	Bridge Farm, Bristol Road, WSM	Weston-super-Mare	Weston-super-Mare South Worle	No planning consent - allocated site	Not started	RF	50	50			
NSC	Summer Lane, Locking Castle, WSM	Weston-super-Mare	Weston-super-Mare South Worle	No planning consent - allocated site	Not started	ML	100	100			
NSC	West Wick, Weston-super-Mare	Weston-super-Mare	Weston-super-Mare South Worle	No planning consent - allocated site	Not started	ML	100	100			
NSC	Parts of phases 1&2, areas 1,2,3,4,6,7,8 & 9 Summer Lane Wolvershill Road, West Wick, Locking Castle, Weston super Mare, Somerset	Weston-super-Mare	Weston-super-Mare South Worle	Full Planning consent	Under construction	NC	62	62			
NSC	The Old Sorting Office, Langford Road, Weston-super-Mare	Weston-super-Mare	Weston-super-Mare South	Full Planning consent	Under construction	NC	51	51			
NSC	Former Quadron Depot, Mendip Road, Weston-super-Mare	Weston-super-Mare	Weston-super-Mare East	Full Planning consent	Not started	NC	65	65			
NSC	Parklands Village	Weston-super-Mare	Hutton & Locking / Banwell & Winscombe	Consent for part of site	Under construction	NC	3650	1945	1540	**165**	
NSC	Winterstoke Village	Weston-super-Mare	Weston-super-Mare East	Consent for part of site	Not started	NC	2550	1150	1200	200	

Appendix B. Church Road Traffic Adjustment

TECHNICAL NOTE

Bristol City Council Clean Air Plan – FBC
Church Road Traffic Flow Adjustment

Prepared for: Bristol City Council

Prepared by: Jacobs

Date: April 2020

Project Number: 673846.ER.20

1. Introduction

The purpose of this Technical note is to report findings of investigations into traffic flows on Church Road in Bristol.

2. Context

To meet UK Government regulations, local authorities must demonstrate that they are working towards the National Air Quality Objectives. The objective level for concentrations of NO_2 and PM10 within the UK national legislation are the same as limits set within the European Ambient Air Quality Directive – AAQD (2008/50/EC) (annual mean of 40 µg/m^3) but are applied and assessed differently. Air Quality Objectives only apply where people are exposed for the averaging period of the objective (i.e. for a year) and therefore compliance with air quality objectives is assessed at building facades (where people are regularly present). Compliance with AAQD as transcribed by the Joint Air Quality Unit (JAQU) in order to comply with European air quality reporting protocols stipulate that compliance of Limit Values must be achieved at specific road side locations (i.e. within 4m) where there is public accessibility. This Technical Note will inform the Full Business Case for the delivery of a package of measures which will bring about compliance with the Limit Value for annual mean nitrogen dioxide in the shortest time possible in Bristol.

This Technical Note supports Modelling Methodology T3 report (FBC-23).

3. Overview of issue

Air Quality modelling undertaken and reported in AQ3 and appended to the Full Business Case has identified Church Road at the location shown in Figure 3.1 as having the highest exceedance of NO_2 for the Hybrid Option. Further analysis of the data at this critical location has shown that the 2015 base modelling results have overestimated the concentrations recorded at the monitoring site by approximately 25%.

Traffic flows in the 2015 base year model were compared against a nearby DfT 2015 AADT estimate which has shown that the modelled flows could be significantly higher.

Traffic flows in the GBATS model were validated at the nearby locations, near to Lawrence Hill station to the west and along the A420 further to the east, but not on the section of Church Road next to St George Park, which is the location reported as having the highest NO_2 level. The GBATS validation at these other locations has been checked and has shown a good fit to the observed data.

Additional analysis was conducted using available count data in order to identify potential reasons for such a discrepancy in traffic flows and to establish the best estimate for AADT at this location.

This note summarises the findings from the analysis.

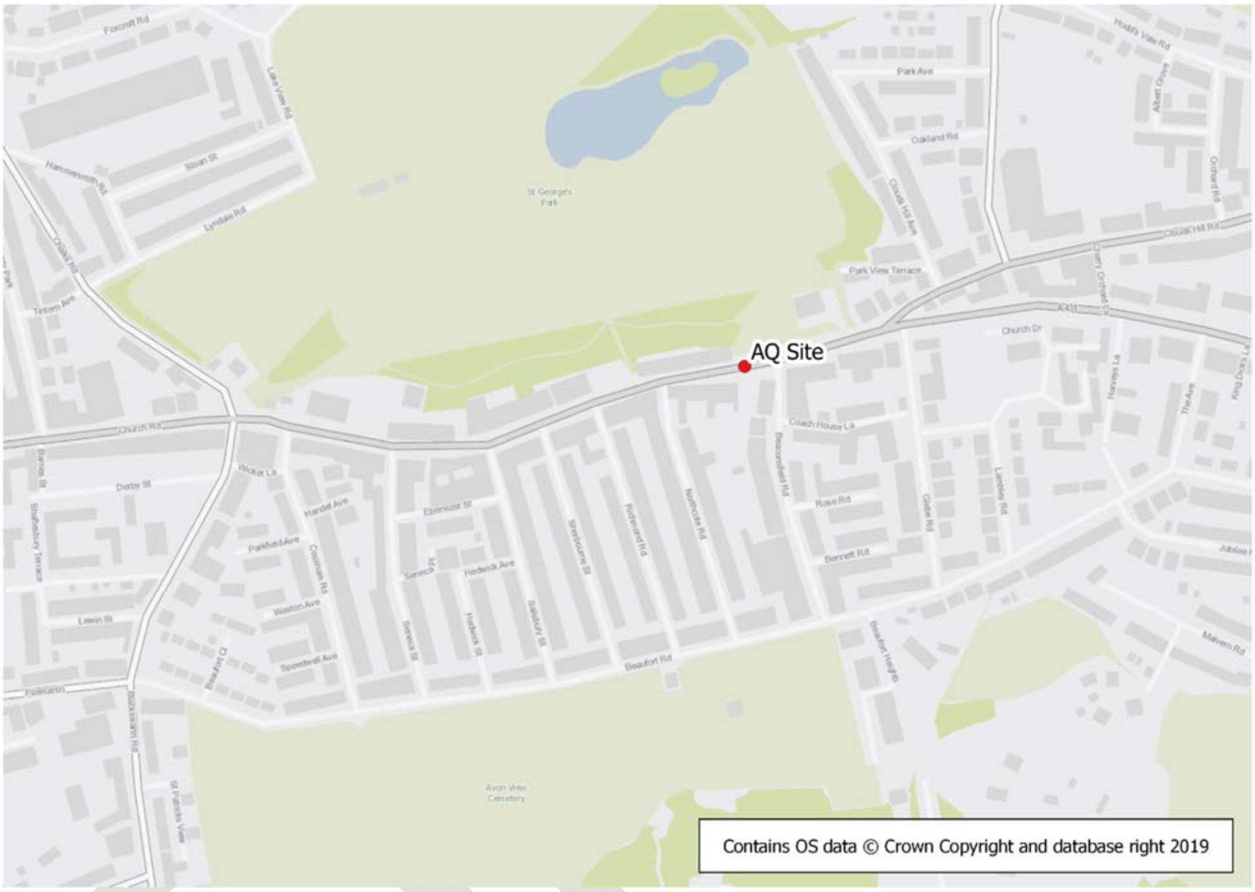

Figure 3.1: Air Quality Monitoring Site

4. Count Data

4.1 Traffic Flow Analysis

The locations of the count sites on Church Road are shown in Figure 4.1. There are two data sources available for the section of Church Road next to St George Park which include the DfT site and data recorded by SCOOT loops at A420 Church Road / A420 Clouds Hill Road / A431 Summerhill Road junction. The summary of the data for the two locations can be found in Table 4.1.

A comparison of the above count data at an hourly level for the modelled peaks is summarised in Table 4.2. As can be seen from the comparison, the DfT data for Eastbound direction is consistently lower throughout the modelled periods compared to the SCOOT data.

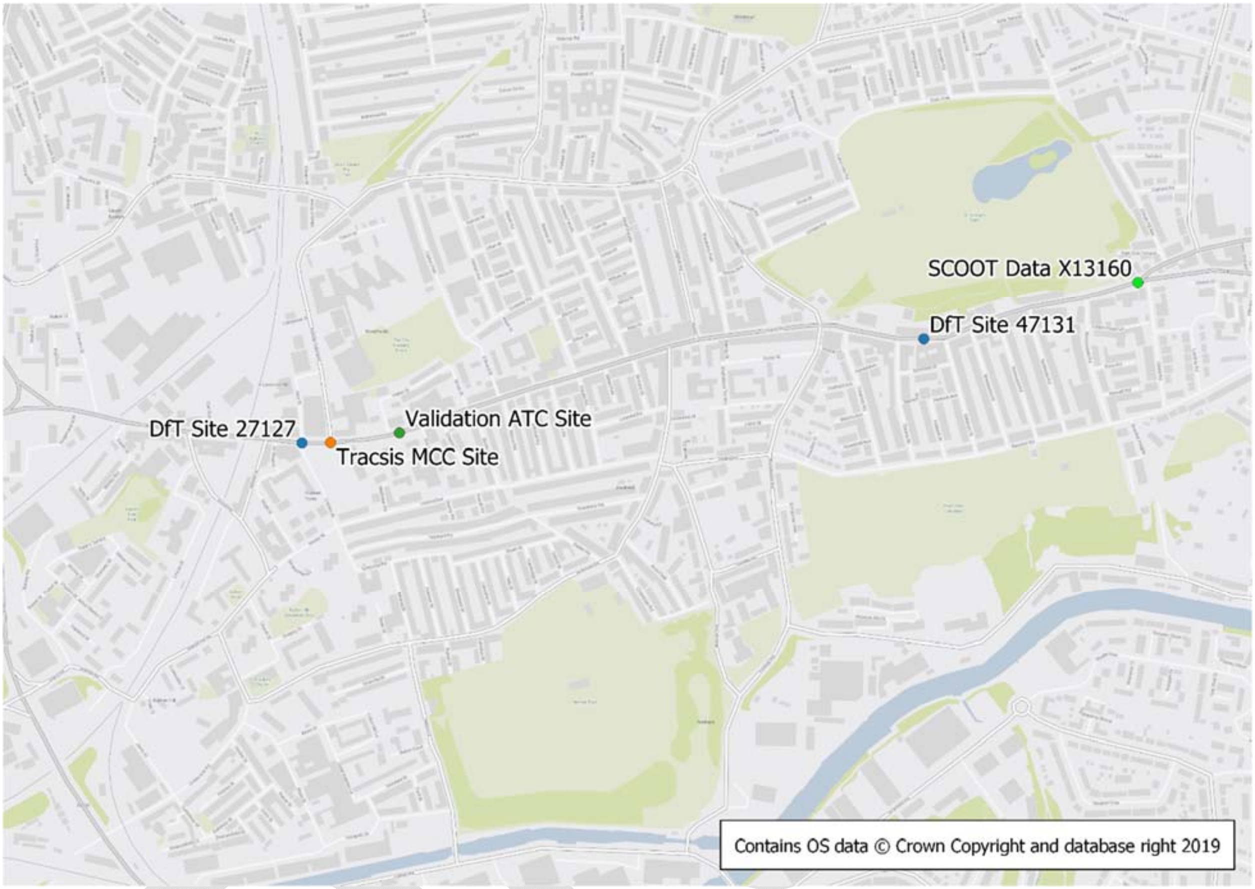

Figure 4.1: Count Site Locations

Table 4.1: Church Road Traffic Count Data (near St George Park)

Source	DfT Site 47131			SCOOT Data X13160		
Location	Church Road (near St George Park)					
Date	MCC (19/06/2017)			SCOOT (30/09/2019-04/11/2019)		
Time Period	AM	IP	PM	AM	IP	PM
Inbound (WB)	758	638	713	681	649	739
Outbound (EB)	596	581	863	687	666	1002
Total	1354	1219	1576	1368	1315	1741

Table 4.2: Comparison of Traffic Count Data (near St George Park)

	DfT Count 47131 - SCOOT Data X13160			
	% Difference			
Time Period	AM	IP	PM	Total
Inbound (WB)	11%	-2%	-4%	2%
Outbound (EB)	-13%	-13%	-14%	-13%
Total	-1%	-7%	-9%	-6%

Since there are only two data sources available for the section of Church Road near St George Park, a similar comparison was done for the section of Church Road next to Lawrence Hill station to see how DfT data compares to other observed data.

The data for the three different count sites at the section of Church Road next to Lawrence Hill station is summarised in Table 4.3Table 4.3. A comparison of data is provided in

Table 4.4. The comparison shows that the DfT site has the lowest traffic flow recorded compared to the other two count sites next to Lawrence Hill Station. The total flow across the 3 modelled peak hours is 28% higher for the GBATS ATC validation count from 2013 while for the turning count undertaken by Tracsis in 2015, is 17% higher.

As the modelled flows were validated to a higher observed traffic volume this could partially explain why the AADT estimate from the model is higher compared to the DfT data on the St George Park section of Church Rd.

Table 4.3: Church Road Traffic Count Data (near Lawrence Hill Station)

Source	DfT Site 27127			Tracsis Site			GBATS Validation Site		
Location	Church Road (near Lawrence Hill Station)								
Date	MCC (14/04/2016)			MCC (13/09/2016)			ATC (19/06/2013 -02/07/2013)		
Time Period	AM	IP	PM	AM	IP	PM	AM	IP	PM
Inbound (WB)	669	710	701	1006	747	748	1312	829	850
Outbound (EB)	607	720	844	635	736	1091	625	754	1078
Total	1276	1430	1545	1641	1483	1839	1937	1583	1928

Table 4.4: Comparison of Traffic Count Data (near Lawrence Hill Station)

	Tracsis Count - DfT Count 27127				GBATS Validation Count - DfT Count 27127			
	% Difference							
Time Period	AM	IP	PM	Total	AM	IP	PM	Total
Inbound (WB)	50%	5%	7%	20%	96%	17%	21%	44%
Outbound (EB)	5%	2%	29%	13%	3%	5%	28%	13%
Total	29%	4%	19%	17%	52%	11%	25%	28%

5. GBATS Assignment Check

GBATS assignments were checked to identify any anomalies in the routing which might have caused an increase in Church Road traffic. Flow diagrams with modelled PCU flows for AM, IP and PM time periods are provided in Figures Figure 5.1 to Figure 5.3.

The diagrams show that a high proportion of traffic routing through the section of Church Road next to St George Park originates from the side roads, including Avonvale Road and Chalks Road. While the volume of traffic joining from Chalks Road looks in line with the expectation, the flow on Avonvale Road looks slightly higher than expected. It is noted that there is a fairly high degree of 'rat-running' on minor residential roads in this area making it challenging to model flows with accuracy in this vicinity. Further, a lack of observed data does not allow for the full analysis of the potential issue.

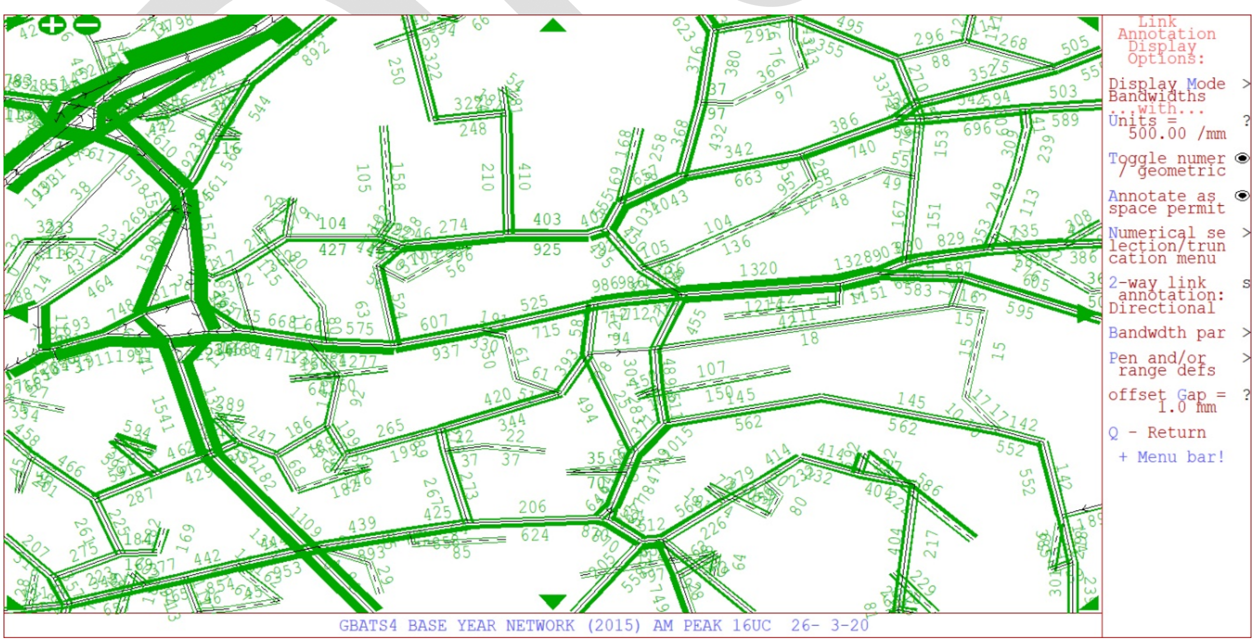

Figure 5.1: GBATS 2015 Base - AM Peak Modelled PCU Flows

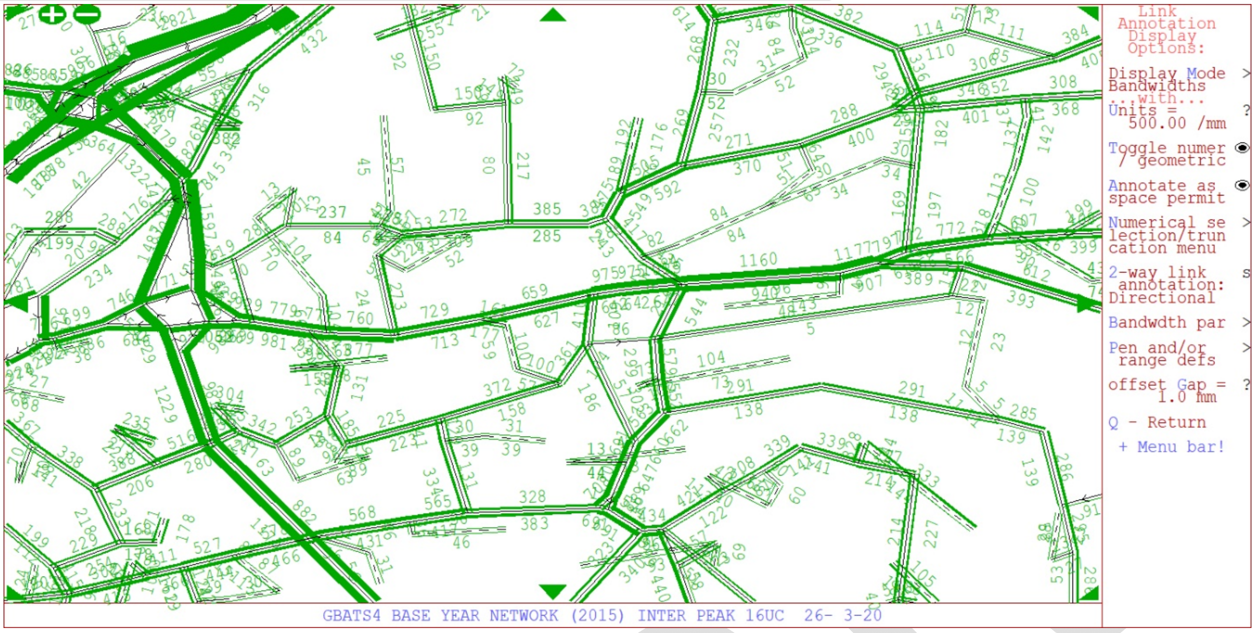

Figure 5.2: GBATS 2015 Base – IP Modelled PCU Flows

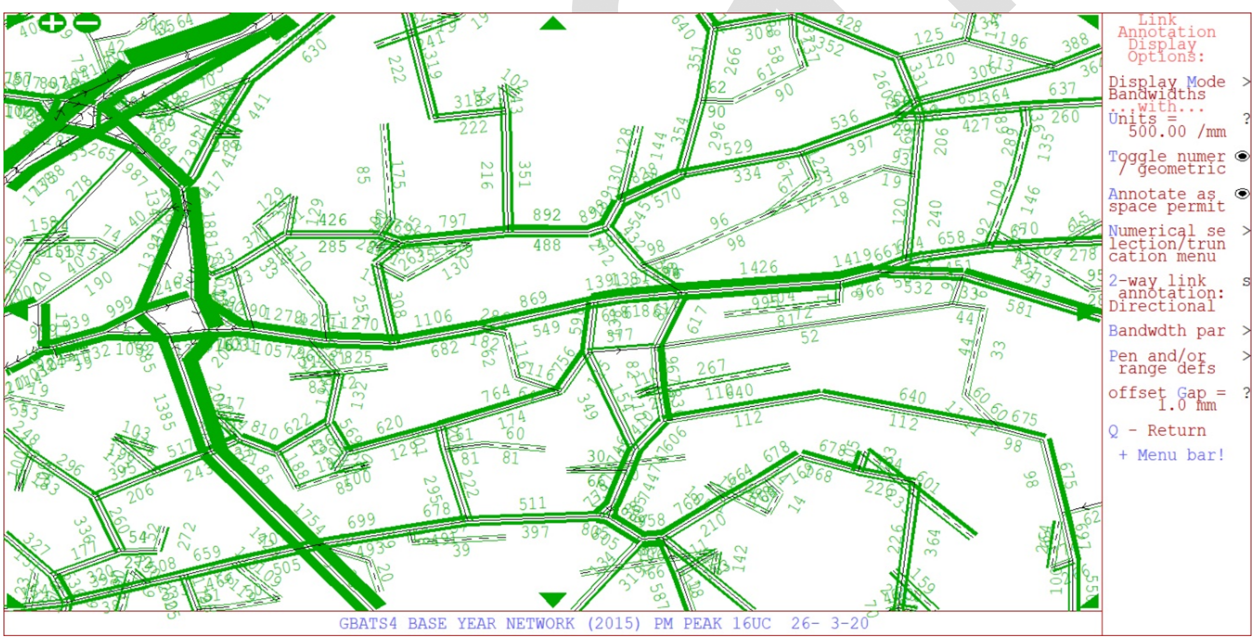

Figure 5.3: GBATS 2015 Base – PM Modelled PCU Flows

6. Adjustment Factors

Following the analysis reported, adjustment factors will be applied to Church Road traffic flows in order to improve the accuracy of the Air Quality modelling for this location for the FBC. SCOOT data was considered a more reliable estimate of observed flows as it was recorded over a longer period than the

MCC data collected by DfT for the duration of one day. Comparison at the section next to Lawrence Hill Station also suggested that the DfT count data was low in relation to other available data sources.

Additional adjustment was required for the SCOOT data to convert it from 2019 to the GBATS modelled base year of 2015. The DfT estimates across different years at the section of Church Road next to St George Park were used to derive the factors to convert the SCOOT data from 2019 to 2015.

Two-way and directional adjustment factors were calculated and are shown in

Table 6.1 below.

Based on the differences in the comparison by direction, it is proposed to use the directional adjustment factors.

Table 6.1: Church Road Adjustment Factors

CAZ Expansion Method: AADT				
Location	Church Road (near St George Park)		GBATS Model - SCOOT Data X13160	Adjustment factors
Source	SCOOT Data X13160	GBATS Model	% Diff	
Year	2015 (est)	2015		
Inbound (WB)	9260	12476	35%	0.74
Outbound (EB)	10502	15423	47%	0.68
Total	19762	27899	41%	0.71

7. Summary

Analysis of the count data available for Church Road was conducted to identify the potential reasons for the discrepancy between the AADT estimates from 2015 base year modelling and DfT data. It has shown that the DfT count recorded a lower traffic volume compared to the ATC for the GBATS validation location on Church Road. This could partially explain the discrepancy between the modelled traffic flows and the DfT estimate.

However, based on the checks of the model assignment it is suggested that there might be a certain extent of overestimation of volumes on the section of Church Road next to St George Park therefore it could be adjusted to better reflect the observed flow.

From the two available data sources SCOOT data was considered a more reliable estimate of the observed flow at the location as it covered a longer period than the DfT data. In addition, the comparison of the count data at the two locations on Church Road suggested that DfT count data might be underestimating the observed flows on Church Road.

Adjustment factors were calculated for both directional and 2-way AADT. Due to the differences by direction it is proposed to use the directional adjustment factors.

These adjustment factors have been applied in the scheme modelling reported in the FBC work.

Appendix C. Future Year Infrastructure and Service Changes

Future Year Infrastructure and Service Changes

Scheme ID	UA(s)	Scheme name	Scheme description	Scheme type	nc/mt/rf/hy - see classification	Opening date
RC-01	BCC	20mph speed limits	Roll out of 20mph speed limits across Bristol	Traffic management	nc	Mar-15
RC-02	SG	CPNN Off-site Works Package	Capacity and safety improvements on Gipsy Patch Lane.	Junction improvement	nc	2015
RC-03	SG	CPNN Off-site Works Package	A38 Filton roundabout. Capacity and safety improvements on 3-arms.	Junction improvement	nc	2015
RC-04	SG	CPNN Off-site Works Package	Widening of M5 J16 motorway off-slips, A38 North and circulatory carriageway.	Junction improvement	nc	2015
RC-05	SG	CPNN Off-site Works Package	SCHEME CHANGE. Signing & lining changes on M5 J17 southbound off-slip. Widening of Merlin Road exit from roundabout and Highwood Lane entry to Merlin Road junction.	Junction improvement	nc	2015
RC-06	SG	CPNN Off-site Works Package	Widening of southbound approach at A38 Aztec West Rbt	Junction improvement	mt	2015
RC-07	BCC	CPNN Off-site Works Package	A4018 Bus Corridor. Crow Lane, Charlton Road, Greystoke Avenue junction improvements	Junction improvement	mt	2015
RC-08	SG	CPNN Off-site Works Package	Local bus service enhancements	Public Transport	mt	2016
RC-09	SG	Cribbs Patchway (Filton Airfield) New Neighbourhood On-site Highways	Network of highway schemes on development site and access junctions onto A4018, A38, Merlin Road, Charlton Rd (bus only).	Highways	mt	Phased 2016-26
RC-10_AVTM	BCC	MetroBus: Ashton Vale to Temple Meads	Rapid transit from Ashton Vale to Temple Meads via Bristol city centre	Major scheme	nc	Jul-15
RC-10_NFTH	BCC/SG	MetroBus: North Fringe to Hengrove Package	North Fringe to Hengrove Package	Major scheme	nc	2017
RC-12	BCC/NSC	MetroBus: South Bristol Link	New highway link and bus route between A370 and Hengrove Park	Major scheme	nc	2016/17
RC-13	BCC	Residents parking	Roll out of residents parking permit scheme across central Bristol		nc	various
RC-14	BCC	Temple Circus Project	Redesign of Temple Circus roundabout		nc	
RC-14	BCC	Temple Circus Project	Related changes to the end of Victoria Street, The Friary, Temple Way, Temple Gate, connection with Redcliffe Way, Bath Bridge Roundabout		nc	
RC-16	BCC	Feeder Road Cycle Route	Creation of a shared use footway and alterations to three junctions: Avon Street (minor) Marsh Lane (minor) Feeder Road (more significant)	Walk & cycle	mt	
RC-18	BCC	New Junction at Cattle Market Road/Feeder Road:	Part of the works to construct a bridge into the Diesel Depot (Arena Site)	Junction improvement	nc	
RC-19	Highways England	Managed Motorway	Sections of M4 (between junctions 19 and 20), and M5 (between junctions 15 and 17) converted to Smart motorway. Smart motorways help relieve congestion Hard shoulder used as a running lane to create additional capacity.	Major scheme	nc	Jan-14
RC-20	SGC	PT for new developments	Addition of additional bus routes serving CPNN.	Public Transport	mt	
RC-21	BCC	PT for new developments		Public Transport	mt	
RC-22	BCC	St James Barton rbt	Improvement works on roundabout		nc	
RC-23	NSC	M5 J21	Outbound scheme and SB off (Weston Package)		nc	
RC-24	SGC	Hambrook Jn scheme	Improvement scheme at junction;		nc	
RC-25	SG	Cribbs Patchway Metrobus Extension	Extending the NFHP Metrobus route from The Mall back to Parkway; selective bus priority along route	Major scheme	mt	
RC-26	Highways England	M5 Junction 19	Replacement of left turn off the south bound exit slip, with a two lanes		nc	
RC-27	Network Rail	London Paddington – South Wales Rail Electrification	Extra services between Bristol Temple Meads and London Paddington via Bristol Parkway included	Major scheme	nc	
RC-28	BCC	Portway P&R Rail Station	Opening of rail station at Portway Park and Ride Site	Public Transport	mt	

Agenda Item 16

Bristol City Council Clean Air Plan

ANPR Data Analysis and Application Report

FBC-24 | 7

February 2021

Bristol City Council

Bristol City Council Clean Air Plan

Document Title: ANPR Data Analysis and Application Report
Document No.: FBC-24
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Date: February 2021
Client Name: Bristol City Council
Client No: Client Reference
Project Manager: HO
Author: KW/JA

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1	31.08.2018	Draft	KW/JG	CB	BL	BL
2	25.01.2019	Draft Report	KW/JG	JB	HO	HO
3	14.10.2019	Draft Report	KW/JG	JB	HO	HO
4	28.10.2019	Draft Report	KW/JG	JB	HO	HO
5	31.03.2020	Draft Report	KW	CB	HO	HO
6	22.01.2021	Draft Report	KW	CB	HO	HO
7	17.02.21	Draft Report	KW	CB	HO	HO

Contents

Acronyms and Abbreviations

AQMA	Air Quality Management Area
AQAP	Air Quality Action Plan
AQO	Air Quality Objective
B&NES	Bath and North East Somerset
BCC	Bristol City Council
CAZ	Clean Air Zone
Defra	Department for Environment, Food & Rural Affairs
DfT	Department for Transport
EU	European Union
EV	Electric Vehicle
HGV	Heavy Goods Vehicle
JAQU	Joint Air Quality Unit
LA	Local Authority
LGV	Light Goods Vehicle
NOx	Nitrogen Oxides
NO_2	Nitrogen Dioxide
SP	Stated Preference

1. Introduction

1.1 Context

Poor air quality is the largest known environmental risk to public health in the UK[1]. Investing in cleaner air and doing more to tackle air pollution are priorities for the EU and UK governments, as well as for Bristol City Council (BCC). The Mayor of Bristol has often cited Bristol's 'moral and legal duty' to improve air quality in the city and the administration recognises that achieving improved air quality is not solely a transport issue. Notwithstanding the Council's work on a Clean Air Zone, efforts have been made to make citizens more aware of – and take personal responsibility for – various sources of air pollution, from traffic fumes to solid fuel burning. The Mayor has articulated a 'call to action' for local people, businesses and organisations to consider how small changes can make a significant difference in cutting toxic fumes across the city. BCC has monitored and endeavoured to address air quality in Bristol for decades and declared its first Air Quality Management Area in 2001. Despite this, Bristol has ongoing exceedances of the legal limits for Nitrogen Dioxide (NO_2) and these are predicted to continue until around 2027 without intervention.

The added context is that of the COVID-19 pandemic. Recent research suggests that poor air quality may be correlated with higher death / infection rates from COVID-19. This is further compounded by growing evidence that suggests that those from black, Asian and minority ethnic communities are more at risk of catching and dying from the virus and the fact that individuals from these communities are more likely to live in areas where air quality is poor. The challenge of maintaining public health and supporting economic recovery while also achieving legal air quality levels after lockdown restrictions are lifted will remain live and intersecting issues for the foreseeable future.

The UK Government continue to transpose European Union law into its Environment Bill[2] , to ensure that certain standards of air quality continue to be met, by setting air quality assessment levels (AQALs) on the concentrations of specific air pollutants. It's very unlikely that these AQALs will differ to EU Limit Values prescribed by the European Union's Air Quality Directive and transcribed in the UK's Air Quality Standards Regulation 2010. Therefore, these Limit Values will remain in enforcement post-Brexit. In common with many EU member states, the EU Limit Value for annual mean nitrogen dioxide (NO_2) is breached in the UK and there are on-going breaches of the NO_2 limit value in Bristol. The UK government is taking steps to remedy this breach in as short a time as possible, with the aim of reducing the harmful impacts on public health. Within this objective, the Government has published a UK Air Quality Plan and a Clean Air Zone Framework, both originally published in 2017 (noting there have been subsequent revisions). The latter document provides the expected approach for local authorities when implementing and operating a Clean Air Zone (CAZ). The following business cases have been submitted to JAQU for the Clean Air Plan; Strategic Outline Case (April 2018), and an Outline Business Case (November 2019 and updated between April and June 2020).

1.2 ANPR Surveys

Permanent Automatic Number Plate Recognition (ANPR) camera data is available in and around Bristol City Centre and data was obtained from Bristol City Council for the duration of six months in 2017 (February – July).

In addition to these sites, Jacobs (then CH2M) commissioned IDC to carry out surveys at an additional 24 sites for the duration of one week between the dates of 18/07/2017 and 24/07/2017.

Figure 1-1 shows the location of both the permanent and commissioned ANPR sites.

The camera locations for additional surveys carried out by IDC have been selected to cover all of the key routes to/from Bristol City Centre for both the Inner and Medium Cordon areas.

[1] Public Health England (2014) Estimating local mortality burdens associated with particular air pollution. https://www.gov.uk/government/publications/estimating-local-mortality-burdens-associated-with-particulate-air-pollution
[2] Environment Bill 2019-21 https://services.parliament.uk/bills/2019-21/environment.html

The surveys capture both directions of traffic in each location. The surveys capture the number plate of each vehicle that passes the camera, along with the date/time and direction of journey. This enabled vehicles to be matched at multiple locations, providing an understanding of the movements across/within the city and how long these journeys take.

The registration data from the ANPR surveys have been cross referenced with data purchased from Carweb to gain information on vehicle type, fuel type and Euro Standard. The information on the vehicle specifications was obtained for June and July in 2017 to compare the July data with equivalent data from June, a neutral month (March through to November, avoiding the Thursday before and all of the week of a bank holiday, and the school holidays).

1.3 ANPR Data Application

The data collected has been used to determine the proportion of compliant vehicles within the current fleet when compared to the CAZ framework criteria.

The vehicles that do not comply with the CAZ standards are as follows:

- Petrol vehicles with emissions standards earlier than Euro 4/IV (approximately registered pre-2006); and
- Diesel vehicles with emissions standards earlier than Euro 6/VI (approximately registered pre-2015).

This information has been applied to the traffic model, by vehicle type, in order to separate out those vehicles which would be affected by CAZ charges and those that would not.

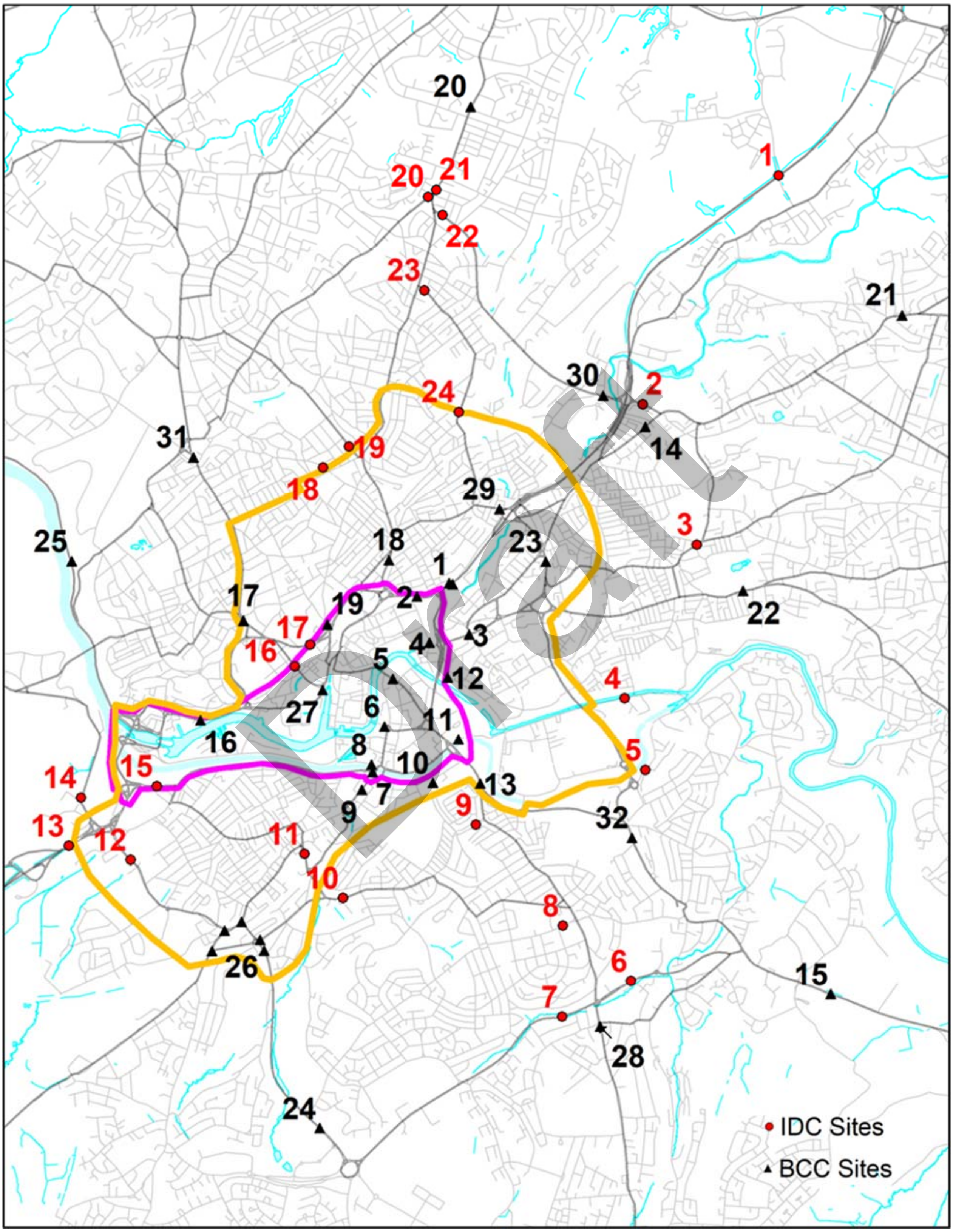
The existing highway model has 6 user classes: Car Non-business (Low Income), Car Non-business (Medium Income), Car Non-business (High Income), Car Business, LGV and HGV. These has been split into 16 user classes using the compliance splits derived from the ANPR data, for each of the modelled years. The matrix compliance splitting processing is as follows:

- Car user classes split into Car and Taxi user classes:
- HGV user class split into HGV and Coach user classes; and
- Car, Taxi, LGV, HGV and Coach matrices split into compliant and non-compliant matrices using the time period splits.

The ANPR data collected has also been used to determine fuel type and HGV type to aid the further splits of the Transport Model link flow data during post-processing (outside the model) to feed into the Air Quality Model.

Also, Euro Standards have been calculated from the ANPR data for compliant and non-compliant vehicles, for each modelled year. These overwrite the national Euro Standards in the Emissions Factor Toolkit (EFT) used as an interface between the Transport Model and the Air Quality Model.

Figure 1-1: ANPR Survey Locations



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2. ANPR Data Analysis

2.1 Compliance Splits

The week in July (18/07/2017 - 24/07/2017) provided a better coverage of the routes to/from Bristol due to the additional surveys undertaken by IDC. However, the 2017 ANPR surveys were undertaken in July 2017 due to the programme pressures of the Feasibility Study at that time.

Data from permanent BCC sites was used to assess whether there is any substantial difference in fleet composition between the neutral month of June and summer month of July. As can be seen in Table 2-1, the comparison has not shown any substantial difference in the compliance splits.

Table 2-1: Compliance Splits by Time Period for BCC sites

Vehicle Category	June 2017						July 2017					
	AM		IP		PM		AM		IP		PM	
	Comp-liant	Non-comp-liant	Comp-liant	Non-comp-liant	Comp-liant	Non-comp-liant	Comp-liant	Non-comp-liant	Comp-liant	Non-comp-liant	Comp-liant	Non-comp-liant
Cars	52%	48%	49%	51%	50%	50%	52%	48%	50%	50%	50%	50%
LGV	10%	90%	11%	89%	10%	90%	11%	89%	12%	88%	10%	90%
HGV rigid	36%	64%	34%	66%	29%	71%	37%	63%	35%	65%	30%	70%
HGV artic	54%	46%	55%	45%	56%	44%	54%	46%	56%	44%	57%	43%
HGV	39%	61%	38%	62%	36%	64%	41%	59%	39%	61%	36%	64%
Taxi	21%	79%	17%	83%	19%	81%	21%	79%	17%	83%	19%	81%
Bus	25%	75%	26%	74%	26%	74%	26%	74%	26%	74%	26%	74%
Coach	27%	73%	28%	72%	33%	67%	28%	72%	29%	71%	35%	65%
Total	42%	58%	40%	60%	44%	56%	43%	57%	41%	59%	44%	56%

Table 2-2 shows the compliance splits calculated across all ANPR sites for the week in July for which the further sites were surveyed.

Table 2-2: Compliance Splits by Time Period for BCC and IDC sites

Vehicle Category	18 July – 25 July 2017 (excluding weekends)					
	AM		IP		PM	
	Compliant	Non-compliant	Compliant	Non-compliant	Compliant	Non-compliant
Cars	52%	48%	50%	50%	50%	50%
LGV	11%	89%	12%	88%	10%	90%
HGV rigid	36%	64%	35%	65%	31%	69%
HGV artic	55%	45%	56%	44%	58%	42%
HGV	40%	60%	39%	61%	38%	62%
Taxi	20%	80%	17%	83%	19%	81%
Bus	24%	76%	24%	76%	24%	76%
Coach	28%	72%	29%	71%	31%	69%
Total	43%	57%	41%	59%	44%	56%

For further calculations the data for the week in July from BCC and IDC sites was used.

The ANPR data has been processed in a number of ways to determine which was the most appropriate method of segmentation to apply the compliance splits to the transport model matrices. The following were assessed:

- By time period and CAZ Cordon (Medium and Inner);
- By time period and travel pattern by CAZ Cordon (Medium and Inner) e.g. trips through or to the Cordon area; and
- By time period and grouped corridors within Bristol.

Figure 2-1 shows the grouping of ANPR sites by corridor for the analysis purposes.

This analysis enabled identification of the relationship between fleet composition and movements through the city, by matching registration number plates between cameras and identifying the vehicle details. The trip frequency was also taken into consideration when calculating the compliance splits. Weightings were allocated to each vehicle record based on how often it was captured by ANPR cameras within the surveyed period.

Tables 2-3 to 2-7 show the processed 2017 data by time period, travel pattern and corridor respectively.

The ANPR data processing has shown that for all vehicle types (with the exception of buses), the compliance splits remain relatively uniform across the corridors and by travel pattern, but they do vary slightly by time period. Therefore, the compliance splits were derived from the time period splits over all areas for the middle cordon.

Table 2-3: Compliance Splits by Time Period – Inner Cordon (2017)

Vehicle Category	Inner Cordon					
	AM		IP		PM	
	Compliant	Non-compliant	Compliant	Non-compliant	Compliant	Non-compliant
Cars	53%	47%	51%	49%	51%	49%
LGV	11%	89%	13%	87%	11%	89%
HGV rigid	38%	62%	35%	65%	29%	71%
HGV artic	54%	46%	57%	43%	54%	46%
HGV	41%	59%	39%	61%	35%	65%
Taxi	20%	80%	16%	84%	19%	81%
Bus	26%	74%	26%	74%	25%	75%
Coach	34%	66%	32%	68%	33%	67%
Total	44%	56%	41%	59%	45%	55%

Table 2-4: Compliance Splits by Time Period – Medium Cordon (2017)

Vehicle Category	Medium Cordon					
	AM		IP		PM	
	Compliant	Non-compliant	Compliant	Non-compliant	Compliant	Non-compliant
Cars	52%	48%	51%	49%	51%	49%
LGV	11%	89%	13%	87%	11%	89%
HGV rigid	37%	63%	35%	65%	29%	71%
HGV artic	55%	45%	57%	43%	54%	46%
HGV	40%	60%	39%	61%	35%	65%
Taxi	20%	80%	16%	84%	19%	81%
Bus	25%	75%	26%	74%	25%	75%
Coach	31%	69%	32%	68%	33%	67%
Total	43%	57%	41%	59%	45%	55%

Figure 2-1: Analysed Corridors

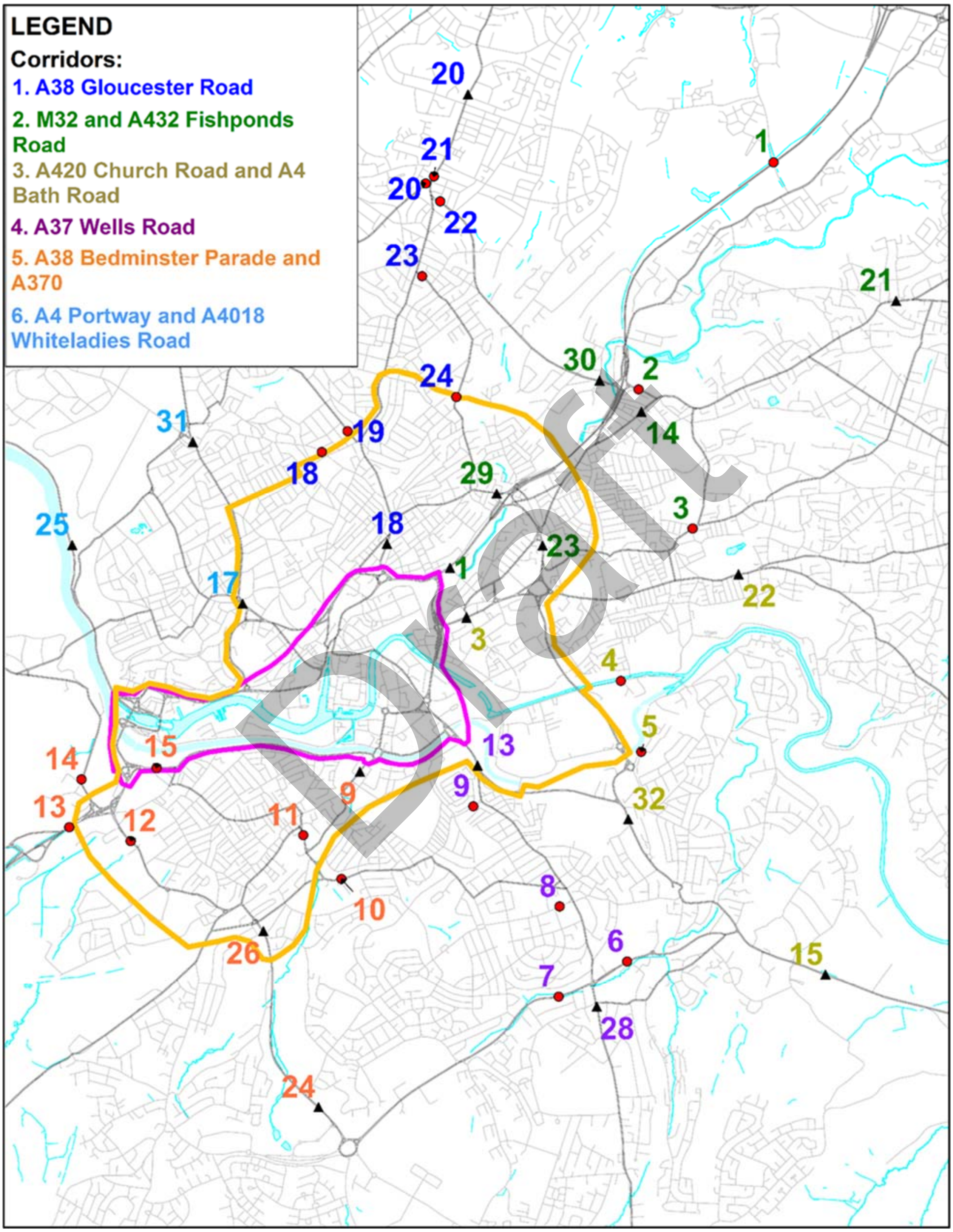

Table 2-5: Compliance Splits by Travel Pattern – Inner Cordon (2017)

Vehicle Category	Inner Cordon Through Trips Proportion						Inner Cordon Non-Through Trips Proportion					
	AM		IP		PM		AM		IP		PM	
	Comp-liant	Non-comp-liant	Comp-liant	Non-comp-liant	Comp-liant	Non-comp-liant	Comp-liant	Non-comp-liant	Comp-liant	Non-comp-liant	Comp-liant	Non-comp-liant
Cars	53%	47%	51%	49%	51%	49%	52%	48%	50%	50%	51%	49%
LGV	12%	88%	14%	86%	11%	89%	11%	89%	12%	88%	10%	90%
HGV rigid	42%	58%	38%	62%	31%	69%	36%	64%	34%	66%	31%	69%
HGV artic	58%	42%	58%	42%	57%	43%	49%	51%	54%	46%	55%	45%
HGV	45%	55%	42%	58%	38%	62%	39%	61%	37%	63%	37%	63%
Taxi	21%	79%	18%	82%	20%	80%	19%	81%	16%	84%	18%	82%
Bus	30%	70%	29%	71%	28%	72%	24%	76%	23%	77%	26%	74%
Coach	42%	58%	38%	62%	38%	62%	29%	71%	27%	73%	32%	68%
Total	43%	57%	41%	59%	44%	56%	44%	56%	41%	59%	44%	56%

Table 2-6: Compliance Splits by Travel Pattern – Medium Cordon (2017)

Vehicle Category	Medium Cordon Through Trips Proportion						Medium Cordon Non-Through Trips Proportion					
	AM		IP		PM		AM		IP		PM	
	Comp-liant	Non-comp-liant	Comp-liant	Non-comp-liant	Comp-liant	Non-comp-liant	Comp-liant	Non-comp-liant	Comp-liant	Non-comp-liant	Comp-liant	Non-comp-liant
Cars	52%	48%	50%	50%	50%	50%	52%	48%	49%	51%	50%	50%
LGV	11%	89%	13%	87%	10%	90%	11%	89%	12%	88%	9%	91%
HGV rigid	41%	59%	37%	63%	34%	66%	35%	65%	34%	66%	32%	68%
HGV artic	60%	40%	58%	42%	60%	40%	53%	47%	56%	44%	58%	42%
HGV	45%	55%	41%	59%	41%	59%	38%	62%	38%	62%	38%	62%
Taxi	21%	79%	19%	81%	20%	80%	20%	80%	17%	83%	18%	82%
Bus	23%	77%	23%	77%	22%	78%	27%	73%	26%	74%	30%	70%
Coach	30%	70%	33%	67%	27%	73%	29%	71%	27%	73%	32%	68%
Total	41%	59%	40%	60%	43%	57%	43%	57%	41%	59%	44%	56%

Table 2-7: Compliance Splits by Corridor (2017)

Vehicle Category	AM											
	1		2		3		4		5		6	
	A38 Goucester Road		M32 and A432 Fishponds Road		A420 Church Road and A4 Bath Road		A37 Wells Road		A38 Bedminster Parade and A370		A4 Portway and A4018 Whiteladies Road	
	Comp-liant	Non-Comp-liant	Comp-liant	Non-Comp-liant	Comp-liant	Non-Comp-liant	Comp-liant	Non-Comp-liant	Comp-liant	Non-Comp-liant	Comp-liant	Non-Comp-liant
Cars	51%	49%	51%	49%	52%	48%	51%	49%	51%	49%	55%	45%
LGV	10%	90%	11%	89%	12%	88%	10%	90%	9%	91%	11%	89%
HGV rigid	29%	71%	34%	66%	36%	64%	36%	64%	37%	63%	40%	60%
HGV artic	48%	52%	58%	42%	59%	41%	56%	44%	49%	51%	58%	42%
HGV	30%	70%	41%	59%	40%	60%	41%	59%	39%	61%	44%	56%
Taxi	21%	79%	23%	77%	18%	82%	18%	82%	21%	79%	19%	81%
Bus	17%	83%	29%	71%	20%	80%	30%	70%	14%	86%	39%	61%
Coach	7%	93%	27%	73%	11%	89%	10%	90%	28%	72%	37%	63%

Table 2-7: Compliance Splits by Corridor (2017)

Total	43%	57%	43%	57%	42%	58%	42%	58%	41%	59%	45%	55%
IP												
Vehicle Category	1		2		3		4		5		6	
	A38 Goucester Road		M32 and A432 Fishponds Road		A420 Church Road and A4 Bath Road		A37 Wells Road		A38 Bedminster Parade and A370		A4 Portway and A4018 Whiteladies Road	
	Comp-liant	Non-Comp-liant	Comp-liant	Non-Comp-liant	Comp-liant	Non-Comp-liant	Comp-liant	Non-Comp-liant	Comp-liant	Non-Comp-liant	Comp-liant	Non-Comp-liant
Cars	49%	51%	49%	51%	50%	50%	50%	50%	49%	51%	53%	47%
LGV	11%	89%	12%	88%	13%	87%	12%	88%	11%	89%	13%	87%
HGV rigid	26%	74%	34%	66%	34%	66%	34%	66%	37%	63%	39%	61%
HGV artic	41%	59%	57%	43%	59%	41%	55%	45%	55%	45%	51%	49%
HGV	27%	73%	40%	60%	38%	62%	40%	60%	40%	60%	42%	58%
Taxi	20%	80%	18%	82%	17%	83%	16%	84%	19%	81%	17%	83%
Bus	18%	82%	31%	69%	21%	79%	28%	72%	13%	87%	36%	64%
Coach	10%	90%	36%	64%	12%	88%	5%	95%	24%	76%	18%	82%
Total	41%	59%	41%	59%	41%	59%	42%	58%	41%	59%	43%	57%
PM												
Vehicle Category	1		2		3		4		5		6	
	A38 Goucester Road		M32 and A432 Fishponds Road		A420 Church Road and A4 Bath Road		A37 Wells Road		A38 Bedminster Parade and A370		A4 Portway and A4018 Whiteladies Road	
	Comp-liant	Non-Comp-liant	Comp-liant	Non-Comp-liant	Comp-liant	Non-Comp-liant	Comp-liant	Non-Comp-liant	Comp-liant	Non-Comp-liant	Comp-liant	Non-Comp-liant
Cars	50%	50%	49%	51%	50%	50%	49%	51%	49%	51%	53%	47%
LGV	8%	92%	11%	89%	11%	89%	9%	91%	9%	91%	11%	89%
HGV rigid	19%	81%	30%	70%	34%	66%	34%	66%	29%	71%	38%	62%
HGV artic	31%	69%	58%	42%	68%	32%	65%	35%	55%	45%	62%	38%
HGV	20%	80%	38%	62%	39%	61%	44%	56%	35%	65%	47%	53%
Taxi	20%	80%	21%	79%	17%	83%	18%	82%	17%	83%	18%	82%
Bus	18%	82%	31%	69%	19%	81%	27%	73%	12%	88%	38%	62%
Coach	7%	93%	31%	69%	17%	83%	10%	90%	29%	71%	35%	65%
Total	45%	55%	44%	56%	44%	56%	43%	57%	42%	58%	47%	53%

2.2 Bus Splits

Bus compliance was split using information provided to Jacobs by First Bus, using Euro Standard of vehicle by service. For the other service providers, the compliance splits from the ANPR data have been used.

2.3 Taxi and Coach Splits

The Transport Model was not originally developed with separate taxi or coach user classes. Therefore, the ANPR data has also been used to split the taxi fleet from the car matrices and the coaches from the HGV matrices, by applying global factors for each time period. The ANPR data provides general splits by time period. Table 2-8 shows the splits used.

Table 2-8: Taxi and Coach Splits

Vehicle Type	AM	IP	PM
Car + Taxi	452,360	451,916	287,596
Taxi	16,847	28,103	14,880
Taxi %	3.7%	6.2%	5.2%
HGV + Coach	20,701	23,590	5,151
Coach	1,256	1,854	1,046
Coach %	6.1%	7.9%	20.3%

2.4 Fuel Type Splits

The ANPR data collected has been used to determine the proportions of vehicles by fuel type, to split the traffic data during post-processing for inputs into the EFT. Fuel type splits have been identified for cars and LGVs (HGVs, buses and coaches are all Diesel). Table 2-9 shows the fuel type splits obtained from the 2017 ANPR data.

Table 2-9: Fuel Type Splits (2017)

Vehicle Category	Flows			Proportion		
	Petrol	Diesel	Electric	Petrol	Diesel	Electric
Cars	1,270,394	977,197	3,030	56.45%	43.42%	0.13%
LGVs	2,902	447,045	644	0.64%	99.21%	0.14%

2.5 HGV Type Splits

HGV rigid / artic splits have also been derived from the 2017 ANPR data, as the HGV matrices need to be split into rigid and artic, by compliance, for a more accurate level of detail for inputs into the EFT for each modelled year. The daily ratios for 2017 are shown in Table 2-10.

Table 2-10: HGV Rigid / Artic Ratio (2017)

Vehicle Type	Average	Compliant	Non-Compliant
Rigid HGV	81.1%	69.7%	84.8%
Artic HGV	18.9%	30.3%	15.2%

2.6 Euro Standard Splits

The EFT has national Euro Standard splits within it. These can be overwritten with splits calculated from local data. The values based on the 2017 ANPR data are shown in Table 2-11 by vehicle type.

The 'global' Euro splits for buses have been derived from ANPR data since they are applied globally in the EFT. Since separate EFTs have been used for compliant and non-compliant vehicles the bus Euro splits for First buses have only been used to sub-divide compliant and non-compliant buses into specific Euro Standards in the EFT calculations. The compliant / non-compliant splits for First buses at a service level have been derived from operator data.

Table 2-11: 2017 Euro Standard Splits

Petrol Car	Calculated Bristol Euro Proportions 2017	EFT Default Proportions 2017 - England (not London)
1Pre-Euro 1	0.00	-
2Euro 1	0.01	-
3Euro 2	0.06	0.01
4Euro 3	0.24	0.11
5Euro 4	0.27	0.23
6Euro 5	0.25	0.34
7Euro 6*	0.17	0.20
7Euro 6c*	-	0.12

Diesel Car	Calculated Bristol Euro Proportions 2017	EFT Default Proportions 2017 - England (not London)
1Pre-Euro 1	0.00	-
2Euro 1	0.00	-
3Euro 2	0.01	0.00
4Euro 3	0.14	0.06
5Euro 4	0.23	0.19
6Euro 5	0.38	0.40
7Euro 6	0.25	0.22
7Euro 6*	-	0.13
7Euro 6c*	-	0.00

Petrol LGV	Calculated Bristol Euro Proportions 2017	EFT Default Proportions 2017 - England (not London)
1Pre-Euro 1	0.21	-
2Euro 1	0.07	0.00
3Euro 2	0.25	0.03
4Euro 3	0.26	0.11
5Euro 4	0.17	0.20
6Euro 5	0.03	0.34
7Euro 6*	0.02	0.32
7Euro 6c*	-	-

Diesel LGV	Calculated Bristol Euro Proportions 2017	EFT Default Proportions 2017 - England (not London)
1Pre-Euro 1	0.00	-
2Euro 1	0.01	0.00
3Euro 2	0.03	0.01
4Euro 3	0.13	0.05
5Euro 4	0.23	0.20
6Euro 5	0.49	0.41
7Euro 6*	0.11	0.33
7Euro 6c*	-	-
7Euro 6d*	-	-

Rigid HGV	Calculated Bristol Euro Proportions 2017	EFT Default Proportions 2017 - England (not London)
1Pre-Euro I	0.00	-
2Euro I	0.00	-
3Euro II	0.02	0.01
4Euro III	0.10	0.09
5Euro IV	0.13	0.08
6Euro V_EGR	0.10	0.07
7Euro V_SCR	0.29	0.20
8Euro VI	0.35	0.55
9Euro II SCRRF	-	-
10Euro III SCRR	-	-
11Euro IV SCRR	-	-
12Euro V EGR +	-	-

Artic HGV	Calculated Bristol Euro Proportions 2017	EFT Default Proportions 2017 - England (not London)
1Pre-Euro I	0.00	-
2Euro I	0.00	-
3Euro II	0.00	0.00
4Euro III	0.05	0.02
5Euro IV	0.05	0.03
6Euro V_EGR	0.08	0.06
7Euro V_SCR	0.25	0.18
8Euro VI	0.57	0.72
9Euro II SCRRF	-	-
10Euro III SCRR	-	-
11Euro IV SCRR	-	-
12Euro V EGR +	-	-

Buses	Calculated Bristol Euro Proportions 2017	EFT Default Proportions 2017 - England (not London)
1Pre-Euro I	0.00	-
2Euro I	0.00	-
3Euro II	0.15	0.00
4Euro III	0.40	0.05
5Euro IV	0.09	0.04
6Euro V_EGR	0.03	0.04
7Euro V_SCR	0.09	0.13
8Euro VI	0.24	0.73
9Euro II SCRRF	-	-
10Euro III SCRR	-	-
11Euro IV SCRR	-	-
12Euro V EGR +	-	-

Coaches	Calculated Bristol Euro Proportions 2017	EFT Default Proportions 2017 - England (not London)
1Pre-Euro I	0.11	-
2Euro I	0.01	-
3Euro II	0.02	0.00
4Euro III	0.16	0.05
5Euro IV	0.10	0.04
6Euro V_EGR	0.06	0.04
7Euro V_SCR	0.17	0.13
8Euro VI	0.38	0.73
9Euro II SCRRF	-	-
10Euro III SCRR	-	-
11Euro IV SCRR	-	-
12Euro V EGR +	-	-

3. Base Year 2015

3.1 Compliance Splits

The base year compliance splits were determined from the data collected at the ANPR sites in 2017 and adjusted to 2015 using the change in fleet compliance between the years. The change in compliance was derived from the national values available in EFT. Table 3-1 shows the 2015 compliance splits.

Table 3-1: Compliance Splits by Time Period, Medium Cordon (2015)

Vehicle Category	Medium Cordon					
	AM		IP		PM	
	Compliant	Non-compliant	Compliant	Non-compliant	Compliant	Non-compliant
Cars	36.1%	63.9%	34.7%	65.3%	35.3%	64.7%
LGV	0.2%	99.8%	0.2%	99.8%	0.2%	99.8%
HGV rigid	20.2%	79.8%	19.0%	81.0%	15.2%	84.8%
HGV artic	35.0%	65.0%	36.3%	63.7%	34.0%	66.0%
HGV	22.7%	77.3%	21.7%	78.3%	19.2%	80.8%
Taxi	11.5%	88.5%	9.1%	90.9%	10.7%	89.3%
Bus	7.6%	92.4%	7.9%	92.1%	7.7%	92.3%
Coach	14.7%	85.3%	15.1%	84.9%	15.8%	84.2%
Total	28.4%	74.8%	27.1%	76.6%	30.0%	71.3%

3.2 Fuel Type Splits

The 2017 ANPR fuel splits for cars and LGVs have been adjusted to 2015 using the change over time in the latest WebTAG databook fuel split table. These were applied to the traffic link data extracted from the model runs during post-processing. Table 3-2 shows the fuel type splits obtained from the 2015 calculations.

Table 3-2: Fuel Type Splits (2015)

Vehicle Category	Proportion		
	Petrol	Diesel	Electric
Cars	55.21%	44.74%	0.04%
LGVs	0.80%	99.15%	0.05%

3.3 HGV Type Splits

During the post-processing of the transport link data, the HGV matrices have been split into rigid and artic, by compliance, for a more accurate level of detail for inputs into the EFT. These has been derived from the 2017 ANPR data worked back to 2015. The daily ratios for 2015 are shown in Table 3-3.

Table 3-3: HGV Rigid / Artic Ratio (2015)

Vehicle Type	Average	Compliant	Non-Compliant
Rigid HGV	81.1%	69.6%	84.8%
Artic HGV	18.9%	30.3%	15.2%

3.4 Euro Standard Splits

The EFT has national Euro Standard splits within it. These have been overwritten with splits derived from the 2017 ANPR data worked back to 2015. The results of which are shown in Table 3-4.

Table 3-4: 2015 Euro Standard Splits

Petrol Car	Calculated Bristol Euro Proportions 2015	EFT Default Proportions 2015 - England (not London)
1Pre-Euro 1	-	-
2Euro 1	-	0.00
3Euro 2	0.12	0.03
4Euro 3	0.35	0.21
5Euro 4	0.26	0.29
6Euro 5	0.22	0.40
7Euro 6*	0.05	0.08
7Euro 6c*	-	-

Diesel Car	Calculated Bristol Euro Proportions 2015	EFT Default Proportions 2015 - England (not London)
1Pre-Euro 1	-	-
2Euro 1	-	0.00
3Euro 2	0.03	0.01
4Euro 3	0.23	0.12
5Euro 4	0.26	0.27
6Euro 5	0.40	0.51
7Euro 6	0.08	0.09
7Euro 6*	-	-
7Euro 6c*	-	0.00

Petrol LGV	Calculated Bristol Euro Proportions 2015	EFT Default Proportions 2015 - England (not London)
1Pre-Euro 1	-	-
2Euro 1	0.25	0.01
3Euro 2	0.32	0.07
4Euro 3	0.29	0.25
5Euro 4	0.13	0.31
6Euro 5	0.01	0.35
7Euro 6*	-	-
7Euro 6c*	-	-

Diesel LGV	Calculated Bristol Euro Proportions 2015	EFT Default Proportions 2015 - England (not London)
1Pre-Euro 1	-	-
2Euro 1	0.08	0.01
3Euro 2	0.04	0.02
4Euro 3	0.19	0.12
5Euro 4	0.26	0.32
6Euro 5	0.43	0.53
7Euro 6*	-	-
7Euro 6c*	-	-
7Euro 6d*		-

Rigid HGV	Calculated Bristol Euro Proportions 2015	EFT Default Proportions 2015 - England (not London)
1Pre-Euro I	-	-
2Euro I	-	0.01
3Euro II	0.04	0.03
4Euro III	0.14	0.14
5Euro IV	0.19	0.13
6Euro V_EGR	0.11	0.09
7Euro V_SCR	0.34	0.27
8Euro VI	0.19	0.33
9Euro II SCRRF		-
10Euro III SCRRF		-
11Euro IV SCRRF		-
12Euro V EGR + SCRRF		-

Artic HGV	Calculated Bristol Euro Proportions 2015	EFT Default Proportions 2015 - England (not London)
1Pre-Euro I	-	-
2Euro I	-	0.00
3Euro II	0.01	0.00
4Euro III	0.08	0.03
5Euro IV	0.09	0.06
6Euro V_EGR	0.12	0.09
7Euro V_SCR	0.35	0.28
8Euro VI	0.36	0.52
9Euro II SCRRF		-
10Euro III SCRRF		-
11Euro IV SCRRF		-
12Euro V EGR + SCRRF		-

Buses	Calculated Bristol Euro Proportions 2015	EFT Default Proportions 2015 - England (not London)
1Pre-Euro I	-	-
2Euro I	-	-
3Euro II	0.20	0.01
4Euro III	0.56	0.20
5Euro IV	0.12	0.15
6Euro V_EGR	0.02	0.10
7Euro V_SCR	0.07	0.29
8Euro VI	0.03	0.26
9Euro II SCRRF		-
10Euro III SCRRF		-
11Euro IV SCRRF		-
12Euro V EGR + SCRRF		-

Coaches	Calculated Bristol Euro Proportions 2015	EFT Default Proportions 2015 - England (not London)
1Pre-Euro I	-	-
2Euro I	-	-
3Euro II	0.04	0.01
4Euro III	0.38	0.20
5Euro IV	0.22	0.15
6Euro V_EGR	0.07	0.10
7Euro V_SCR	0.22	0.29
8Euro VI	0.08	0.26
9Euro II SCRRF		-
10Euro III SCRRF		-
11Euro IV SCRRF		-
12Euro V EGR + SCRRF		-

4. Baseline 2021/2023/2031

4.1 Compliance Splits

The fleet projection tool within the EFT v9.1b has been used to project the euro standard splits from the 2017 ANPR data to the Baseline years. The forecast compliance splits by vehicle type for the year of implementation of CAZ (2021) are summarised in Table 4-1, the forecast compliance splits the interim year of 2023 are shown in Table 4-2 and the forecast compliance splits for 2031 are summarised in Table 4-3. It should be note that the EFT does not go beyond 2030, therefore 2030 was used as a proxy for 2031.

Table 4-1: Compliance Splits by Time Period (2021)

Vehicle Category	AM		IP		PM	
	Compliant	Non-compliant	Compliant	Non-compliant	Compliant	Non-compliant
Cars	72.7%	27.3%	71.4%	28.6%	72.0%	28.0%
LGV	58.0%	42.0%	63.1%	36.9%	58.2%	41.8%
HGV rigid	73.9%	26.1%	72.5%	27.5%	66.7%	33.3%
HGV artic	85.7%	14.3%	86.4%	13.6%	85.2%	14.8%
HGV	76.6%	23.4%	75.6%	24.4%	72.6%	27.4%
Taxi	66.0%	34.0%	66.0%	34.0%	66.0%	34.0%
Bus	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%
Coach	68.8%	31.2%	69.6%	30.4%	70.6%	29.4%
Total	70.6%	29.4%	70.7%	29.3%	70.9%	29.1%

Table 4-2: Compliance Splits by Time Period (2023)

Vehicle Category	AM		IP		PM	
	Compliant	Non-compliant	Compliant	Non-compliant	Compliant	Non-compliant
Cars	82.9%	17.1%	82.1%	17.9%	82.5%	17.5%
LGV	73.3%	26.7%	77.3%	22.7%	73.5%	26.5%
HGV rigid	85.1%	14.9%	84.1%	15.9%	80.1%	19.9%
HGV artic	92.4%	7.6%	92.8%	7.2%	92.0%	8.0%
HGV	86.8%	13.2%	86.2%	13.8%	84.2%	15.8%
Taxi	74.5%	25.5%	74.5%	25.5%	74.5%	25.5%
Bus	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%
Coach	81.1%	18.9%	81.7%	18.3%	82.4%	17.6%
Total	81.5%	18.5%	81.6%	18.4%	81.6%	18.4%

Table 4-3: Compliance Splits by Time Period (2031)

Vehicle Category	AM		IP		PM	
	Compliant	Non-compliant	Compliant	Non-compliant	Compliant	Non-compliant
Cars	98.2%	1.8%	98.1%	1.9%	98.2%	1.8%
LGV	97.0%	3.0%	97.6%	2.4%	97.0%	3.0%
HGV rigid	98.8%	1.2%	98.7%	1.3%	98.3%	1.7%
HGV artic	99.4%	0.6%	99.5%	0.5%	99.4%	0.6%
HGV	99.0%	1.0%	98.9%	1.1%	98.7%	1.3%
Taxi	92.8%	7.2%	90.8%	9.2%	92.2%	7.8%
Bus	99.4%	0.6%	99.4%	0.6%	99.4%	0.6%
Coach	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%
Total	101.1%	2.1%	101.4%	2.3%	99.0%	2.2%

4.2 Fuel Type Splits

The EFT v9.1b has been used for the fuel splits for 2021, 2023 and 2031. An additional adjustment has been made to car fuel splits due to identification by BCC of an increase in petrol taxis replacing diesel. These were applied to the traffic link data extracted from the model runs via post-processing before input to the EFT and for splitting the car matrices when modelling the diesel ban scenario. Table 4-4 shows the fuel type splits from the 2021, 2023 and 2031 projected ANPR data.

Table 4-4: Fuel Type Splits (2021, 2023 and 2031)

Vehicle Category	2021			2023			2031		
	Petrol	Diesel	Electric	Petrol	Diesel	Electric	Petrol	Diesel	Electric
Cars	60.46%	38.71%	0.83%	61.42%	37.18%	1.40%	61.92%	28.88%	9.20%
LGVs	0.47%	99.38%	0.15%	0.44%	99.21%	0.35%	0.31%	95.91%	3.78%

4.3 HGV Type Splits

During the post-processing of the transport link data, the HGV matrices have been split into rigid and artic, by compliance. This has been derived from the projected 2021, 2023 and 2031 ANPR data with daily ratios as shown in Table 4-5.

Table 4-5: HGV Rigid / Arctic Ratio (2021, 2023 and 2031)

Vehicle Type	2021		2023		2031	
	Compliant	Non-Compliant	Compliant	Non-Compliant	Compliant	Non-Compliant
Rigid HGV	75.7%	88.3%	77.1%	89.1%	78.7%	89.9%
Artic HGV	24.3%	11.7%	22.9%	10.9%	21.3%	10.1%

4.4 Euro Standard Splits

The EFT has national Euro Standard splits within it. These have been overwritten with splits calculated based on the 2021, 2023 and 2031 projected ANPR data. The results of this are shown in Tables 4-6 to 4-8 for 2021, 2023 and 2031 respectively.

Table 4-6: Euro Standard Splits (2021)

Petrol Car	Calculated Proportions 2021 - Bristol	Default Euro Proportions 2021 - England (not London)
1Pre-Euro 1	-	-
2Euro 1	-	-
3Euro 2	0.01	-
4Euro 3	0.08	0.02
5Euro 4	0.13	0.08
6Euro 5	0.34	0.22
7Euro 6*	0.18	0.13
7Euro 6c*	0.26	0.54

Diesel Car	Calculated Proportions 2021 - Bristol	Default Euro Proportions 2021 - England (not London)
1Pre-Euro 1	-	-
2Euro 1	-	-
3Euro 2	-	-
4Euro 3	0.04	0.01
5Euro 4	0.11	0.07
6Euro 5	0.37	0.26
7Euro 6	0.19	0.15
7Euro 6*	0.28	0.30
7Euro 6c*	-	0.21

Petrol LGV	Calculated Proportions 2021 - Bristol	Default Euro Proportions 2021 - England (not London)
1Pre-Euro 1	-	-
2Euro 1	-	-
3Euro 2	0.03	-
4Euro 3	0.07	0.03
5Euro 4	0.06	0.08
6Euro 5	0.36	0.22
7Euro 6*	0.33	0.17
7Euro 6c*	0.14	0.50

Diesel LGV	Calculated Proportions 2021 - Bristol	Default Euro Proportions 2021 - England (not London)
1Pre-Euro 1	-	-
2Euro 1	-	-
3Euro 2	0.01	-
4Euro 3	0.03	0.01
5Euro 4	0.10	0.07
6Euro 5	0.27	0.21
7Euro 6*	0.20	0.14
7Euro 6c*	0.39	0.38
7Euro 6d*	-	0.18

Rigid HGV	Calculated Proportions 2021 - Bristol	Default Euro Proportions 2021 - England (not London)
1Pre-Euro I	-	-
2Euro I	-	-
3Euro II	0.04	-
4Euro III	0.16	0.02
5Euro IV	0.04	0.02
6Euro V_EGR	0.02	0.03
7Euro V_SCR	0.05	0.09
8Euro VI	0.70	0.83
9Euro II SCRRF	-	-
10Euro III SCRRF	-	-
11Euro IV SCRRF	-	-
12Euro V EGR +	-	-

Artic HGV	Calculated Proportions 2021 - Bristol	Default Euro Proportions 2021 - England (not London)
1Pre-Euro I	-	-
2Euro I	-	-
3Euro II	0.02	-
4Euro III	0.07	-
5Euro IV	0.03	-
6Euro V_EGR	0.02	0.01
7Euro V_SCR	0.07	0.04
8Euro VI	0.79	0.94
9Euro II SCRRF	-	-
10Euro III SCRRI	-	-
11Euro IV SCRRI	-	-
12Euro V EGR +	-	-

Buses	Calculated Proportions 2021 - Bristol	Default Euro Proportions 2021 - England (not London)
1Pre-Euro I	-	-
2Euro I	-	-
3Euro II	0.00	-
4Euro III	0.05	0.05
5Euro IV	0.01	0.04
6Euro V_EGR	0.00	0.04
7Euro V_SCR	0.01	0.13
8Euro VI	0.91	0.73
9Euro II SCRRF	-	-
10Euro III SCRRF	-	-
11Euro IV SCRRF	-	-
12Euro V EGR +	-	-

Coaches	Calculated Proportions 2021 - Bristol	Default Euro Proportions 2021 - England (not London)
1Pre-Euro I	-	-
2Euro I	-	-
3Euro II	-	-
4Euro III	0.02	0.05
5Euro IV	0.01	0.04
6Euro V_EGR	0.01	0.04
7Euro V_SCR	0.02	0.13
8Euro VI	0.94	0.73
9Euro II SCRRF	-	-
10Euro III SCRRI	-	-
11Euro IV SCRRI	-	-
12Euro V EGR +	-	-

Table 4-7: Euro Standard Splits (2023)

Petrol Car	Calculated Proportions 2023 - Bristol	Default Euro Proportions 2023 - England (not London)
1Pre-Euro 1	-	-
2Euro 1	-	-
3Euro 2	-	-
4Euro 3	0.03	0.01
5Euro 4	0.06	0.04
6Euro 5	0.27	0.16
7Euro 6*	0.14	0.11
7Euro 6c*	0.49	0.68

Diesel Car	Calculated Proportions 2023 - Bristol	Default Euro Proportions 2023 - England (not London)
1Pre-Euro 1	-	-
2Euro 1	-	-
3Euro 2	-	-
4Euro 3	0.02	-
5Euro 4	0.05	0.03
6Euro 5	0.29	0.19
7Euro 6	0.15	0.13
7Euro 6*	0.36	0.25
7Euro 6c*	0.12	0.40

Petrol LGV	Calculated Proportions 2023 - Bristol	Default Euro Proportions 2023 - England (not London)
1Pre-Euro 1	-	-
2Euro 1	-	-
3Euro 2	0.01	-
4Euro 3	0.03	0.01
5Euro 4	0.02	0.03
6Euro 5	0.29	0.12
7Euro 6*	0.22	0.10
7Euro 6c*	0.42	0.74

Diesel LGV	Calculated Proportions 2023 - Bristol	Default Euro Proportions 2023 - England (not London)
1Pre-Euro 1	-	-
2Euro 1	-	-
3Euro 2	-	-
4Euro 3	0.01	-
5Euro 4	0.05	0.03
6Euro 5	0.19	0.15
7Euro 6*	0.15	0.10
7Euro 6c*	0.40	0.25
7Euro 6d*	0.19	0.46

Rigid HGV	Calculated Proportions 2023 - Bristol	Default Euro Proportions 2023 - England (not London)
1Pre-Euro I	-	-
2Euro I	-	-
3Euro II	-	-
4Euro III	0.01	0.01
5Euro IV	0.02	0.01
6Euro V_EGR	0.03	0.02
7Euro V_SCR	0.09	0.05
8Euro VI	0.84	0.91
9Euro II SCRRF	-	-
10Euro III SCRRF	-	-
11Euro IV SCRRF	-	-
12Euro V EGR +	-	-

Artic HGV	Calculated Proportions 2023 - Bristol	Default Euro Proportions 2023 - England (not London)
1Pre-Euro I	-	-
2Euro I	-	-
3Euro II	-	-
4Euro III	-	-
5Euro IV	-	-
6Euro V_EGR	0.01	0.01
7Euro V_SCR	0.03	0.02
8Euro VI	0.96	0.98
9Euro II SCRRF	-	-
10Euro III SCRR	-	-
11Euro IV SCRR	-	-
12Euro V EGR +	-	-

Buses	Calculated Proportions 2023 - Bristol	Default Euro Proportions 2023 - England (not London)
1Pre-Euro I	-	-
2Euro I	-	-
3Euro II	0.02	-
4Euro III	0.09	0.03
5Euro IV	0.02	0.02
6Euro V_EGR	0.01	0.03
7Euro V_SCR	0.03	0.08
8Euro VI	0.84	0.84
9Euro II SCRRF	-	-
10Euro III SCRRF	-	-
11Euro IV SCRRF	-	-
12Euro V EGR +	-	-

Coaches	Calculated Proportions 2023 - Bristol	Default Euro Proportions 2023 - England (not London)
1Pre-Euro I	-	-
2Euro I	-	-
3Euro II	-	-
4Euro III	0.04	0.03
5Euro IV	0.02	0.02
6Euro V_EGR	0.01	0.03
7Euro V_SCR	0.04	0.08
8Euro VI	0.88	0.84
9Euro II SCRRF	-	-
10Euro III SCRR	-	-
11Euro IV SCRR	-	-
12Euro V EGR +	-	-

Table 4-8: Euro Standard Splits (2031)

Petrol Car	Calculated Proportions 2031 - Bristol	Default Euro Proportions 2031 - England (not London)
1Pre-Euro 1	-	-
2Euro 1	-	-
3Euro 2	-	-
4Euro 3	-	-
5Euro 4	0.00	0.00
6Euro 5	0.05	0.01
7Euro 6*	0.04	0.02
7Euro 6c*	0.91	0.97

Diesel Car	Calculated Proportions 2031 - Bristol	Default Euro Proportions 2031 - England (not London)
1Pre-Euro 1	-	-
2Euro 1	-	-
3Euro 2	-	-
4Euro 3	-	-
5Euro 4	0.00	0.00
6Euro 5	0.04	0.02
7Euro 6	0.04	0.03
7Euro 6*	0.19	0.10
7Euro 6c*	0.73	0.86

Petrol LGV	Calculated Proportions 2031 - Bristol	Default Euro Proportions 2031 - England (not London)
1Pre-Euro 1	-	-
2Euro 1	-	-
3Euro 2	-	-
4Euro 3	-	-
5Euro 4	0.00	0.00
6Euro 5	0.02	0.00
7Euro 6*	0.02	0.00
7Euro 6c*	0.96	0.99

Diesel LGV	Calculated Proportions 2031 - Bristol	Default Euro Proportions 2031 - England (not London)
1Pre-Euro 1	-	-
2Euro 1	-	-
3Euro 2	-	-
4Euro 3	-	-
5Euro 4	0.00	0.00
6Euro 5	0.03	0.02
7Euro 6*	0.04	0.02
7Euro 6c*	0.12	0.08
7Euro 6d*	0.81	0.88

Rigid HGV	Calculated Proportions 2031 - Bristol	Default Euro Proportions 2031 - England (not London)
1Pre-Euro I	-	-
2Euro I	-	-
3Euro II	-	-
4Euro III	-	-
5Euro IV	0.00	-
6Euro V_EGR	0.00	0.00
7Euro V_SCR	0.01	0.00
8Euro VI	0.99	0.99
9Euro II SCRRF	-	-
10Euro III SCRR	-	-
11Euro IV SCRR	-	-
12Euro V EGR +	-	-

Artic HGV	Calculated Proportions 2031 - Bristol	Default Euro Proportions 2031 - England (not London)
1Pre-Euro I	-	-
2Euro I	-	-
3Euro II	-	-
4Euro III	-	-
5Euro IV	-	-
6Euro V_EGR	0.00	0.00
7Euro V_SCR	0.00	0.00
8Euro VI	1.00	1.00
9Euro II SCRRF	-	-
10Euro III SCRR	-	-
11Euro IV SCRR	-	-
12Euro V EGR +	-	-

Buses	Calculated Proportions 2031 - Bristol	Default Euro Proportions 2031 - England (not London)
1Pre-Euro I	-	-
2Euro I	-	-
3Euro II	-	-
4Euro III	0.00	-
5Euro IV	-	-
6Euro V_EGR	0.00	0.00
7Euro V_SCR	0.01	0.01
8Euro VI	0.98	0.98
9Euro II SCRRF	-	-
10Euro III SCRR	-	-
11Euro IV SCRR	-	-
12Euro V EGR +	-	-

Coaches	Calculated Proportions 2031 - Bristol	Default Euro Proportions 2031 - England (not London)
1Pre-Euro I	-	-
2Euro I	-	-
3Euro II	-	-
4Euro III	-	-
5Euro IV	-	-
6Euro V_EGR	0.00	0.00
7Euro V_SCR	0.01	0.01
8Euro VI	0.98	0.98
9Euro II SCRRF	-	-
10Euro III SCRR	-	-
11Euro IV SCRR	-	-
12Euro V EGR +	-	-

Bristol City Council Clean Air Plan Business Case

LGV/HGV Validation Report

FBC-25 | 6

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Bristol City Council

Bristol City Council Clean Air Plan Business Case

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5	05.02.2021	Revision 5	SL	KW	KW	HO
6	17.02.2021	Revision 6	SL	KW	KW	HO

Contents

1. Introduction

1.1 Clean Air Zone context

Poor air quality is the largest known environmental risk to public health in the UK[1]. Investing in cleaner air and doing more to tackle air pollution are priorities for the EU and UK governments, as well as for Bristol City Council (BCC). The Mayor of Bristol has often cited Bristol's 'moral and legal duty' to improve air quality in the city and the administration recognises that achieving improved air quality is not solely a transport issue. Notwithstanding the Council's work on a Clean Air Zone, efforts have been made to make citizens more aware of – and take personal responsibility for – various sources of air pollution, from traffic fumes to solid fuel burning. The Mayor has articulated a 'call to action' for local people, businesses and organisations to consider how small changes can make a significant difference in cutting toxic fumes across the city. BCC has monitored and endeavoured to address air quality in Bristol for decades and declared its first Air Quality Management Area in 2001. Despite this, Bristol has ongoing exceedances of the legal limits for Nitrogen Dioxide (NO_2) and these are predicted to continue until around 2027 without intervention.

The added context is that of the COVID-19 pandemic. Recent research suggests that poor air quality may be correlated with higher death / infection rates from COVID-19. This is further compounded by growing evidence that suggests that those from black, Asian and minority ethnic communities are more at risk of catching and dying from the virus and the fact that individuals from these communities are more likely to live in areas where air quality is poor. The challenge of maintaining public health and supporting economic recovery while also achieving legal air quality levels after lockdown restrictions are lifted will remain live and intersecting issues for the foreseeable future.

The UK Government continue to transpose European Union law into its Environment Bill[2], to ensure that certain standards of air quality continue to be met, by setting air quality assessment levels (AQALs) on the concentrations of specific air pollutants. It's very unlikely that these AQALs will differ to EU Limit Values prescribed by the European Union's Air Quality Directive and transcribed in the UK's Air Quality Standards Regulation 2010. Therefore, these Limit Values will remain in enforcement post-Brexit. In common with many EU member states, the EU Limit Value for annual mean nitrogen dioxide (NO_2) is breached in the UK and there are on-going breaches of the NO_2 limit value in Bristol. The UK government is taking steps to remedy this breach in as short a time as possible, with the aim of reducing the harmful impacts on public health. Within this objective, the Government has published a UK Air Quality Plan and a Clean Air Zone Framework, both originally published in 2017 (noting there have been subsequent revisions). The latter document provides the expected approach for local authorities when implementing and operating a Clean Air Zone (CAZ). The following business cases have been submitted to JAQU for the Clean Air Plan; Strategic Outline Case (April 2018), and an Outline Business Case (November 2019 and updated between April and June 2020).

Following the submission of the OBC, further work was undertaken to develop the scheme, which resulted in the development of a new option - the Small area CAZ D. This work, and the option development work undertaken as part of the OBC, is presented in an updated Option Assessment Report (Appendix C FBC-16). The OBC version of this report is appended to the updated Option Assessment Report.

1.2 Purpose of this Report

This report sets out light and heavy goods vehicle link flow validation used in modelling. Previous versions of this report have been issued in March 2018, January 2019 and October 2019.

[1] Public Health England (2014) Estimating local mortality burdens associated with particular air pollution. https://www.gov.uk/government/publications/estimating-local-mortality-burdens-associated-with-particulate-air-pollution
[2] Environment Bill 2019-21 https://services.parliament.uk/bills/2019-21/environment.html

2. Base Year Model

In 2013, BCC commissioned CH2M (now Jacobs) to update the existing GBATS model, primarily to assess the MetroWest scheme. The updated model is called the GBATS4 Metro Model (GBATS4M). The GBATS4M model consists of:

- A Highway Assignment Model representing vehicle-based movements across the Greater Bristol area for a 2013 autumn weekday morning peak hour (08:00-09:00), an average inter-peak hour (10:00-16:00) and an evening peak hour (17:00-18:00);
- A Public Transport (PT) Assignment Model representing bus and rail-based movements across the same area and time periods; and
- A five-stage multi-modal incremental Variable Demand Model (VDM) that forecasts changes in trip frequency and choice of main mode, time period of travel, destination, and sub-mode choice, in response to changes in generalised costs across the 12-hour period (07:00 – 19:00).

The full model validation is set in OBC-22 Model Validation Report (T2) in Appendix Ei of the OBC. A summary of the highway model validation is provided below as relevant context for the assessment of light and heavy goods vehicles.

2.1 Highway Model

The GBATS4M highway model included an update of the trips to/from the city centre with roadside interview data. The model has been validated using the guidance, measures and criteria recommended in WebTAG M3.1. The following comparisons between modelled and observed data have been reported in OBC-22 Model Validation Report (T2):

- Total flows for cordons and screenlines, lights and all vehicles;
- Traffic Flows on individual links, lights and all vehicles; and
- Journey times (both cruise and net) for a range of key routes.

- The analysis shows that the three models meet the WebTAG acceptability guidelines:
- Regarding matrix estimation changes;
- For traffic flows on links across the total cordon and screenlines and at the individual calibration, and independent validation sites; and
- For journey times.

All three models (AM, inter-peak and PM) achieve acceptable levels of convergence and are stable based on delay/cost.

3. Base Year Model – LGV and HGV Validation

The light and heavy goods vehicles have not previously been validated separately, as traffic flows on individual links and screenlines have been validated against the number of cars and the total number of vehicles.

For this note, a check has been undertaken of the validation of goods vehicles on a series of short screenlines in accordance with WebTAG M3.1 Section 9.3.1.

It should be noted that JAQU, as outlined in the Evidence Package section 2.1.2, require that all reasonable efforts are made to bring the transport model as close as reasonably possible to WebTAG validation criteria. In instances where models would require significant update, JAQU will not require all WebTAG guidance on validation to be followed where impacts of any shortcomings can be overcome elsewhere in the analysis.

3.1 Validation Criteria and Acceptability Guidelines

Highway model validation acceptability guidelines are specified in TAG M3.1. However, TAG M3.1 states that a model can still be deemed as 'fit for purpose' if it does not meet these guidelines, and indeed if they are met that the model is not automatically deemed so. If these criteria cannot be fully met, the importance of the relevant locations to overall model validation and assessment of proposed schemes should be reviewed to ensure the model is still fit for purpose.

The validation criteria and acceptability guidelines as specified in TAG M3.1 are shown in Table 3.1 below. The observed flow and screenline flow criteria have been applied to "all vehicles" and "cars/LGVs" in the validation report. Hence the need for additional checks relating to goods vehicles in this note.

Table 3.1 – WebTAG Acceptability Guidelines

Criteria and Measure		Acceptability Guideline	
Flow Difference Criteria			
1	Total screenline flows (normally > 5 links) to be within +/- 5%	All (or nearly all) screenlines	
2	Observed (individual) link flow < 700vph	Modelled flow within +/- 100vph	> 85% of links
	Observed (individual) link flow 700 to 2700vph	Modelled flow within +/- 15%	> 85% of links
	Observed (individual) link flow > 2700vph	Modelled flow within +/- 400vph	> 85% of links
GEH Criteria			
3	GEH statistic for individual link flows <5		> 85% of links
Journey Time Validation			
4	Modelled times along routes should be within 15% (or 1 minute, if higher)		> 85% of links

The GEH statistic is used as an indicator of the extent to which the modelled flows match the corresponding observed flows. This is recommended in the guidelines contained in TAG M3.1 and is defined as:

$$GEH = \sqrt{\frac{(M - C)^2}{0.5(M + C)}}$$

Where: M = modelled flow; and C = observed flow.

3.2 Screenlines and Cordons

A wide range of traffic counts, forming a number of calibration and validation screenlines and cordons, across the area were conducted during development of the model in 2013. Screenlines and cordons were selected to capture all the major trip movements. The screenlines were designed to be sufficiently long to show the quality of the matrix and the cordons were intended to be suitably 'watertight' and include all main roads in the network that intersect them.

The calibration screenlines and cordons were the Inner, South, East, North West Inner, River and Railway sections of the city as shown in Figure 3.1. The validation screenlines and cordons were the Outer, Middle and North-West Outer and North-East sections as shown in Figure 3.2.

The screenlines and cordons were segmented into smaller sections and counts grouped into a series of short screenlines to compare observed and modelled LGV and HGV flows.

Figure 3.1- Calibration Traffic Count Cordons and Screenlines

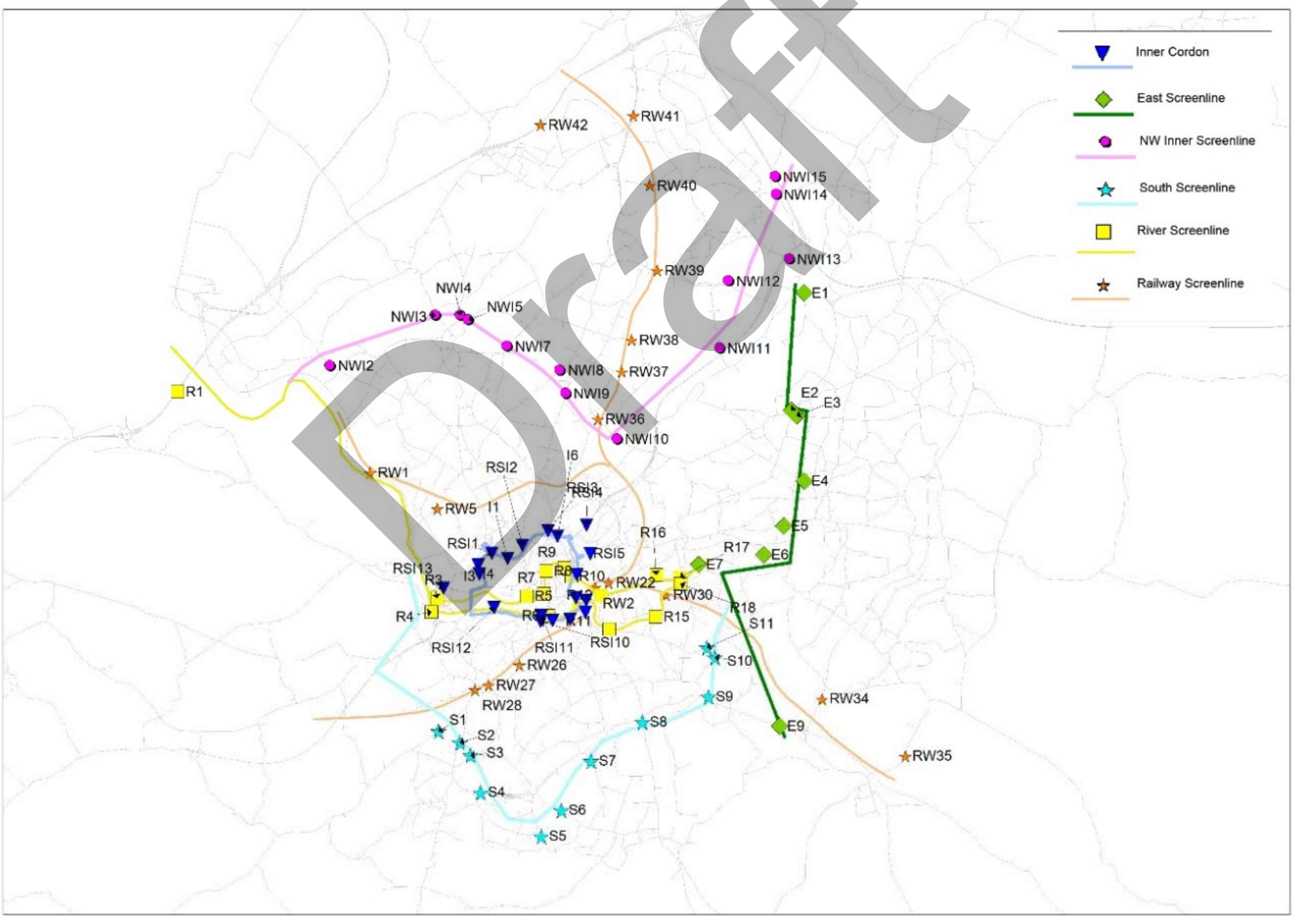
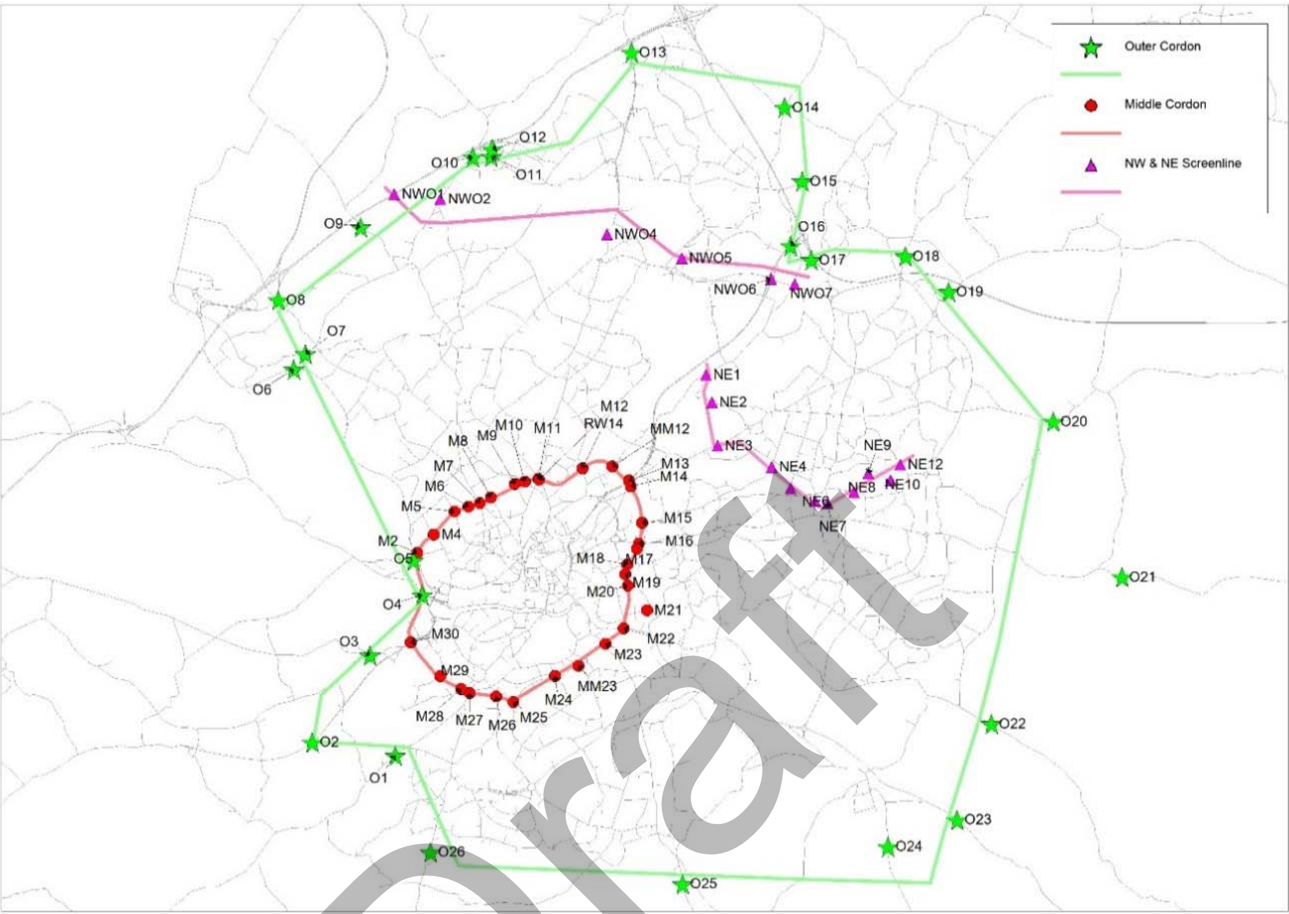


Figure 3.2- Validation Traffic Count Cordons and Screenlines



3.3 Results

Tables 3.2 (AM), 3.3 (IP) and 3.4 (PM) present the percentage of short screenlines that meet the flow difference and GEH criteria for each screenline or cordon, in Table 3.1, in accordance with TAG M3.1.

Considering the GEH validation set out in Tables 3.2 to 3.4 the calibration/validation of LGVs is reasonable, with between 78-84% of short screenlines meeting WebTAG GEH criteria in each time period. For HGVs between 56-68% of short screenlines meet the criteria. The WebTAG link flow difference criteria results show that the calibration/validation of LGVs is good with between 90-94% of screenlines meeting WebTAG criteria in each time period. For HGVs between 81-86% of screenlines meet the criteria.

Table 3.2 – AM Peak Short Screenlines Flow Calibration/Validation Summary

Screenlines and Cordon		No. short screen-lines	LGVs		HGVs		Total Good Vehicles	
			% Links GEH (PCUs)	% link flow difference (PCUs)	% Links GEH (PCUs)	% link flow difference (PCUs)	% Links GEH (PCUs)	% link flow difference (PCUs)
Calibration total		**62**	**88%**	**93%**	**63%**	**82%**	**73%**	**77%**
Calibration Cordons & Screenlines	Inner (In)	8	100%	100%	75%	100%	88%	100%
	Inner (Out)	8	88%	100%	88%	100%	88%	100%
	East (In)	3	100%	100%	33%	100%	100%	100%
	East (Out)	3	67%	100%	100%	100%	100%	100%
	NW Inner (In)	4	75%	75%	75%	75%	75%	75%
	NW Inner (Out)	4	50%	50%	75%	75%	25%	25%
	South (In)	3	100%	100%	67%	67%	100%	100%
	South (Out)	3	100%	100%	67%	100%	67%	67%
	River (WBSB)	7	100%	100%	57%	71%	71%	57%
	River (EBNB)	7	86%	86%	29%	57%	57%	57%
	RW (SB)	6	100%	100%	20%	40%	40%	60%
	RW (NB	6	83%	83%	83%	83%	83%	67%
Validation total		**64**	**80%**	**94%**	**52%**	**81%**	**73%**	**83%**
Validation and Cordons & Screenlines	Outer (In)	12	100%	100%	67%	83%	75%	92%
	Outer (Out)	12	92%	100%	33%	75%	83%	83%
	Middle (In)	11	64%	73%	36%	64%	64%	73%
	Middle (Out)	11	64%	100%	45%	73%	73%	82%
	NW Outer (In)	4	100%	100%	75%	100%	100%	100%
	NW Outer (Out)	4	100%	100%	75%	100%	100%	75%
	NE (In)	5	80%	100%	80%	100%	60%	80%
	NE (Out)	5	40%	80%	40%	100%	40%	80%
All		**126**	**84%**	**94%**	**57%**	**81%**	**73%**	**80%**

Table 3.3 – Inter Peak Short Screenlines Flow Calibration/Validation Summary

Screenlines and Cordon		No. short screen-lines	LGVs		HGVs		Total Good Vehicles	
			% Links GEH (PCUs)	% link flow difference (PCUs)	% Links GEH (PCUs)	% link flow difference (PCUs)	% Links GEH (PCUs)	% link flow difference (PCUs)
Calibration total		62	80%	87%	75%	88%	77%	80%
Calibration Cordons & Screenlines	Inner (In)	8	100%	100%	88%	100%	100%	100%
	Inner (Out)	8	100%	100%	75%	88%	63%	88%
	East (In)	3	67%	100%	67%	100%	100%	100%
	East (Out)	3	67%	67%	67%	100%	100%	100%
	NW Inner (In)	4	75%	75%	75%	75%	50%	50%
	NW Inner (Out)	4	75%	75%	50%	75%	50%	25%
	South (In)	3	67%	67%	100%	100%	67%	67%
	South (Out)	3	33%	33%	100%	100%	33%	33%
	River (WBSB)	7	71%	86%	71%	86%	71%	71%
	River (EBNB)	7	71%	100%	57%	71%	86%	86%
	RW (SB)	6	100%	100%	100%	100%	100%	100%
	RW (NB	6	83%	67%	67%	67%	83%	83%
Validation total		64	77%	93%	60%	83%	75%	82%
Validation and Cordons & Screenlines	Outer (In)	12	100%	100%	55%	73%	82%	82%
	Outer (Out)	12	100%	100%	64%	91%	82%	82%
	Middle (In)	11	55%	82%	55%	82%	64%	73%
	Middle (Out)	11	55%	82%	82%	91%	82%	82%
	NW Outer (In)	4	100%	100%	33%	67%	100%	100%
	NW Outer (Out)	4	100%	100%	33%	33%	67%	67%
	NE (In)	5	60%	100%	40%	100%	40%	80%
	NE (Out)	5	60%	100%	80%	100%	80%	100%
All		126	78%	90%	68%	86%	76%	81%

Table 3.4 – PM Peak Short Screenlines Flow Calibration/Validation Summary

Screenlines and Cordon		No. short screenlines	LGVs		HGVs		Total Good Vehicles	
			% Links GEH (PCUs)	% link flow difference (PCUs)	% Links GEH (PCUs)	% link flow difference (PCUs)	% Links GEH (PCUs)	% link flow difference (PCUs)
Calibration total		62	92%	95%	53%	83%	85%	88%
Calibration Cordons & Screenlines	Inner (In)	8	100%	100%	75%	100%	88%	100%
	Inner (Out)	8	100%	100%	75%	100%	88%	100%
	East (In)	3	67%	100%	33%	100%	100%	100%
	East (Out)	3	67%	67%	0%	67%	100%	100%
	NW Inner (In)	4	75%	75%	50%	50%	100%	100%
	NW Inner (Out)	4	75%	75%	50%	50%	75%	75%
	South (In)	3	100%	100%	33%	100%	100%	100%
	South (Out)	3	67%	100%	33%	100%	100%	100%
	River (WBSB)	7	100%	100%	86%	86%	86%	86%
	River (EBNB)	7	100%	100%	43%	57%	57%	57%
	RW (SB)	6	100%	100%	40%	80%	60%	60%
	RW (NB	6	100%	83%	50%	83%	100%	83%
Validation total		64	70%	88%	58%	81%	84%	89%
Validation and Cordons & Screenlines	Outer (In)	12	100%	100%	42%	75%	83%	83%
	Outer (Out)	12	75%	83%	75%	92%	100%	100%
	Middle (In)	11	45%	82%	55%	82%	91%	91%
	Middle (Out)	11	55%	73%	36%	55%	73%	82%
	NW Outer (In)	4	100%	100%	50%	100%	100%	100%
	NW Outer (Out)	4	100%	100%	50%	75%	75%	75%
	NE (In)	5	40%	100%	100%	100%	100%	100%
	NE (Out)	5	60%	80%	80%	100%	40%	80%
All		126	81%	91%	56%	82%	85%	89%

It should be noted that if the individual link flows were taken into consideration, then the calibration and validation of the light and heavy goods vehicles looks slightly better. Tables 3.5 (AM), 3.6 (IP) and 3.7 (PM) present a summary of the individual link flow calibration/validation. These show 86-87% of links meet GEH criteria and 98-99% of links meet the flow difference criteria for LGVs. For HGVs, around 70% of links meet the GEH criteria and 92-94% meet the flow difference criteria.

Table 3.5 – AM Peak Link Flow Calibration/Validation Summary

Screenlines and Cordon	No. Links	LGVs		HGVs		Total Good Vehicles	
		% Links GEH (PCUs)	% links DMRB flow (PCUs)	% Links GEH (PCUs)	% links DMRB flow (PCUs)	% Links GEH (PCUs)	% links DMRB flow (PCUs)
Calibration total	164	88%	99%	73%	93%	82%	94%
Validation total	146	84%	99%	62%	92%	75%	92%
All	**310**	**86%**	**99%**	**68%**	**93%**	**78%**	**93%**

Table 3.6– Inter Peak Link Flow Calibration/Validation Summary

Screenlines and Cordon	No. Links	LGVs		HGVs		Total Good Vehicles	
		% Links GEH (PCUs)	% links DMRB flow (PCUs)	% Links GEH (PCUs)	% links DMRB flow (PCUs)	% Links GEH (PCUs)	% links DMRB flow (PCUs)
Calibration total	164	83%	99%	79%	97%	82%	95%
Validation total	146	86%	99%	71%	94%	79%	92%
All	**310**	**87%**	**99%**	**72%**	**94%**	**81%**	**93%**

Table 3.7 – PM Peak Link Flow Calibration/Validation Summary

Screenlines and Cordon	No. Links	LGVs		HGVs		Total Good Vehicles	
		% Links GEH (PCUs)	% links DMRB flow (PCUs)	% Links GEH (PCUs)	% links DMRB flow (PCUs)	% Links GEH (PCUs)	% links DMRB flow (PCUs)
Calibration total	164	86%	100%	66%	95%	84%	96%
Validation total	146	83%	97%	71%	90%	84%	96%
All	**310**	**86%**	**98%**	**72%**	**92%**	**83%**	**95%**

To explore the model fit further for HGVs, Tables 3.8 to 3.10 show the short screenline results for the inner and middle cordon for the AM, inter-peak and PM respectively, as they represent the closest data to the inner and middle CAZ boundaries. To aid interpretation, the GEH values are presented as negative where model flows are lower than the observed flow.

Table 3.8 – AM Short Screenline Results – Inner and Middle Cordon HGVs

Sub-cordon	No. of links	HGV Observed	Model	GEH	DMRB Link Flow
Inner Cordon					
Tyndalls - inbound	3	180.7	84.3	-8.4	y
St Pauls - inbound	3	124.6	143.1	1.6	y
Old Market - inbound	2	71.6	68.3	-0.4	y
Temple Meads - inbound	2	163.8	79.5	-7.6	y
Bath Rd - inbound	3	95.3	57.8	-4.3	y
Bedminster - inbound	3	120.0	112.5	-0.7	y
Hotwells - inbound	1	93.6	103.5	1.0	y
Clifton - inbound	2	10.7	3.3	-2.8	y
Inbound *	19	860.3	652.2	75%	100%
Tyndalls - outbound	3	131.3	63.8	-6.8	y
St Pauls - outbound	3	175.0	180.6	0.4	y
Old Market - outbound	2	69.0	75.6	0.8	y
Temple Meads - outbound	2	49.8	71.0	2.7	y
Bath Rd - outbound	3	159.0	222.3	4.6	y
Bedminster - outbound	3	88.0	71.0	-1.9	y
Hotwells - outbound	1	136.5	85.5	-4.8	y
Clifton - outbound	2	5.3	6.4	0.4	y
Outbound *	19	814.0	776.2	88%	100%
Both directions *	38	1674.3	1428.4	81%	100%
Middle Cordon					
Clifton - inbound	4	207.5	223.6	1.1	y
Cotham - inbound	3	7.6	16.0	2.4	y
A38 - inbound	2	295.0	64.8	-17.2	n
Ashley Hill - inbound	2	27.9	75.7	6.6	y
M32 corridor - inbound	2	340.4	208.5	-8.0	n
Lawrence Hill - inbound	3	157.2	58.4	-9.5	y
Spine Rd - inbound	5	649.5	498.6	-6.3	n
Totterdown - inbound	3	69.5	60.0	-1.2	y
Parsons St - inbound	3	206.8	190.0	-1.2	y
Ashton Vale - inbound	2	78.5	15.7	-9.1	y
A370 - inbound	1	285.0	108.1	-12.6	n
Inbound *	30	2325	1519	36%	64%
Clifton - outbound	4	281.0	227.1	-3.4	y
Cotham - outbound	3	10.2	57.0	8.1	y
A38 - outbound	2	367.1	56.1	-21.4	n
Ashley Hill - outbound	2	22.9	53.9	5.0	y
M32 corridor - outbound	2	393.7	329.0	-3.4	y
Lawrence Hill - outbound	3	61.2	20.3	-6.4	y
Spine Rd - outbound	5	595.2	376.1	-9.9	n
Totterdown - outbound	3	156.6	202.6	3.4	y
Parsons St - outbound	3	300.7	143.4	-10.6	n
Ashton Vale - outbound	2	29.1	11.1	-4.0	y
A370 - outbound	1	164.9	132.2	-2.7	y
Outbound *	30	2382	1609	45%	73%
Both directions *	60	4707	3128	41%	68%

Table 3.9 – IP Short Screenline Results – Inner and Middle Cordon HGVs

Sub-cordon	No. of links	HGV Observed	Model	GEH	DMRB Link Flow
Inner Cordon					
Tyndalls - inbound	3	112.4	50.3	-6.9	y
St Pauls - inbound	3	186.4	233.6	3.3	y
Old Market - inbound	2	50.3	69.3	2.4	y
Temple Meads - inbound	2	117.6	70.7	-4.8	y
Bath Rd - inbound	3	166.6	201.3	2.6	y
Bedminster - inbound	3	166.8	163.7	-0.2	y
Hotwells - inbound	1	83.5	51.1	-3.9	y
Clifton - inbound	2	5.6	9.0	1.3	y
Inbound *	19	889.2	849.0	88%	100%
Tyndalls - outbound	3	113.5	78.9	-3.5	y
St Pauls - outbound	3	202.0	266.1	4.2	y
Old Market - outbound	2	53.9	53.1	-0.1	y
Temple Meads - outbound	2	52.5	104.5	5.9	y
Bath Rd - outbound	3	214.4	355.0	8.3	n
Bedminster - outbound	3	105.0	84.4	-2.1	y
Hotwells - outbound	1	54.8	27.6	-4.2	y
Clifton - outbound	2	3.0	18.8	4.8	y
Outbound *	19	799.0	988.4	75%	88%
Both directions *	38	1688.2	1837.4	81%	94%
Middle Cordon					
Clifton - inbound	4	246.8	308.5	3.7	y
Cotham - inbound	3	12.3	6.3	-2.0	y
A38 - inbound	2	216.1	30.2	-16.8	n
Ashley Hill - inbound	2	29.2	25.7	-0.7	y
M32 corridor - inbound	2	343.8	382.9	2.1	y
Lawrence Hill - inbound	3	94.3	81.6	-1.4	y
Spine Rd - inbound	5	485.5	366.3	-5.8	n
Totterdown - inbound	3	90.0	174.7	7.4	y
Parsons St - inbound	3	188.0	273.9	5.7	y
Ashton Vale - inbound	2	58.4	24.8	-5.2	y
A370 - inbound	1	139.7	123.4	-1.4	y
Inbound *	30	1904	1798	55%	82%
Clifton - outbound	4	265.3	278.8	0.8	y
Cotham - outbound	3	10.6	5.5	-1.8	y
A38 - outbound	2	205.0	29.2	-16.2	n
Ashley Hill - outbound	2	22.0	19.2	-0.6	y
M32 corridor - outbound	2	433.9	399.2	-1.7	y
Lawrence Hill - outbound	3	96.8	46.0	-6.0	y
Spine Rd - outbound	5	546.8	450.2	-4.3	y
Totterdown - outbound	3	145.2	142.8	-0.2	y
Parsons St - outbound	3	273.0	286.5	0.8	y
Ashton Vale - outbound	2	43.8	44.2	0.1	y
A370 - outbound	1	178.1	141.2	-2.9	y
Outbound *	30	2221	1843	82%	91%
Both directions *	60	4125	3641	68%	86%

Table 3.10 – PM Short Screenline Results – Inner and Middle Cordon HGVs

Sub-cordon	No. of links	HGV Observed	Model	GEH	DMRB Link Flow
Inner Cordon					
Tyndalls - inbound	3	69.2	6.1	-10.3	y
St Pauls - inbound	3	77.9	93.8	1.7	y
Old Market - inbound	2	12.5	11.0	-0.5	y
Temple Meads - inbound	2	118.9	108.7	-1.0	y
Bath Rd - inbound	3	60.6	125.9	6.8	y
Bedminster - inbound	3	63.0	42.8	-2.8	y
Hotwells - inbound	1	40.3	19.0	-3.9	y
Clifton - inbound	2	4.1	0.8	-2.1	y
Inbound *	19	446.5	408.0	75%	100%
Tyndalls - outbound	3	66.2	42.7	-3.2	y
St Pauls - outbound	3	60.2	10.4	-8.4	y
Old Market - outbound	2	14.6	19.4	1.2	y
Temple Meads - outbound	2	31.7	126.5	10.7	y
Bath Rd - outbound	3	72.4	71.6	-0.1	y
Bedminster - outbound	3	121.2	139.5	1.6	y
Hotwells - outbound	1	147.0	99.4	-4.3	y
Clifton - outbound	2	1.8	1.2	-0.5	y
Outbound *	19	515.0	510.7	75%	100%
Both directions *	38	961.5	918.7	75%	100%
Middle Cordon					
Clifton - inbound	4	256.1	38.0	-18.0	n
Cotham - inbound	3	2.5	10.0	3.0	y
A38 - inbound	2	169.3	26.3	-14.5	n
Ashley Hill - inbound	2	0.0	11.8		y
M32 corridor - inbound	2	81.3	120.1	3.9	y
Lawrence Hill - inbound	3	52.9	26.1	-4.3	y
Spine Rd - inbound	5	327.9	239.8	-5.2	y
Totterdown - inbound	3	63.2	38.2	-3.5	y
Parsons St - inbound	3	156.7	76.1	-7.5	y
Ashton Vale - inbound	2	41.4	46.8	0.8	y
A370 - inbound	1	111.8	16.7	-11.9	y
Inbound *	30	1263	650	55%	82%
Clifton - outbound	4	119.2	87.0	-3.2	y
Cotham - outbound	3	0.0	17.3		y
A38 - outbound	2	152.8	18.0	-14.6	n
Ashley Hill - outbound	2	5.1	6.5	0.6	y
M32 corridor - outbound	2	134.6	80.2	-5.3	y
Lawrence Hill - outbound	3	151.5	32.0	-12.5	n
Spine Rd - outbound	5	475.5	207.1	-14.5	n
Totterdown - outbound	3	84.1	84.9	0.1	y
Parsons St - outbound	3	293.6	108.8	-13.0	n
Ashton Vale - outbound	2	35.6	10.3	-5.3	y
A370 - outbound	1	290.1	98.4	-13.8	n
Outbound *	30	1742	750	36%	55%
Both directions *	60	3005	1400	45%	68%

Tables 3.11 (AM), 3.12 (IP) and 3.13 (PM) present a summary of the HGV calibration/validation for each of the cordons and screenlines throughout Bristol.

Jacobs

Table 3.11 – AM Peak Screenline and Cordon Calibration/Validation Summary

Screenlines and Cordon	No. of Counts	HGVs			
		Observed	Modelled	% difference	GEH
Inner (In)	21	344	261	-24%	4.79
Inner (Out)	21	326	310	-5%	0.85
Inner (Total)	42	670	571	-15%	3.95
East (In)	8	224	152	-32%	5.25
East (Out)	8	186	161	-13%	1.87
East (Total)	16	409	313	-24%	5.08
NW Inner (In)	13	620	702	13%	3.21
NW Inner (Out)	13	602	668	11%	2.64
NW Inner (Total)	26	1221	1371	12%	4.15
South (In)	11	220	183	-17%	2.60
South (Out)	11	193	207	8%	1.05
South (Total)	22	413	391	-5%	1.10
River (WBSB)	16	838	819	-2%	0.64
River (EBNB)	16	924	743	-20%	6.27
River (Total)	32	1762	1562	-11%	4.90
Railway (SB)	17	971	740	-24%	7.91
Railway (NB)	16	322	282	-12%	2.31
Railway (Total)	33	1293	1022	-21%	7.98
Outer (In)	26	993	847	-15%	4.80
Outer (Out)	26	834	903	8%	2.33
Outer (Total)	52	1827	1750	-4%	1.82
Middle (In)	30	930	608	-35%	11.62
Middle (Out)	30	953	644	-32%	10.95
Middle (Total)	60	1883	1251	-34%	15.96
NW Outer (In)	6	528	508	-4%	0.91
NW Outer (Out)	6	565	563	0%	0.06
NW Outer (Total)	12	1093	1071	-2%	0.67
NE (In)	12	126	141	12%	1.35
NE (Out)	12	111	121	9%	0.95
NE (Total)	24	237	263	11%	1.63
Total	614	21,381	18,868	-12%	17.72

Table 3.12 – Inter Peak Screenline and Cordon Calibration/Validation Summary

Screenlines and Cordon	No. of Counts	HGVs			
		Observed	Modelled	% difference	GEH
Inner (In)	21	356	340	-5%	0.86
Inner (Out)	21	320	395	24%	4.01
Inner (Total)	42	675	735	9%	2.25
East (In)	8	233	197	-15%	2.44
East (Out)	8	249	205	-18%	2.92
East (Total)	16	482	403	-17%	3.79
NW Inner (In)	13	552	647	17%	3.90
NW Inner (Out)	13	554	699	26%	5.81
N WInner (Total)	26	1105	1346	22%	6.88
South (In)	11	234	258	10%	1.56
South (Out)	11	237	244	3%	0.43
South (Total)	22	471	502	7%	1.42
River (WBSB)	16	900	894	-1%	0.19
River (EBNB)	16	929	1,002	8%	2.36
River (Total)	32	1828	1896	4%	1.57
Railway (SB)	17	830	754	-9%	2.71
Railway (NB)	16	343	335	-2%	0.43
Railway (Total)	33	1173	1088	-7%	2.51
Outer (In)	26	873	787	-10%	2.96
Outer (Out)	26	807	937	16%	4.41
Outer (Total)	52	1679	1724	3%	1.09
Middle (In)	30	762	719	-6%	1.56
Middle (Out)	30	888	737	-17%	5.30
Middle (Total)	60	1650	1456	-12%	4.91
NW Outer (In)	6	512	500	-2%	0.53
NW Outer (Out)	6	520	595	14%	3.19
NW Outer (Total)	12	1033	1096	6%	1.94
NE (In)	12	105	130	24%	2.32
NE (Out)	12	106	150	41%	3.83
NE (Total)	24	211	279	32%	4.37
Total	614	20,404	20,773	2%	2.57

Table 3.13 – PM Peak Screenline and Cordon Calibration/Validation Summary

Screenlines and Cordon	No. of Counts	HGVs			
		Observed	Modelled	% difference	GEH
Inner (In)	21	179	163	-9%	1.18
Inner (Out)	21	206	204	-1%	0.12
Inner (Total)	42	385	367	-4%	0.88
East (In)	8	117	70	-40%	4.87
East (Out)	8	179	59	-67%	10.98
East (Total)	16	296	129	-56%	11.45
NW Inner (In)	13	331	356	7%	1.32
NW Inner (Out)	13	337	445	32%	5.43
NW Inner (Total)	26	669	800	20%	4.86
South (In)	11	152	83	-45%	6.35
South (Out)	11	158	70	-56%	8.23
South (Total)	22	310	153	-51%	10.30
River (WBSB)	16	509	443	-13%	3.02
River (EBNB)	16	470	572	22%	4.48
River (Total)	32	978	1015	4%	1.15
Railway (SB)	17	479	341	-29%	6.81
Railway (NB)	16	215	158	-27%	4.19
Railway (Total)	33	693	498	-28%	7.99
Outer (In)	26	516	483	-6%	1.47
Outer (Out)	26	497	424	-15%	3.38
Outer (Total)	52	1012	907	-10%	3.41
Middle (In)	30	505	260	-49%	12.54
Middle (Out)	30	697	300	-57%	17.77
Middle (Total)	60	1202	560	-53%	21.63
NW Outer (In)	6	319	249	-22%	4.17
NW Outer (Out)	6	269	382	42%	6.28
NW Outer (Total)	12	588	631	7%	1.75
NE (In)	12	66	54	-18%	1.53
NE (Out)	12	58	101	74%	4.82
NE (Total)	24	124	155	25%	2.65
Total	614	12,392	10,279	-17%	19.85

4. Conclusion

The model has been validated using the guidance, measures and criteria recommended in TAG M3.1. The additional validation of goods vehicles set out in this note highlights the following:

- LGVs are generally well calibrated/validated on both the short screenline level and an individual link level screenlines and cordons;
- HGVs do not pass the WebTAG guidance for GEH statistics, but are close for the link flow difference criteria for the short screenlines and pass when each link is looked at individually;
- For both light and heavy goods vehicles, where WebTAG guidance is not met, the modelled flows are under assigned in some locations, over assigned in others; and
- The middle cordon relates closely to the medium CAZ boundary and the inner cordon relates closely to the small CAZ boundary. The calibration/validation of HGVs for the inner cordon is deemed more important than the middle cordon due the location of the compliance exceedances within Bristol. The HGV fit along the inner cordon is better than the middle cordon.

Bristol City Council Clean Air Plan Business Case

Primary Behavioural Response Calculation Methodology

FBC-26 | 7

February 2021

Bristol City Council

Bristol City Council Clean Air Plan Business Case

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6	17/12/2020	Draft 7	KW	CB	CB	HO
7	17/02/2021	Draft 7	KW	CB	CB	HO

Contents

1. Introduction

1.1 Clean Air Zone context

Poor air quality is the largest known environmental risk to public health in the UK[1]. Investing in cleaner air and doing more to tackle air pollution are priorities for the EU and UK governments, as well as for Bristol City Council (BCC). The Mayor of Bristol has often cited Bristol's 'moral and legal duty' to improve air quality in the city and the administration recognises that achieving improved air quality is not solely a transport issue. Notwithstanding the Council's work on a Clean Air Zone, efforts have been made to make citizens more aware of – and take personal responsibility for – various sources of air pollution, from traffic fumes to solid fuel burning. The Mayor has articulated a 'call to action' for local people, businesses and organisations to consider how small changes can make a significant difference in cutting toxic fumes across the city. BCC has monitored and endeavoured to address air quality in Bristol for decades and declared its first Air Quality Management Area in 2001. Despite this, Bristol has ongoing exceedances of the legal limits for Nitrogen Dioxide (NO_2) and these are predicted to continue until around 2027 without intervention.

The added context is that of the COVID-19 pandemic. Recent research suggests that poor air quality may be correlated with higher death / infection rates from COVID-19. This is further compounded by growing evidence that suggests that those from black, Asian and minority ethnic communities are more at risk of catching and dying from the virus and the fact that individuals from these communities are more likely to live in areas where air quality is poor. The challenge of maintaining public health and supporting economic recovery while also achieving legal air quality levels after lockdown restrictions are lifted will remain live and intersecting issues for the foreseeable future.

The UK Government continue to transpose European Union law into its Environment Bill[2] , to ensure that certain standards of air quality continue to be met, by setting air quality assessment levels (AQALs) on the concentrations of specific air pollutants. It's very unlikely that these AQALs will differ to EU Limit Values prescribed by the European Union's Air Quality Directive and transcribed in the UK's Air Quality Standards Regulation 2010. Therefore, these Limit Values will remain in enforcement post-Brexit. In common with many EU member states, the EU Limit Value for annual mean nitrogen dioxide (NO_2) is breached in the UK and there are on-going breaches of the NO_2 limit value in Bristol. The UK government is taking steps to remedy this breach in as short a time as possible, with the aim of reducing the harmful impacts on public health. Within this objective, the Government has published a UK Air Quality Plan and a Clean Air Zone Framework, both originally published in 2017 (noting there have been subsequent revisions). The latter document provides the expected approach for local authorities when implementing and operating a Clean Air Zone (CAZ). The following business cases have been submitted to JAQU for the Clean Air Plan; Strategic Outline Case (April 2018), and an Outline Business Case (November 2019 and updated between April and June 2020).

Following the submission of the OBC, further work was undertaken to develop the scheme, which resulted in the development of a new option - the Small area CAZ D. This work, and the option development work undertaken as part of the OBC, is presented in an updated Option Assessment Report (Appendix C FBC-16). The OBC version of this report is appended to the updated Option Assessment Report.

1.2 Purpose of this Report

This document is written to support the FBC and the methodology for calculating the behavioural response rates of non-compliant vehicles when they enter the scheme.

[1] Public Health England (2014) Estimating local mortality burdens associated with particular air pollution. https://www.gov.uk/government/publications/estimating-local-mortality-burdens-associated-with-particulate-air-pollution
[2] Environment Bill 2019-21 https://services.parliament.uk/bills/2019-21/environment.html

2. Overview of Methodology

The aim is to determine the local proportions for each of the four primary responses for non-compliant vehicles to the implementation of the scheme, which will replace the percentages shown in Table 2-1.

Table 2-1: 'Table 2 – Behavioural responses to charging Clean Air Zones' from JAQU Evidence Package

Proportions of non-compliant vehicle trips which react to the zone								
	Petrol Cars	Diesel Cars	Petrol LGVs	Diesel LGVs	RHGVs	AHGVs	Buses	Coaches
Pay charge – Continue into zone	7.1%	7.1%	20.3%	20.3%	8.7%	8.7%	0.0%	15.6%
Avoid Zone – Trips removed, modelled elsewhere	21.4%	21.4%	10.0%	10.0%	4.3%	4.3%	0.0%	0.0%
Cancel journey – trips removed completely	7.1%	7.1%	6.0%	6.0%	4.3%	4.3%	6.4%	12.5%
Upgrade Vehicle – trips replaced with compliant trips	64.3%	64.3%	63.8%	63.8%	82.6%	82.6%	93.6%	71.9%

Note: RHGVs – Rigid HGVs and AHGVs- Artic HGVs

The results from the local stated preference surveys have been used to determine primary behavioural responses rates for non-compliant cars if a CAZ were implemented in Bristol. For non-compliant light goods vehicles (LGVs), LGV responses from the stated preference surveys were used. Bus and Taxi responses are based on discussions with BCC and the service providers. For coaches, there are ongoing discussions with local coach operators to understand the fleet and likely responses, however due to the uncertainty and the relatively small proportion of the fleet that are coaches, the national response rates have been used as taken from 'Table 2 – Behavioural responses to charging Clean Air Zones' within the JAQU Evidence package, also shown above. The response rates for HGVs have also been taken from 'Table 2 – Behavioural responses to charging Clean Air Zones' in the Evidence Package, provided by JAQU in absence of reasonable local data.

3. Stated Preference Surveys

Stated preference surveys have been undertaken to determine local behavioural responses to the implementation of a charging CAZ in Bristol. The structure, implementation and outcomes of the survey are provided fully in OBC-28, Stated Preference Survey Report, whilst a brief summary is set out in this report.

The main part of the survey are two stated preference exercises, the first asked the respondent to consider their most recent trip through the zone and how they would have responded from the following choices:

- Paid the charge and travelled as before;
- Made the same journey but changed mode;
- Not have made the journey at all;
- Made the same journey purpose but changed the destination;
- Made the same journey but changed route to avoid the zone; or,
- Made the same journey but switched to another compliant vehicle in their household (this option will only be shown if the respondent has indicated in an earlier question that such a vehicle exists).

The second exercise asked respondents about the longer-term choice of whether they would continue to pay the charge to travel in the zone or would pay to upgrade the vehicle to a compliant one for a given hypothetical cost.

Once completed, the survey data underwent a cleaning process to identify and discard nonsensical questionnaires.

Statistical models were fitted to the data for each exercise and then combined into a single model in order to allow predictions to be made on behavioural changes in response to a specified charge level and upgrade cost. This information was then fed into the highway transport model as detailed in FBC-23, Local Plan Transport Modelling Methodology Report (T3), and outputs are detailed in FBC-27, Local Plan Transport Modelling Forecasting Report (T4).

4. Upgrade Costs

In order to determine the primary response rates over a range of CAZ charges from the stated preference surveys, an upgrade cost is required. The methodology for calculating the upgrade costs for Cars, LGVs and HGVs is outlined below.

The upgrade costs of other vehicle types (Taxi, Buses and Coaches) were not used to calculate the primary response rates. The primary response rates were determined by other information collated and this is discussed in the next section.

4.1 Cars

The cost of a new car was calculated by determining the most popular car models in the local area. A national list was obtained from the www.smmt.co.uk website, which is comparable with the most popular car models identified from the Bristol Automatic Number Plate Registration (ANPR) data. Prices for Petrol and Diesel models of the list of popular cars were extracted from the Parkers database for new car prices. Table 4-1 shows the new car prices for the most popular cars.

Table 4-1: New Car Prices based on Most Popular Cars

Model	**New**					
	Petrol			**Diesel**		
	High	**Low**	**Ave**	**High**	**Low**	**Ave**
Ford Fiesta	£ 20,000	£ 13,200	**£ 16,600**	£ 19,000	£ 14,200	**£ 16,600**
Ford Focus	£ 22,400	£ 17,600	**£ 20,000**	£ 22,500	£ 19,100	**£ 20,800**
Vauxhall Corsa	£ 19,300	£ 11,800	**£ 15,550**	£ 17,500	£ 13,500	**£ 15,500**
Vauxhall Astra	£ 23,400	£ 14,500	**£ 18,950**	£ 21,900	£ 16,100	**£ 19,000**
Volkswagen Golf	£ 25,000	£ 18,500	**£ 21,750**	£ 24,500	£ 19,100	**£ 21,800**
BMW 3 Series	£ 29,000	£ 22,900	**£ 25,950**	£ 32,500	£ 24,500	**£ 28,500**
MINI	£ 15,905	£ 20,635	**£ 18,270**			**£ -**
Volkswagen Polo	£ 17,500	£ 15,500	**£ 16,500**	£ 17,400	£ 15,800	**£ 16,600**
Renault Clio	£ 15,000	£ 11,000	**£ 13,000**	£ 15,500	£ 12,500	**£ 14,000**
Audi A3	£ 33,500	£ 20,500	**£ 27,000**	£ 31,000	£ 20,500	**£ 25,750**
Toyota Yaris	£ 14,500	£ 12,500	**£ 13,500**			**£ -**
Mercedes C Class	£ 35,500	£ 26,000	**£ 30,750**	£ 38,000	£ 27,000	**£ 32,500**
Average	**£ 22,584**	**£ 17,053**	**£ 19,818**	**£ 23,980**	**£ 18,230**	**£ 17,588**

4.2 LGVs and HGVs

The cost of a new LGV, rigid HGV and artic HGV have been calculated from the Publication by Road Haulage Association on the LGV and HGV operating costs, 2018, linked below.
http://www.transportengineer.org.uk/article-images/166209/Out_of_our_hands.pdf

Table 4-2: LGV and HGV 2018 New Vehicle Costs

Vehicle type	Detailed Vehicle Type	2018 Cost
LGV	Car derivative Vans - diesel	£14,244
	Vans of 3.5 tonnes gvw - diesel	£26,186
	Average	**£20,215**
Rigid HGV	7.5 tonne gvw	£42,570
	10 to 12 tonnes gvw	£50,419
	12 to 14 tonnes gvw	£53,934
	16 to 18 tonnes gvw	£70,929
	3 axle rigid veh 26 tonnes gvw	£90,457
	4 axle rigid tipper	£98,334
	Average	**£67,774**
Artic LGV	33 tonne gvw artic, 2 axle	£56,579
	38 tonne gvw artic, 2 axle	£81,300
	38 tonne gvw , 3 axle	£81,300
	32.5 tonne gvw drawbar combination, 2 axle	£63,363
	40 tonne gvw, 3 axle	£99,747
	44 tonne gvw, 3 axle	£106,680
	Average	**£81,495**

4.3 Depreciation Rates

A non-compliant vehicle will not always be replaced with a new compliant vehicle; therefore, depreciation rates were used to calculate the value of differing vehicles and ages. Table 4-3 shows the depreciation rates from the National data inputs for Local Economic Models, provided by JAQU for this project. These have been used, since no locally derived depreciation values are available.

Table 4-3 Depreciation Rates

Veh Type	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10+
Cars	37%	18%	16%	16%	16%	16%	16%	16%	16%	16%
LGVs	37%	18%	16%	16%	16%	16%	16%	16%	16%	16%
RHGVs	35%	18%	18%	18%	18%	18%	18%	18%	18%	18%
AHGVs	35%	18%	18%	18%	18%	18%	18%	18%	18%	18%
Buses	35%	18%	18%	18%	18%	18%	18%	18%	18%	18%

4.4 Vehicle Value by Age and Vehicle Type

The depreciation rates were used to calculate the value of Cars (Petrol and Diesel), LGVs and HGVs (Rigid and Artic) by age pivoting from the new prices calculated above. Table 4-4 shows the value by age and vehicle type.

Table 4-4: Value by Age and Vehicle Type

Year >>	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005
Cars (Petro	£12,486	£10,238	£8,600	£7,224	£6,068	£5,097	£4,282	£3,597	£3,021	£2,538	£2,132	£1,791	£1,504
Cars (Diese	£11,080	£9,086	£7,632	£6,411	£5,385	£4,524	£3,800	£3,192	£2,681	£2,252	£1,892	£1,589	£1,335
LGVs	£12,735	£10,443	£8,772	£7,369	£6,190	£5,199	£4,367	£3,669	£3,082	£2,589	£2,174	£1,827	£1,534
Rigid HGV	£44,053	£36,123	£29,621	£24,289	£19,917	£16,332	£13,392	£10,982	£9,005	£7,384	£6,055	£4,965	£4,071
Artic HGV	£52,972	£43,437	£35,618	£29,207	£23,950	£19,639	£16,104	£13,205	£10,828	£8,879	£7,281	£5,970	£4,896

Year >>	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992
Cars (Petro	£1,263	£1,061	£892	£749	£629	£528	£444	£373	£313	£263	£221	£186	£156
Cars (Diese	£1,121	£942	£791	£665	£558	£469	£394	£331	£278	£233	£196	£165	£138
LGVs	£1,289	£1,083	£909	£764	£642	£539	£453	£380	£319	£268	£225	£189	£159
Rigid HGV	£3,339	£2,738	£2,245	£1,841	£1,509	£1,238	£1,015	£832	£682	£560	£459	£376	£309
Artic HGV	£4,014	£3,292	£2,699	£2,213	£1,815	£1,488	£1,220	£1,001	£821	£673	£552	£452	£371

4.5 Average Upgrade Cost by Vehicle Type

Upgrade costs for each vehicle type and Euro Standard (and fuel type for cars) were calculated using the depreciated vehicle values presented in Table 4-4, comparing the resale cost of a non-compliant vehicle and the cost of purchasing a compliant vehicle.

To derive an average upgrade cost by vehicle type, the upgrade costs by vehicle type and euro standard were weighted by vehicle type sightings. The sightings of each vehicle type were calculated from the ANPR survey data for Bristol, split by euro standard. Table 4-5 shows the vehicle types split by euro standard.

Table 4-5: Vehicle Type by Euro Standard

Eurostandard	Cars			HGVs	
	Diesel	Petrol	LGV	Artic	Rigid
Euro 0	881	3758	1630	33	62
Euro 1	2253	7922	4232	28	125
Euro 2	10567	74509	13139	57	1484
Euro 3	132979	306612	56654	818	6512
Euro 4	222200	344012	104469	781	8629
Euro 5	366712	312304	220162	5752	24799
Euro 6	241605	221277	50323	9832	22576
Total	977197	1270394	450609	17301	64187

It was necessary to also account for 'secondary' behavioural responses within these calculations, to estimate the proportion of vehicles replaced by new or used vehicles, and the switch between diesel and petrol cars. In the absence of more accurate/local information, JAQU's assumptions from paragraph 3.3 of the Evidence Package, have been used, and are as follows:

- 25% of those with a non-compliant vehicle who upgrade will buy a brand-new vehicle of the same fuel type.
- The other 75% will replace their vehicle with a second-hand complaint vehicle. Of these, 75% of diesels owners will switch to petrol with the remainder keeping the same fuel type.

Table 4-6 shows the weighted upgrade cost calculations for Cars (Petrol and Diesel), LGV and HGVs (Rigid and Artic). The cost of resale is based on the lowest value of that vehicle type and euro standard. The cost of a compliant vehicle was calculated using on the secondary behavioural responses outlined above, and also based on an assumption that the lowest cost second-hand compliant vehicle will be purchased.

Table 4-6: Weighted Upgrade Costs

Vehicle Type	Euro Class	Euro Class Count	Resale Cost	Cost of Compliant Vehicle	Cost to Upgrade per vehicle	Cost to Upgrade total
Car (Petrol)	Euro 0	3758	£0	£ 6,297.58	£6,298	£23,666,314.01
	Euro 1	7922	£156	£ 6,297.58	£6,142	£48,654,184
	Euro 2	74509	£373	£ 6,297.58	£5,925	£441,446,269
	Euro 3	306612	£629	£ 6,297.58	£5,669	£1,738,037,809
	Weighted Average					**£5,732.69**
Car (Diesel)	Euro 0	881	£0	£ 6,835.12	£6,835	£6,021,743
	Euro 1	2253	£138	£ 6,835.12	£6,697	£15,087,769
	Euro 2	10567	£331	£ 6,835.12	£6,504	£68,730,373
	Euro 3	132979	£558	£ 6,835.12	£6,277	£834,692,484
	Euro 4	222200	£1,335	£ 6,835.12	£5,500	£1,222,161,742
	Euro 5	366712	£3,800	£ 6,835.12	£3,035	£1,113,107,712
	Weighted Average					**£4,431.54**
Weighted Average Car						**£4,884.47**
LGVs	Euro 0	1630	£0	£ 8,772	£8,772	£14,298,650.07
	Euro 1	4232	£159	£ 8,772	£8,613	£36,450,762
	Euro 2	13139	£380	£ 8,772	£8,392	£110,260,790
	Euro 3	56654	£642	£ 8,772	£8,131	£460,627,054
	Euro 4	104469	£1,534	£ 8,772	£7,238	£756,137,560
	Euro 5	220162	£4,367	£ 8,772	£4,405	£969,761,165
	Weighted Average					**£5,864.65**
HGV Rigid	Euro 0	62	£0	£29,621	£29,621	£1,836,516.36
	Euro 1	125	£309	£29,621	£29,313	£3,664,085.54
	Euro 2	1484	£832	£29,621	£28,789	£42,722,852.53
	Euro 3	6512	£1,509	£29,621	£28,112	£183,064,099.07
	Euro 4	8629	£4,071	£29,621	£25,550	£220,469,669.70
	Euro 5	24799	£13,392	£29,621	£16,229	£402,458,711.37
	Weighted Average					**£20,528.61**
HGV artic	Euro 0	33	£0	£35,618	£35,618	£1,175,398.35
	Euro 1	28	£371	£35,618	£35,247	£986,919.31
	Euro 2	57	£1,001	£35,618	£34,617	£1,973,191.44
	Euro 3	818	£1,815	£35,618	£33,803	£27,650,954.02
	Euro 4	781	£4,896	£35,618	£30,722	£23,994,264.50
	Euro 5	5752	£16,104	£35,618	£19,514	£112,246,825.31
	Weighted Average					**£22,496.66**

5. Proposed Charge Rates

The charges were initially set for cars, taxis and LGVs so that the responses of avoid zone, change mode / cancel journey and replace vehicle combined roughly equated to the combined JAQU CAZ responses in Table 2-1. These charges were found to be insufficient to bring about compliance and so testing with higher charges was undertaken. As the charge level increases, the additional response diminishes, and the final values arrived at are shown in Table 5-1 for the Small sized charging zone.

Table 5-1 Bristol Small CAZ Proposed Charges

Charge Vehicle Class	Charge per day
Cars	£9.00
Taxis	£9.00
LGVs	£9.00
HGVs	£100.00
Buses	£100.00
Coaches	£100.00

6. Primary Behavioural Responses

6.1 Calculated Response Rates for Small CAZ D

The methodology for calculating the primary response rates for all relevant vehicle types is summarised as follows:

- Cars – The upgrade cost has been used to determine a range of primary responses for different charge rates using the stated preference survey responses for non-compliant cars from the Small zone area;
- LGVs – The primary response rates are calculated from the stated preference survey responses which were identified as a 'van'. Again, the upgrade cost is used to determine a range of primary responses for different charge rates from the Small zone area;
- HGVs – The primary behavioural responses rates for HGVs were taken from 'Table 2 – Behavioural responses to charging Clean Air Zones' in the Evidence Package, provided by JAQU.;
- Taxis – The taxi response rate is based on Bristol enforcing compliance for Taxis through their licensing agreements with taxi operators;
- Coaches – The initial response rates for coaches were taken from 'Table 2 – Behavioural responses to charging Clean Air Zones' in the Evidence Package, provided by JAQU; and
- Buses – The response rates for buses were determined through discussions between Bristol and bus operators.

An adjustment for foreign vehicles has been applied to the responses rates calculated from the methodology set out above, as foreign vehicles cannot be reliably charged (their details are not captured in the DVLA database in order to determine if the vehicle is compliant and so enforcement can only occur through a manual process with limited powers). The final response rates will assume a 'worst case', i.e. that these vehicles continue to drive within the zone but do not pay the charge. In reality it is unlikely that this will be the case for all foreign vehicles.

Table 6-1 shows the final primary behavioural response rates by vehicle type produced by the methodology set out above and the charge rates in Table 5-1. These are the response rates that have been applied within the traffic model.

Table 6-1: Final Primary Behavioural Response Rates for Small CAZ D

Response	Cars Low Income	Cars Medium Income	Cars High Income	Cars Employers Business	Taxis	LGVs	HGVs	Buses	Coaches
Pay Charge	4.3%	10.4%	5.4%	6.8%	4.1%	15.9%	8.8%	0.0%	17.8%
Avoid Zone	15.6%	19.0%	15.7%	7.7%	0.0%	19.2%	4.3%	0.0%	0.0%
Cancel Journey / Change Mode	39.8%	20.4%	14.2%	30.7%	0.0%	2.6%	4.3%	6.4%	11.4%
Replace Vehicle	40.4%	50.3%	64.6%	54.8%	95.9%	62.2%	82.6%	93.6%	70.8%