Bath Clean Air Plan

Bath and North East Somerset Council

AQ2 Local Plan Air Quality Modelling Methodology Report

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2	13.12.19	Updated FBC Draft	AC (AQC)	CB	DJL
3	17.01.2020	Final FBC	AC (AQC)	CB	DJL

Contents

Acronyms and Abbreviations

ADMS	Atmospheric Dispersion Modelling System
ANPR	Automatic Number Plate Recognition
AQMA	Air Quality Management Area
ATC	Automatic Traffic Counters
BANES	Bath and North East Somerset Council
CAZ	Clean Air Zone
COPERT	Computer Programme to calculate Emissions from Road Transport
Defra	Department for Environment, Food & Rural Affairs
DfT	Department for Transport
EFT	Emission Factor Toolkit
fNO_2	Primary Nitrogen Dioxide
GBATH	Greater Bath Area Transport Model
HDV	Heavy Duty Vehicle
HGV	Heavy Goods Vehicle
JAQU	Joint Air Quality Unit (Defra and the Department for Transport)
LGV	Light Goods Vehicle
LSOA	Lower Super Output Area
$\mu g/m^3$	Microgrammes per cubic metre
NO_2	Nitrogen dioxide
NO	Nitrogen oxide
NOx	Nitrogen oxides (taken to be NO_2 + NO)
PCM	Pollution Climate Mapping
PM_{10}	Small airborne particles less than 10 micrometres in aerodynamic diameter
$PM_{2.5}$	Small airborne particles less than 2.5 micrometres in aerodynamic diameter

1. Introduction

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 Bath and North East Somerset Council (B&NES). B&NES has monitored and endeavoured to address air quality in Bath, and wider B&NES, since 2002. Despite this, Bath has ongoing exceedances of the legal limits for Nitrogen Dioxide (NO_2) and these are predicted to continue until 2025 without intervention.

In 2017 the government published a UK Air Quality Plan for Nitrogen Dioxide[2] setting out how compliance with the EU Limit Value for annual mean NO_2 will be reached across the UK in the shortest possible time. Due to forecast air quality exceedances, B&NES, along with 27 other Local Authorities, was directed by Minister Therese Coffey (Defra) and Minister Jesse Norman (DfT) in 2017 to produce a Clean Air Plan (CAP). The Plan must set out how B&NES will achieve sufficient air quality improvements in the shortest possible time. In line with Government guidance B&NES 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.

Jacobs has been commissioned by B&NES to produce an Outline Business Case (OBC) and 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 Bath. The OBC assessed the shortlist of options set out in the Strategic Outline Case[3], and proposed a preferred option including details of delivery. The FBC develops the preferred option set out in the Outline Business Case, detailing the commercial, financial and management requirements to implement and operate the scheme. The OBC and FBC form a bid to central government for funding to implement the CAP.

This document is written to support the OBC and FBC.

1.1 Purpose of this Report

This report sets out the air quality modelling methodology which outlines the approach taken to model the air quality impacts, including a description of the modelling methods used, details of monitoring data for calibration of the model and a description of how transport model outputs have been fed into air quality modelling. It also sets out how the emissions from vehicles of different Euro standards have been calculated and projected, together with how changes in primary NO_2 emission fraction, f-NO_2, have been taken into account.

The air quality modelling methodology is described in detail, in order that JAQU can understand and approve the approach.

[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] https://www.gov.uk/government/publications/air-quality-plan-for-nitrogen-dioxide-no2-in-uk-2017
[3] Bath and North East Somerset Council Clean Air Plan: Strategic Outline Case, March 2018 (http://www.bathnes.gov.uk/sites/default/files/siteimages/Environment/Pollution/strategic_outline_case_bath_28.03.2018_with_annexes.pdf)

2. Air Quality Model Specification

2.1 Model Selection

The selected road traffic emission model was the latest Emission Factor Toolkit (EFT) Version available at the time of the study (v8.0.1a). The use of this emission model is specified in JAQU's 'Transport and Air Quality' guidance and this version of the EFT was provided by JAQU. The EFT is based on the European Environment Agency's COPERT emission tool. The EFT allows users to calculate road transport pollutant emission rates for oxides of nitrogen (NO_X), primary nitrogen dioxide (f-NO_2) and Particulate Matter (PM_{10} & $PM_{2.5}$) for a specified year, road type, vehicle speed and vehicle fleet composition.

Dispersion modelling will be undertaken using ADMS-Roads version 4.1, which is one of the "standard" models recommended in JAQU's 'Transport and Air Quality' guidance. The model is approved by Defra and used extensively in the UK. Typical applications include modelling for Review and Assessment, quantification of air quality action plan measures, such as Low Emission Zones, Clean Air Zones, and assessment of new developments through the planning process.

The ADMS 'Advanced Canyon Module' has been used to allow for a more accurate representation of the dispersion patterns within street canyons, including asymmetrical canyons. The study area includes Bath city centre, which comprises a large number of street canyons. The dispersion of emissions from traffic is influenced by the presence of tall buildings, or other obstacles such as trees, along roads, which leads to elevated roadside pollutant concentrations. To capture this phenomenon, where necessary, buildings and other obstacles within the study area have been represented within ADMS.

2.2 Air Quality Base Model Year

The model base year is 2017, with monitoring data for this year used to verify and adjust the modelled concentrations.

2.3 Air Quality Model Domain

The model domain includes all roads that are listed within the national Pollution Climate Mapping (PCM) model for the study area, as exceeding the annual mean Limit Value in 2020 for NO_2 (as published by Defra), as well as roads where annual mean NO_2 concentrations are known to exceed the national air quality objective, based on the most recent review and assessment report published by BANES.

The domain also includes all potential displacement routes affected by the measures, which have been identified from the traffic model.

Figure 1 below shows the domain for the study, which covers the majority of urban areas in Bath, including the Air Quality Management Area (AQMA). The study area extends well beyond the road network that will be affected by changes in traffic in order that the health impacts can be quantified incorporating all densely populated areas of population (in some cases very small changes in concentrations applied across a large population base can account for significant health impacts).

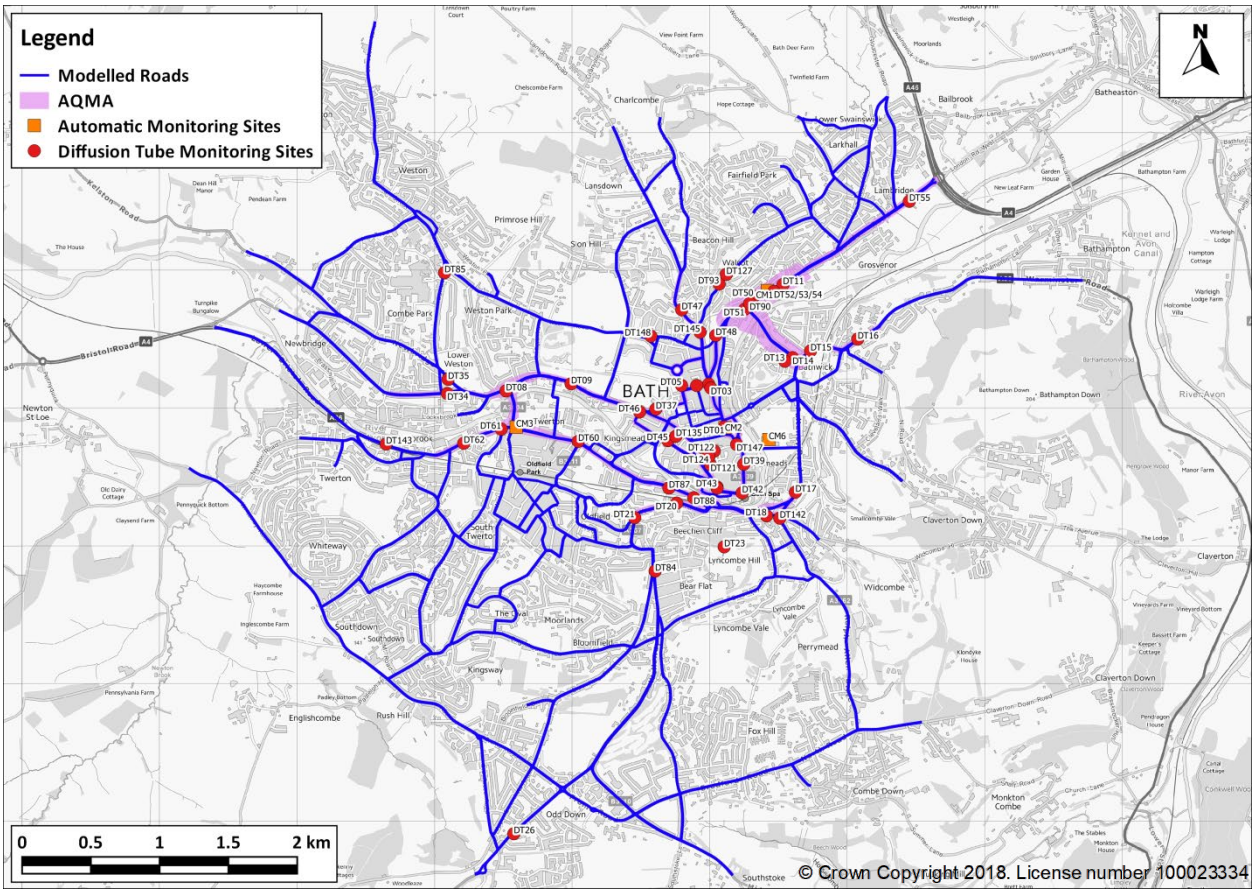

Figure 1: Study Area Showing Modelled Roads, AQMA and 2017 Monitoring Sites

2.4 Air Quality Model Receptor Locations

The following receptor locations will be included in the model:

- Address base information will be used to calculate population-weighted mean concentration values for each Lower Super Output Area (LSOA), which will then be used within the distributional analysis. These will be modelled at a height of 1.5 m to represent relevant exposure. These receptors have not been included in the Target Determination exercise, or the FBC.
- Selected monitoring site locations have been used to verify and calibrate the model. These include automatic and passive (diffusion tube) monitors. These have been modelled at the actual height of each monitor.
- For each link included in the PCM model, multiple receptors have been included within the model at 2 m height and 4 m distance from the kerbside on both sides of the road. For each link, the receptor with the maximum predicted concentration has been used to facilitate a comparison between the local model results and the PCM model.
- A representative set of worst-case receptors for each location identified as either exceeding or likely to exceed the NO_2 annual mean air quality Objective. These have been modelled at a height of 1.5 m to represent relevant exposure for the Air Quality Objectives.

A subset of the receptors listed above (i.e. the third bullet point) has been selected to assess compliance with the NO_2 Limit Value through the target determination process with JAQU. The receptors selected for compliance have been chosen at least 25 m from major junctions and are representative of at least a 100 m length of road (as detailed in the Air Quality Directive (Annex III: A, B, and C)). A number of receptors have been modelled along each relevant PCM link and the worst-case concentration has been reported for the Target Determination exercise.

3. Air Quality Base Year Modelling

3.1 Meteorological data

An appropriate base year and meteorological site location has been used when considering meteorological data, as per Defra Technical Guidance, TG16 (Defra, 2016). The meteorological station located at Filton Airfield in Bristol is considered to be the nearest and most representative meteorological station. Data from this station has thus been used for the year 2017.

As recommended by Defra's Technical Guidance (TG16), meteorological, background pollution, monitoring and emissions data have all been derived from the same base year as the model (i.e. 2017). Table 1 provides more detail of the meteorological site location and modelled parameters. Figure 2 illustrates a wind rose of pre and post processed meteorological data.

Table 1: Meteorological Site location and Modelled Parameters

Parameter	Meteorological Site (Pre Processed)	Study Area (Post Processed)
Location	Filton Airfield	n/a
OS Grid reference	360057, 180491	n/a
Surface Roughness	0.1	1
Minimum Monin Obukhov Length	30	30

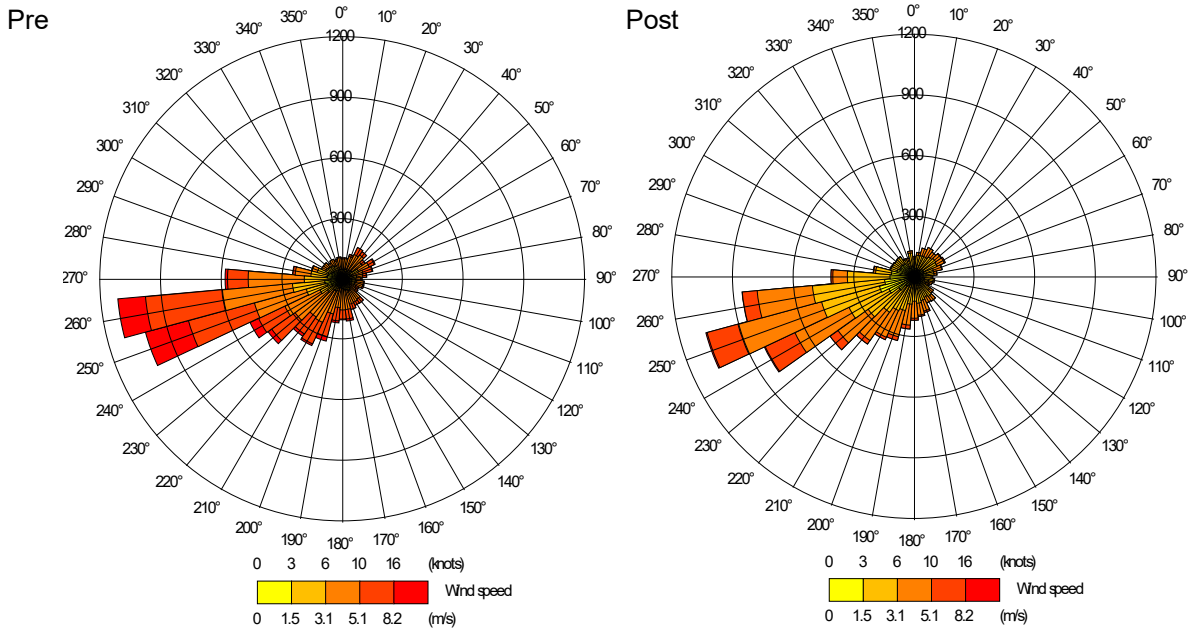

Figure 2: Wind Speed and Direction Data for Filton Airfield 2017, Pre and Post Processed by ADMS-Roads

3.2 Traffic Input Data

Traffic flows by vehicle type have been sourced from the transport model SATURN (GBATH). The following vehicle types are considered: cars (diesel and petrol), Light Good's Vehicles (LGVs), Heavy-Duty Vehicles (HDV) (i.e. the sum of Heavy Goods Vehicles (HGVs), buses and coaches). Motorcycles are not considered given their low number and the lack of data available.

LGV and HDV emissions have been adjusted for uphill roads with a gradient of greater than 2.5%, which is intended to account for the increase in emissions when the LGVs and HDVs are driving uphill. A technical

note explaining the methodology used is included in Appendix A of FBC-11 'AQ3 Air Quality Modelling Report'.

Proportions of rigid and articulated HDVs have been estimated from Automatic Traffic Counter (ATC) data and/or Automatic Number Plate Recognition (ANPR) data, and taxi proportions have been taken from the ANPR data.

Vehicle speeds have been sourced from SATURN and adjusted close to junctions based on experience. Traffic master data has been used to compare speeds at key locations, but no changes to speeds were included. Further assessment of any differences noted is provided in the Sensitivity Test Report (FBC-31, appendix N to FBC).

The fleet composition has been obtained from local ANPR data to provide vehicle details. Emissions have been calculated using the EFT 'advanced user euro split' to reflect the local ANPR data.

Road links have been manually adjusted to reproduce the actual geometry making use of Ordnance Survey Mastermapping.

3.3 NO_X/NO_2 emissions assumptions

The EFT has been used to calculate location specific f-NO_2 values based on the fleet composition for each location for which traffic NOx emissions are calculated.

In order to calculate total NO_2 concentrations from NO_X concentrations, the LAQM NO_X to NO_2 calculator v6.1 (with user defined f-NO_2) has been used. This is the approach recommended by JAQU.

3.4 Background Pollutant data

Background NO_x, NO_2 and PM_{10} concentrations, for the 2017 base year, have been derived from Defra's background mapped data https://uk-air.defra.gov.uk/data/laqm-background-maps?year=2015 based on COPERT 5.0. A calibration with the 2017 urban background diffusion tube air quality monitoring station at Alexandra Park in Bath has been undertaken. The measured nitrogen dioxide concentration at this site in 2017 was 13.1 µg/m^3, while the mapped background for the grid square within which it lies was 9.3 µg/m^3. All mapped background nitrogen dioxide concentrations have therefore been calibrated by applying a factor of 1.41. Since there are no background monitoring sites that measure PM_{10} or $PM_{2.5}$, mapped background concentrations of PM_{10} and $PM_{2.5}$ have not been adjusted.

3.5 Measurement data for model calibration

Modelled NO_x and PM concentrations have been verified against the 2017 BANES automatic monitoring stations and, in the case of NO_2, at a selection of diffusion tubes. Data have been collected in accordance with TG16 and have been bias-adjusted.

All roadside automatic monitoring stations have been included, while a screening of diffusion tube data has been performed to ensure the data used are not significantly affected by non-road sources. The verification, and subsequent calibration, process follows TG16 guidance. Table 2 overleaf provides further detail of the monitoring sites used in the calibration process. Monitors with names beginning "CM" are continuous monitors while those beginning "DT" are diffusion tubes. Figure 1 shows the location of monitors available for 2017 in BANES.

All monitoring sites have QA procedures in place. Diffusion tube data have been bias adjusted and annualised where necessary. The Council's continuous analysers also follow a QA/QC programme; the London Road Monitor is the Bath AURN affiliate site and is managed as part of that network. The Guildhall, Windsor Bridge and Chelsea House sites follow the QA/QC programme described below:

- There are daily checks on the data to ensure analysers and communications are working and faults are reported as soon as possible.
- The sites are inspected and calibrated; checks are made once a month by a member of the Environmental Quality Team at Bristol City Council, using certified traceable gases.
- The sites are also visited once a month by a trained AURN Local Site Operator (LSO) to change the filters and check the analysers. These are planned so the site is visited once a fortnight.
- The analysers are also serviced and re-calibrated at six monthly intervals by the equipment suppliers.
- The results of all service, maintenance and calibration checks are held and used for ratification and scaling of the data.

Annual reports on air quality for LAQM purposes for B&NES Council can be found at http://www.bathnes.gov.uk/services/environment/pollution/air-quality/reports. Reports include details of QA/QC undertaken for monitoring.

Table 2: Details of Monitoring Sites used in Model Calibration

Monitoring Site ID	Location	Distance from kerb (m)	In Canyon?	On gradient?	Measured NO_2 Concentration 2017 (µg/m^3)	Adjusted Modelled Concentration 2017 (µg/m^3)
CM1	London Road	5.00	Yes	No	44.8	42.5
CM2	Guildhall	4.60	Yes	No	30.3	35.1
CM3	Windsor Bridge	2.00	No	No	32.7	37.9
DT01	High Street	3.60	Yes	No	36.0	35.9
DT03	Broad Street	3.50	Yes	Yes	47.5	44.2
DT04	George Street	2.20	Yes	No	35.7	30.3
DT05	Gay Street – Top	5.70	Yes	Yes	36.2	31.3
DT08	Windsor Bridge	4.00	No	No	34.4	35.9
DT09	Upper Bristol Road	1.00	Yes	No	40.2	35.5
DT11	London Road	1.80	Yes	No	38.1	41.9
DT14	Bathwick Street	2.20	Yes	No	43.6	46.5
DT15	Beckford Road	0.25	No	Yes	33.6	32.1
DT16	Warminster Road	1.95	No	Yes	36.0	34.0
DT17	Widcombe School	2.20	Yes	No	35.4	37.1
DT18	Widcombe High Street	3.90	Yes	No	28.2	25.0
DT20	Wells Road	4.50	Yes	No	51.7	45.2
DT21	Wells Road /Upper Oldfield Park	1.65	No	Yes	43.5	41.7
DT26	Upper Wellsway	3.80	No	No	32.1	25.4
DT34	Newbridge Road	1.96	Yes	No	37.6	37.6
DT35	Newbridge Hill	5.70	No	Yes	37.8	36.0
DT37	Charlotte Street	0.25	Yes	Yes	37.8	32.4

Monitoring Site ID	Location	Distance from kerb (m)	In Canyon?	On gradient?	Measured NO_2 Concentration 2017 ($\mu g/m^3$)	Adjusted Modelled Concentration 2017 ($\mu g/m^3$)
DT39	Manvers Street	1.90	Yes	No	38.4	42.7
DT42	Dorchester Street	0.35	Yes	No	58.2	54.0
DT43	St. James Parade	1.20	Yes	No	45.9	48.5
DT45	James Street West	2.10	Yes	No	39.9	37.9
DT46	Little Stanhope Street	0.35	Yes	No	36.6	39.8
DT47	Lansdown Crescent	3.30	No	Yes	30.7	29.1
DT48	Paragon	2.30	No	No	38.4	28.5
DT51	Cleveland Place West	0.40	Yes	No	44.6	40.1
DT52/53/54	Walcot Terrace	0.40	Yes	No	44.7	41.8
DT55	Lambridge	1.70	No	Yes	46.1	51.5
DT60	Victoria Terrace	2.20	Yes	No	46.2	45.8
DT61	Morley Terrace	1.70	No	No	38.5	39.0
DT62	Argyle Terrace	0.90	Yes	No	44.8	35.1
DT84	Bearflat	2.20	Yes	No	32.9	29.8
DT85	RUH North	0.90	Yes	No	32.0	27.7
DT87	Oak Street	2.10	Yes	No	33.4	38.3
DT88	Angel Place	2.60	No	No	42.0	32.8
DT90	Anglo Terrace	1.30	Yes	No	56.6	62.9
DT93	Lower Camden Place, Camden Road	0.15	Yes	Yes	29.4	28.0
DT127	Gays Hill, Camden	0.45	Yes	Yes	30.6	29.7
DT142	Prior Park Road	1.20	Yes	Yes	40.5	37.6
DT143	Rackfield Place	3.90	No	No	32.3	28.7
DT145	Lansdown Road	0.45	Yes	Yes	33.3	37.9

There are a number of monitoring sites that have not been included in the model verification, including ten sites within Bath. All of these sites are located too far away (>15 m) from the modelled roads to provide a robust verification of the local road contribution to concentrations. These sites, along with their distances from the kerb of the nearest modelled road, are presented in Table 3 below.

Table 3: Details of Monitoring Sites not used in Model Calibration

Monitoring Site ID	Location	Distance from kerb (m)
CM4	Chelsea House	15
DT13	Daniel Street	55
DT23	Alexandra Park	275
DT50	Thomas Street	32
DT121	Lower Borough Walls	48
DT122	Stall Street	94
DT123	Beau Street	77
DT124	Bath Street	74
DT135	Rosewell Court	48
DT147	Terrace Walk	26

3.6 Treatment of Canyons

Accurate dispersion modelling in urban areas can be difficult due to the presence of obstacles (buildings, trees, walls, etc.) that modify the wind flow locally and alter dispersion. This is especially the case in so called “street canyons”, where buildings on both sides of the road can lead to the formation of vortices and recirculation of air flow that can trap pollutants and restrict dispersion (often termed as the “canyon effect”). Although street canyons were once defined as narrow streets where the height of buildings on both sides of the road is greater than the road width, there are numerous examples whereby broader streets may also be considered as street canyons, where buildings result in reduced dispersion and elevated concentrations (which may be demonstrated by monitoring data). The model domain in Bath has a large number of street canyons, both due to the presence of historic buildings, but also walls, trees etc. Appendix A contains a table showing the parameters of the canyons included within the advanced canyon module of the ADMS-Roads model. Canyons have been defined manually, using Google street view with OS mapping being used to define canyon widths.

3.7 Treatment of Gradients

Emissions on roads with gradients of over 2.5% have been adjusted following the method outlined in TG16 and guidance from JAQU. The methodology is based on an analysis of the emission factors published for use within the COPERT 4 model. Older vehicles are based on the emission factors published in August 2007, and newer vehicles are based on the September 2014 update. The TG16 and JAQU method is to adjust emissions for pre-2014 HDVs only, with no adjustment for later model vehicles or LGVs.

Despite emissions on roads with gradients being adjusted, the model appeared to be behaving differently at roads with gradients. Further analysis has been carried out, which found a relationship between the NOx underestimation and LGV plus HDV emissions on uphill lanes of gradient roads. This analysis has determined that model predictions are improved if emissions from LGVs and HDVs on uphill lanes of gradient roads are uplifted independently from all other modelled emissions. A technical note explaining this is included in Appendix A of FBC-11 ‘AQ3 Air Quality Modelling Report’. Figure 3 shows the roads in Bath which have been modelled as gradients.

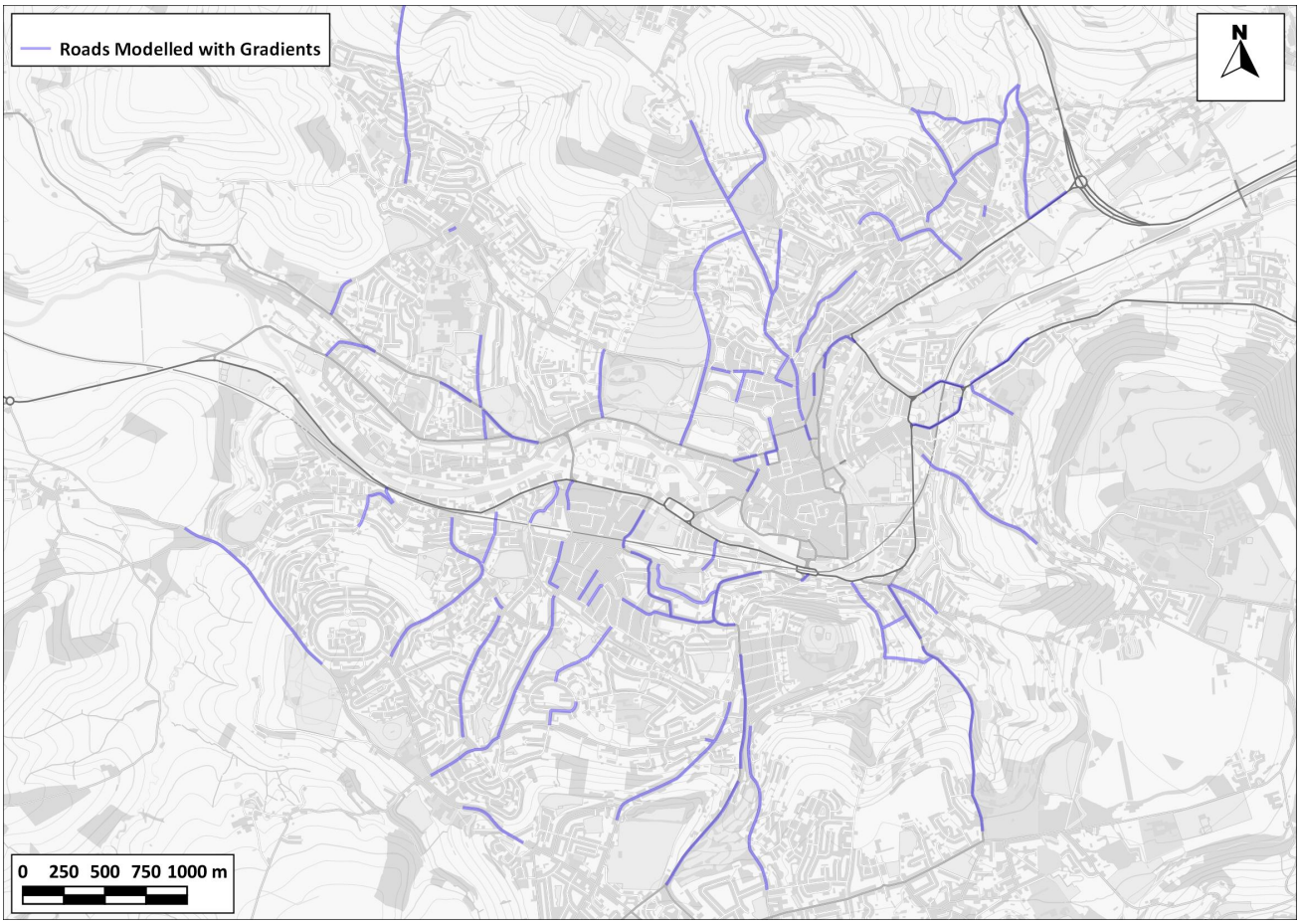

Figure 3: Roads Modelled as Gradients

3.8 Treatment of Flyovers

There are no flyovers in the modelled domain, and therefore have not been included in the model.

3.9 Train Emissions

Trains have not been explicitly included in the model. A technical note agreed with JAQU is included in Appendix B to further explain the reasoning.

3.10 Diurnal Profile for Emissions

Figure 4 shows the diurnal profile for emissions used in the modelling. These flow profiles for the traffic have been derived from the national profiles published by DfT. These profiles for total traffic volumes have thus been assumed to apply to emissions, regardless of any diurnal profiles in speed or congestion.

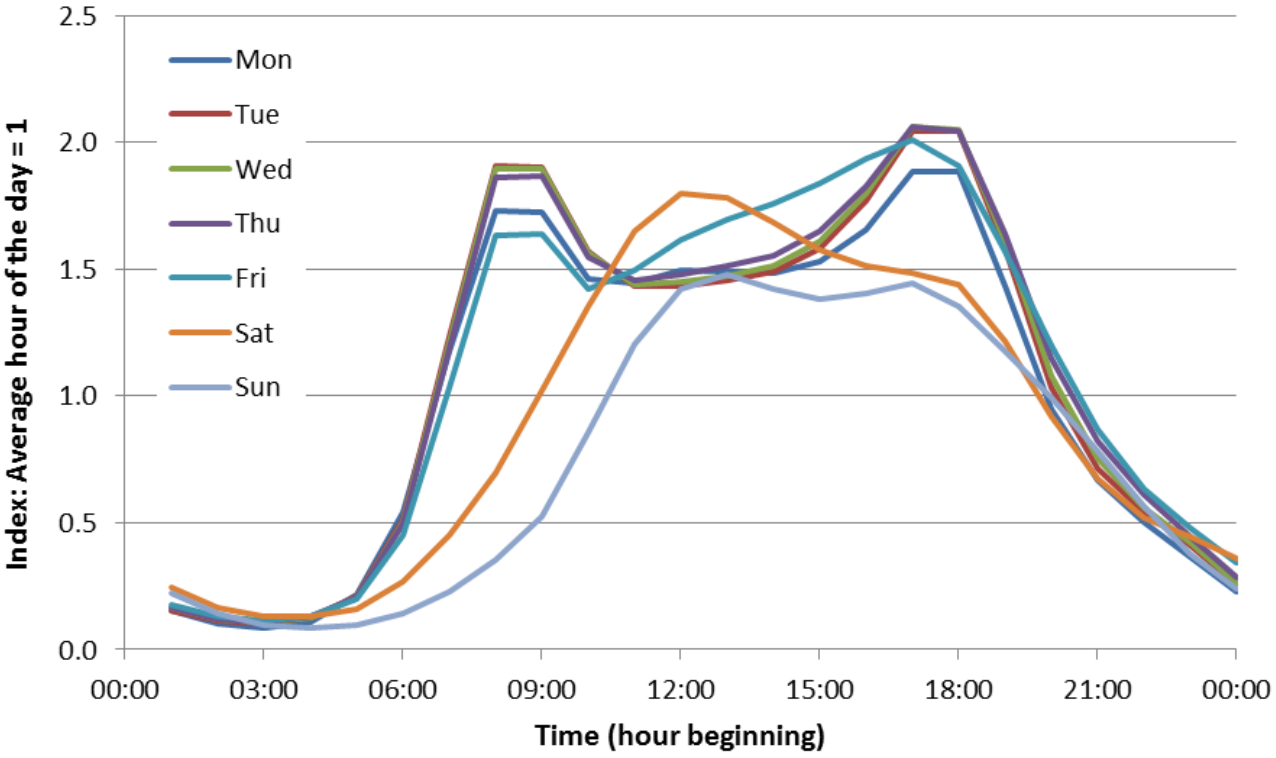

Figure 4: Diurnal Profile for Vehicle Emissions Used in the Modelling

4. Baseline Projections Modelling (without measures)

4.1 Base Year (2017) – for model verification

The latest available version of the transport model that covers BANES is based on the year 2014. A 2017 transport model has been developed using growth factors from 2014 to 2017 (see T3 'Local Plan Transport Modelling Methodology Report' (FBC-13) included in Appendix E of the FBC for more details).

4.2 Compliance Year (2021) - without measures

The compliance year is 2021 and the 2021 traffic flows by vehicle type have been extracted from the 2021 GBATH traffic model.

The 2017 ANPR fleet composition data has been used as the basis for a forecast of the 2021 fleet, since it accurately reflects the local situation. These data have been combined with the anticipated changes in the national fleet set out in the EFT in order to develop a 2021 fleet composition.

In order to calculate future fleet emissions 10 years beyond compliance to inform options appraisal, changes in the national fleet proportions have been applied to the local fleet data established from the ANPR data.

5. Projections Modelling (with measures)

5.1 Compliance Year (2021) - with measures

The impact of measures on air quality have been evaluated for the compliance year 2021. In particular, the effect of measures on the fleet composition in specific areas has been represented in the air quality model.

The 2021 traffic flows have been provided by the GBATH model, which has been used to assess each scenario. Details of the methodology for this assessment are provided in Chapter 5 of T3 'Local Plan Transport Modelling Methodology Report' (FBC-13) in Appendix E of the FBC. Changes in the fleet composition have been estimated using data provided by JAQU on the rate of replacement of existing vehicles with new/used vehicle combined with local ANPR data.

In order to calculate future fleet emissions 10 years beyond compliance to inform the options appraisal, the effect of measures on the traffic flows has been modelled in GBATH 2031 model. The fleet has been estimated using a similar method to 2021, using local ANPR data to reflect the local circumstances and accounting for changes in the national fleet proportions.

Appendix A. Canyon Parameters

Table 4: Details of Street Canyon Parameters Used in the Model

Road	Left Side of Street Canyon					Right Side of Street Canyon				
	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)
Arlington Rd SB	9.0	7.5	7.5	7.5	28.0	10.0	7.0	7.0	7.0	43.3
Avondale Buildings EB	4.0	3.0	2.0	8.0	50.0	6.0	7.0	6.0	7.0	16.4
Barton St NB	8.0	10.0	9.5	15.0	19.9	6.0	12.0	10.0	15.0	17.0
Bathwick Hill EB	13.0	12.0	11.0	12.5	26.6	13.0	12.0	9.0	15.0	25.9
Bathwick Hill NB	8.0	8.0	5.0	12.0	70.0	16.0	15.0	10.0	17.0	32.6
Bathwick Hill NB	8.0	12.0	9.0	15.0	25.2	18.0	12.0	11.0	12.5	26.0
Bathwick Hill SB	10.0	15.0	10.0	17.0	33.4	15.0	8.0	5.0	12.0	70.0
Bathwick Hill SB	10.0	5.0	3.0	10.0	60.0	15.0	7.0	2.0	10.0	30.0
Bathwick Hill WB	10.0	7.0	2.0	10.0	30.0	15.0	5.0	3.0	10.0	60.0
Bathwick St EB	0.0	0.0	0.0	0.0	100.0	13.0	12.0	12.0	12.0	23.4
Bathwick St EB	7.5	12.0	12.0	12.0	5.0	13.0	10.0	10.0	10.0	12.5
Bathwick St EB	7.5	12.0	12.0	12.0	15.7	13.5	15.0	15.0	15.0	33.2
Bathwick St WB	7.5	15.0	15.0	15.0	32.6	13.0	12.0	12.0	12.0	14.9
Bathwick St WB	7.5	10.0	10.0	10.0	13.5	13.0	12.0	12.0	12.0	5.0
Bathwick St WB	7.5	12.0	12.0	12.0	27.0	0.0	0.0	0.0	0.0	100.0
Beckhampton Rd NB	0.0	0.0	0.0	0.0	100.0	9.5	6.5	6.5	6.5	10.0
Beckhampton Rd SB	6.5	6.5	6.5	6.5	10.0	0.0	0.0	0.0	0.0	100.0
Bennett St EB	9.0	12.0	12.0	12.0	20.4	10.0	11.0	11.0	11.0	100.0
Bennett St EB	8.0	12.0	12.0	12.0	10.1	14.0	12.0	12.0	12.0	100.0
Bennett St EB	5.0	12.0	12.0	12.0	46.0	9.7	12.0	12.0	12.0	100.0
Bennett St WB	7.0	11.0	11.0	11.0	36.1	12.0	12.0	12.0	12.0	100.0
Bennett St WB	11.0	12.0	12.0	12.0	20.0	11.0	12.0	12.0	12.0	100.0
Bennett St WB	6.0	12.0	12.0	12.0	45.6	9.0	12.0	12.0	12.0	100.0
Bloomfield Rd NB	10.0	6.0	6.0	6.0	24.9	0.0	0.0	0.0	0.0	100.0
Bloomfield Rd NB	11.0	8.0	7.0	10.0	58.1	0.0	0.0	0.0	0.0	100.0
Bloomfield Rd SB	0.0	0.0	0.0	0.0	100.0	14.0	6.0	6.0	6.0	23.6
Bloomfield Rd SB	0.0	0.0	0.0	0.0	100.0	15.0	8.0	7.0	10.0	57.7
Bradford Rd EB	8.0	7.0	7.0	7.0	21.4	8.0	5.0	5.0	5.0	12.7
Bradford Rd WB	5.0	5.0	5.0	5.0	13.9	11.0	7.0	7.0	7.0	22.6
Bridge Rd NB	7.0	6.0	3.0	7.0	9.2	10.0	6.0	4.0	10.0	26.2
Bridge Rd NB	7.0	6.0	4.0	7.0	18.8	10.0	6.0	5.5	7.0	28.5
Bridge Rd SB	7.0	6.0	5.5	7.0	28.4	11.0	6.0	4.0	7.0	18.7

Road	Left Side of Street Canyon					Right Side of Street Canyon				
	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)
Bridge Rd SB	7.0	6.0	4.0	10.0	25.4	11.0	6.0	3.0	7.0	8.1
Bridge St EB	7.0	13.0	13.0	13.0	5.0	9.0	14.0	14.0	14.0	5.0
Broad Quay NB	0.0	0.0	0.0	0.0	100.0	10.0	16.0	16.0	16.0	45.9
Broad Quay WB	0.0	0.0	0.0	0.0	100.0	13.0	16.0	16.0	16.0	13.0
Broad St NB	5.5	16.0	16.0	16.0	60.2	5.5	10.5	8.5	13.0	12.4
Broad St NB	5.5	11.0	10.0	14.0	45.5	5.5	12.0	9.0	13.0	16.4
Broad St NB	6.0	13.0	8.0	13.0	5.9	6.0	15.0	10.0	20.0	5.9
Broad St NB	6.0	13.0	10.0	13.0	5.0	6.0	14.0	10.0	14.0	5.0
Broad St WB	6.0	13.0	13.0	13.0	10.0	0.0	0.0	0.0	0.0	100.0
Broad St WB	6.0	13.0	13.0	13.0	10.2	6.0	20.0	20.0	20.0	100.0
Brock St EB	6.8	12.0	12.0	12.0	15.4	9.5	12.0	12.0	12.0	100.0
Brock St WB	6.5	12.0	12.0	12.0	13.4	9.3	12.0	12.0	12.0	100.0
Brook Rd NB	6.0	6.5	6.5	7.0	26.0	9.0	6.0	5.0	6.5	19.5
Brook Rd WB	6.0	6.0	5.0	6.5	19.8	9.0	6.5	6.5	7.0	26.3
Brookleaze Buliding2 EB	10.0	7.0	7.0	7.5	10.0	13.0	8.0	4.0	9.2	10.0
Brooklyn Rd EB	7.0	6.0	6.0	6.5	8.2	9.0	6.0	6.0	6.5	9.2
Brooklyn Rd EB	7.0	6.0	6.0	6.5	5.1	9.0	5.0	2.0	6.5	51.5
Brooklyn Rd EB	9.5	3.0	3.0	3.0	24.5	9.0	7.0	6.5	8.0	26.7
Brooklyn Rd NB	9.5	3.0	3.0	3.0	27.7	9.0	8.0	6.5	9.0	50.1
Brooklyn Rd SB	6.5	8.0	6.5	9.0	48.6	12.0	3.0	3.0	3.0	25.6
Brooklyn Rd WB	6.0	5.0	2.0	6.5	51.3	10.0	6.0	6.0	6.5	4.6
Brooklyn Rd WB	6.0	6.0	6.0	6.5	8.9	10.0	6.0	6.0	6.5	7.9
Brooklyn Rd WB	6.5	7.0	6.5	8.0	26.4	12.0	3.0	3.0	3.0	24.2
Brougham Hayes NB	6.0	6.0	1.0	6.5	24.2	12.0	15.0	3.0	15.5	36.6
Brougham Hayes NB	6.0	6.0	2.0	7.0	20.0	12.0	2.0	2.0	9.5	20.0
Brougham Hayes SB	8.0	2.0	2.0	9.5	20.0	9.0	6.0	2.0	7.0	20.0
Brougham Hayes SB	7.0	15.0	3.0	15.5	36.8	11.0	6.0	1.0	6.5	24.4
Brunswick Pl EB	4.5	10.0	3.0	14.0	48.7	8.0	13.0	13.0	13.0	100.0
Brunswick Pl WB	4.5	13.0	13.0	13.0	28.9	7.0	10.0	3.0	14.0	100.0
Camden Crescent NB	10.0	16.5	16.5	16.5	5.0	0.0	0.0	0.0	0.0	100.0
Camden Crescent NB	10.0	16.5	16.5	16.5	5.0	0.0	0.0	0.0	0.0	100.0
Camden Crescent SB	0.0	0.0	0.0	0.0	100.0	12.0	16.5	16.5	16.5	5.0
Camden Crescent SB	0.0	0.0	0.0	0.0	100.0	12.0	16.5	16.5	16.5	5.0

Road	Left Side of Street Canyon					Right Side of Street Canyon				
	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)
Camden Rd EB	4.0	4.0	3.0	10.0	20.0	6.5	6.0	5.0	9.0	32.0
Camden Rd EB	5.0	10.0	9.0	13.0	16.6	11.0	5.0	2.0	12.0	60.0
Camden Rd EB	9.0	9.0	8.0	9.0	30.0	0.0	0.0	0.0	0.0	100.0
Camden Rd NB	5.5	3.0	2.0	7.0	20.0	9.3	9.0	7.0	10.0	5.0
Camden Rd WB	4.0	6.0	5.0	9.0	32.8	6.5	4.0	3.0	10.0	20.0
Camden Rd WB	6.5	9.0	7.0	10.0	5.0	8.0	3.0	2.0	7.0	20.0
Camden Rd WB	8.0	5.0	2.0	12.0	60.0	8.0	10.0	9.0	13.0	16.9
Camden Rd WB	0.0	0.0	0.0	0.0	100.0	12.0	9.0	8.0	9.0	30.0
Cavendish Rd NB	0.0	0.0	0.0	0.0	100.0	9.0	5.0	2.0	15.0	70.0
Cavendish Rd NB	5.0	15.0	15.0	15.0	90.0	11.5	18.0	18.0	18.0	61.5
Cavendish Rd NB	5.0	9.0	9.0	11.5	61.1	11.5	12.0	3.0	17.0	48.7
Cavendish Rd NB	0.0	0.0	0.0	0.0	100.0	15.0	5.0	2.0	15.0	70.0
Cavendish Rd SB	9.0	12.0	3.0	17.0	46.2	8.0	9.0	9.0	11.5	59.2
Cavendish Rd SB	9.0	18.0	18.0	18.0	61.4	8.0	15.0	15.0	15.0	90.0
Cavendish Rd SB	6.0	5.0	2.0	15.0	70.0	0.0	0.0	0.0	0.0	100.0
Cavendish Rd SB	11.0	5.0	2.0	15.0	70.0	0.0	0.0	0.0	0.0	100.0
Chapel Row EB	0.0	0.0	0.0	0.0	100.0	9.0	12.0	12.0	12.0	100.0
Chapel Row EB	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	100.0
Chapel Row NB	4.3	20.0	20.0	20.0	19.7	9.0	10.0	8.0	12.0	100.0
Chapel Row SB	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	100.0
Chapel Row WB	4.5	10.0	8.0	12.0	15.1	8.3	20.0	20.0	20.0	100.0
Chapel Row WB	5.0	12.0	12.0	12.0	4.9	0.0	0.0	0.0	0.0	100.0
Charles St NB	8.5	10.0	10.0	10.0	17.2	10.0	13.0	13.0	13.0	100.0
Charles St NB	9.0	12.0	10.0	12.0	44.0	15.0	14.0	14.0	18.0	100.0
Charles St SB	5.0	13.0	13.0	13.0	28.9	13.0	10.0	10.0	10.0	100.0
Charles St SB	8.0	14.0	14.0	14.0	2.1	14.0	10.0	10.0	10.0	100.0
Charles St SB	8.0	13.0	13.0	13.0	43.1	17.0	12.0	12.0	12.0	100.0
Charlotte Street EB	6.5	11.0	11.0	15.0	2.6	10.0	9.0	8.0	12.0	2.6
Charlotte Street WB	6.0	9.0	8.0	12.0	3.6	10.5	11.0	11.0	15.0	3.6
Cheap St WB	6.0	13.0	13.0	13.0	24.2	5.5	12.5	12.5	18.0	24.2
Cheap St WB	6.0	13.0	13.0	13.0	25.8	5.5	12.5	12.5	40.0	24.2
Circus NB	15.0	14.0	14.0	14.0	9.9	0.0	0.0	0.0	0.0	100.0
Circus SB	15.0	14.0	14.0	14.0	10.1	0.0	0.0	0.0	0.0	100.0

Road	Left Side of Street Canyon					Right Side of Street Canyon				
	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)
Circus W WB	15.0	14.0	14.0	14.0	10.0	0.0	0.0	0.0	0.0	100.0
Claverton Street EB	8.0	9.0	9.0	9.0	5.0	7.0	9.0	9.0	9.0	15.0
Claverton Street EB	8.0	10.0	9.0	10.0	10.0	8.0	12.0	12.0	12.0	76.7
Claverton Street EB	8.0	9.0	7.0	12.0	0.0	9.0	12.0	12.0	12.0	10.0
Cleveland Pl SB	15.0	13.0	13.0	13.0	0.0	0.0	0.0	0.0	0.0	100.0
Cleveland Pl WB	10.0	12.0	12.0	12.0	0.0	0.0	0.0	0.0	0.0	100.0
Combe Park NB	5.0	6.0	2.0	14.0	32.9	7.9	9.5	9.5	9.5	42.5
Combe Park NB	0.0	0.0	0.0	0.0	100.0	7.5	3.0	3.0	3.0	5.0
Combe Park NB	5.0	10.0	5.0	15.0	80.0	18.0	10.0	10.0	10.0	19.3
Combe Park NB	8.0	8.0	7.5	12.0	41.5	19.0	8.5	7.5	10.0	37.9
Combe Park NB	14.0	8.5	7.5	10.0	10.0	19.0	8.5	7.5	10.0	10.0
Combe Park NB	15.0	8.5	7.5	10.0	31.6	19.0	10.6	10.6	10.6	24.7
Combe Park SB	4.2	9.5	9.5	9.5	43.1	8.0	6.0	2.0	8.0	33.6
Combe Park SB	14.0	10.0	10.0	10.0	20.0	8.0	10.0	5.0	15.0	80.0
Combe Park SB	16.0	8.5	7.5	10.0	10.0	17.0	8.5	7.5	10.0	40.0
Combe Park SB	16.0	8.5	7.5	10.0	37.7	17.0	8.0	7.5	12.0	41.4
Combe Park SB	16.0	10.6	10.6	10.6	25.3	18.0	8.5	7.5	10.0	32.1
Combe Park SB	4.0	3.0	3.0	3.0	5.0	0.0	0.0	0.0	0.0	100.0
Combe Rd NB	4.5	6.5	6.5	6.5	35.7	12.0	6.0	6.0	7.5	74.3
Combe Rd SB	8.0	6.5	6.0	7.8	20.0	6.0	6.0	5.0	6.5	40.0
Combe Rd SB	10.0	6.0	6.0	7.5	73.6	7.5	6.5	6.5	6.5	34.0
Combe Rd WB	4.0	6.0	5.0	6.5	40.0	10.0	6.5	6.0	7.8	20.0
Corn St EB	7.0	9.0	9.0	9.0	60.0	7.0	15.0	15.0	15.0	100.0
Corn St EB	4.0	7.0	7.0	7.0	27.1	0.0	0.0	0.0	0.0	100.0
Corn St EB	9.0	12.0	12.0	12.0	5.1	12.0	6.0	6.0	6.0	100.0
Corn St EB	9.0	16.0	16.0	16.0	40.3	12.0	12.0	12.0	12.0	100.0
Corn St WB	0.0	0.0	0.0	0.0	100.0	8.0	7.0	7.0	7.0	100.0
Corn St WB	7.0	6.0	6.0	6.0	40.0	14.0	12.0	12.0	12.0	100.0
Corn St WB	7.0	12.0	12.0	12.0	60.0	14.0	16.0	16.0	16.0	100.0
Coronation Ave NB	6.0	6.0	5.5	6.5	4.5	11.0	6.0	2.0	6.5	12.0
Coronation Ave SB	7.0	6.0	2.0	6.5	11.8	10.0	6.0	5.5	6.5	4.2
Crescent Ln NB	5.0	7.0	6.0	7.0	5.0	0.0	0.0	0.0	0.0	100.0
Crescent Ln SB	0.0	0.0	0.0	0.0	100.0	9.5	7.0	6.0	7.0	100.0

Road	Left Side of Street Canyon					Right Side of Street Canyon				
	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)
Crown Rd EB	6.0	7.0	7.0	7.0	70.0	7.0	4.0	4.0	4.0	20.0
Crown Rd NB	3.0	4.0	4.0	4.0	20.0	10.0	7.0	7.0	7.0	70.0
CS Car Park NB	0.0	0.0	0.0	0.0	100.0	8.0	4.0	4.0	4.0	100.0
CS Car Park SB	4.0	4.0	4.0	4.0	50.0	0.0	0.0	0.0	0.0	100.0
Cynthia Rd EB	5.0	6.5	6.5	6.5	60.2	9.0	6.0	3.5	6.5	5.0
Cynthia Rd EB	6.0	6.0	2.0	7.0	32.1	11.0	6.0	2.0	7.0	80.0
Cynthia Rd SB	8.3	6.0	2.5	7.0	11.6	11.0	6.0	1.5	7.0	9.4
Cynthia Rd WB	5.0	6.0	3.5	6.5	5.0	9.0	6.5	6.5	6.5	60.0
Cynthia Rd WB	7.0	6.0	2.0	7.0	14.2	9.0	6.0	2.0	7.0	33.9
Cynthia Rd WB	8.0	6.0	1.5	7.0	9.4	11.0	6.0	2.5	7.0	11.5
Darlington St NB	9.5	16.5	16.5	16.5	17.6	0.0	0.0	0.0	0.0	100.0
Darlington St SB	0.0	0.0	0.0	0.0	100.0	15.5	16.5	16.5	16.5	18.4
Dartmouth Ave NB	6.0	6.0	2.0	7.0	8.6	8.0	6.5	2.0	8.5	16.0
Dartmouth Ave SB	6.0	6.5	2.0	8.5	16.2	8.0	6.0	2.0	7.0	8.8
Dorchester St EB	6.0	15.0	15.0	15.0	20.0	10.0	12.0	12.0	12.0	60.0
Dorchester St EB	6.0	15.0	15.0	15.0	15.3	11.0	12.0	12.0	12.0	28.0
Dorchester St EB	6.0	15.0	14.0	16.0	10.0	0.0	0.0	0.0	0.0	100.0
Dorchester St EB	7.0	15.0	15.0	15.0	20.0	0.0	0.0	0.0	0.0	100.0
Dorchester St SB	8.0	10.0	10.0	10.0	10.0	8.0	12.0	12.0	14.0	44.1
Dorchester St WB	0.0	0.0	0.0	0.0	100.0	8.0	12.0	12.0	18.0	5.0
Dorchester St WB	0.0	0.0	0.0	0.0	100.0	10.0	15.0	14.0	16.0	10.0
Dorchester St WB	6.0	12.0	12.0	12.0	60.0	10.0	15.0	15.0	15.0	20.0
Dorchester St WB	0.0	0.0	0.0	0.0	100.0	11.0	15.0	15.0	15.0	20.0
Dorchester St WB	6.0	12.0	12.0	12.0	27.0	11.0	15.0	15.0	15.0	14.1
Eastbourne Av EB	12.0	7.0	7.0	7.0	15.0	13.0	7.5	7.5	7.5	10.0
Eastbourne Av WB	10.0	7.5	7.5	7.5	10.0	15.0	7.0	7.0	7.0	15.0
Edward St SB	9.0	12.5	8.5	16.0	20.0	14.0	10.0	8.5	16.0	36.2
Edward St WB	9.0	10.0	8.5	16.0	37.9	14.0	12.5	8.5	16.0	20.0
Entry Hill EB	9.5	9.0	8.5	10.0	12.2	5.0	2.5	2.5	3.0	10.0
Entry Hill NB	7.0	7.0	1.0	10.0	80.0	6.0	3.0	2.5	5.0	55.0
Entry Hill NB	4.5	7.0	2.5	7.5	10.0	7.0	3.0	2.0	7.0	70.0
Entry Hill NB	0.0	0.0	0.0	0.0	100.0	7.5	7.5	2.0	7.5	72.6
Entry Hill NB	3.0	2.5	2.5	3.0	10.0	12.0	9.0	8.5	10.0	9.0

Road	Left Side of Street Canyon					Right Side of Street Canyon				
	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)
Entry Hill NB	5.0	8.0	2.0	10.0	60.0	12.0	7.0	1.5	12.0	40.0
Entry Hill SB	4.5	3.0	2.0	7.0	67.6	7.2	7.0	2.5	7.5	2.9
Entry Hill SB	4.0	3.0	2.5	5.0	55.0	11.0	7.0	1.0	10.0	80.0
Entry Hill SB	9.5	7.0	1.5	12.0	40.0	7.5	8.0	2.0	10.0	60.0
Entry Hill SB	4.8	7.5	2.0	7.5	72.7	0.0	0.0	0.0	0.0	100.0
Fairfield Rd NB	10.0	7.0	7.0	9.0	30.0	11.0	8.0	8.0	8.5	20.0
Fairfield Rd NB	8.0	8.0	8.0	8.5	20.0	13.0	7.0	7.0	9.0	30.0
Fairfield Rd NB	6.5	8.0	7.0	9.0	8.8	15.0	7.5	7.0	7.5	57.4
Fairfield Rd SB	12.0	7.5	7.0	7.5	57.4	9.5	8.0	7.0	9.0	8.7
Frome Rd EB	3.0	2.0	2.0	2.0	20.0	7.0	2.0	2.0	2.0	20.0
Frome Rd EB	6.0	7.5	7.0	7.5	57.6	9.0	3.5	3.5	3.5	38.0
Frome Rd EB	11.0	5.5	5.5	5.5	21.5	15.0	6.0	5.0	6.8	55.1
Frome Rd SB	3.0	2.0	2.0	2.0	20.0	7.0	2.0	2.0	2.0	20.0
Frome Rd WB	4.0	2.0	2.0	2.0	20.0	6.0	2.0	2.0	2.0	20.0
Frome Rd WB	4.0	2.0	2.0	2.0	20.0	6.0	2.0	2.0	2.0	20.0
Frome Rd WB	5.0	3.5	3.5	3.5	38.8	9.0	7.5	7.0	7.5	58.1
Frome Rd WB	11.0	6.0	5.0	6.8	53.1	15.0	5.5	5.5	5.5	18.0
Gay St NB	7.5	13.0	13.0	13.0	4.5	11.0	13.0	13.0	13.0	4.5
Gay St NB	8.0	10.0	3.0	15.0	63.4	10.0	13.0	13.0	13.0	5.0
Gay St NB	7.5	13.0	13.0	13.0	7.7	11.0	13.0	13.0	13.0	26.8
Gay St NB	8.0	14.5	14.5	14.5	63.9	10.0	12.0	12.0	12.0	47.8
Gay St SB	7.5	13.0	13.0	13.0	28.2	11.0	13.0	13.0	13.0	9.5
Gay St SB	6.0	12.0	12.0	12.0	48.6	12.0	14.5	14.5	14.5	64.4
Gay St SB	7.5	13.0	13.0	13.0	5.7	11.0	13.0	13.0	13.0	5.7
Gay St SB	6.0	13.0	12.5	13.0	5.0	12.0	10.0	3.0	15.0	60.7
Grand Parade SB	0.0	0.0	0.0	0.0	100.0	7.0	15.0	9.0	29.0	20.0
Great Pulteney St EB	14.0	18.0	18.0	18.0	5.2	20.0	18.0	18.0	18.0	11.7
Great Pulteney St EB	14.0	18.0	18.0	18.0	25.5	20.0	18.0	18.0	18.0	18.2
Greenway Ln EB	4.0	4.0	2.5	6.0	50.0	6.0	5.0	2.0	8.0	15.0
Greenway Ln WB	4.0	5.0	2.0	8.0	15.0	6.0	4.0	2.5	6.0	50.0
Green Park Rd NB	0.0	0.0	0.0	0.0	100.0	11.0	12.0	12.0	12.0	100.0
Green Park Rd SB	7.0	11.0	11.0	12.0	30.1	0.0	0.0	0.0	0.0	100.0
Grt Pulteney St WB	14.0	18.0	18.0	18.0	19.4	20.0	18.0	18.0	18.0	68.1

Road	Left Side of Street Canyon					Right Side of Street Canyon				
	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)
Grt Pulteney St WB	14.0	18.0	18.0	18.0	11.7	20.0	18.0	18.0	18.0	5.2
Guinea Ln EB	4.0	9.0	9.0	9.0	32.9	7.0	12.0	12.0	12.0	100.0
Guinea Ln EB	4.0	7.0	6.0	9.0	4.7	4.0	7.0	7.0	7.0	100.0
Guinea Ln EB	0.0	0.0	0.0	0.0	100.0	6.5	10.0	8.0	15.0	100.0
Hatfield Rd EB	2.5	4.0	3.0	5.0	39.2	5.5	3.0	3.0	4.0	5.0
Hatfield Rd WB	3.0	3.0	3.0	4.0	5.0	5.0	4.0	3.0	5.0	39.6
Herbert Rd NB	6.0	6.5	6.5	6.5	19.4	9.0	6.5	6.5	6.5	7.0
Herbert Rd SB	6.0	6.5	6.5	6.5	7.0	9.0	6.5	6.5	6.5	19.4
High St EB	5.0	8.0	8.0	8.0	25.0	8.0	8.0	5.0	9.0	50.0
High St EB	5.0	7.0	7.0	7.0	60.0	11.8	9.0	9.0	9.0	19.4
High St EB	5.0	3.5	3.5	7.8	60.0	11.8	7.5	6.0	8.5	32.5
High St EB	6.0	10.0	10.0	10.0	50.0	0.0	0.0	0.0	0.0	100.0
High St NB	6.0	8.0	7.0	9.0	15.0	5.0	6.0	4.0	7.0	30.0
High St NB	8.2	7.5	6.0	8.5	27.0	8.0	3.5	3.5	7.8	60.0
High St NB	0.0	0.0	0.0	0.0	100.0	10.0	15.5	15.5	15.5	5.0
High St NB	10.0	13.0	11.5	14.5	0.0	10.0	14.0	13.0	14.5	5.0
High St NB	11.0	12.5	12.5	12.5	0.0	7.5	16.5	14.0	17.0	5.0
High St NB	7.0	14.0	14.0	14.0	0.0	0.0	0.0	0.0	0.0	100.0
High St WB	4.0	8.0	5.0	9.0	50.0	8.0	8.0	8.0	8.0	25.0
High St WB	8.2	9.0	9.0	9.0	18.9	8.0	7.0	7.0	7.0	60.0
James St W EB	9.0	12.0	12.0	12.0	20.1	12.0	12.0	12.0	12.0	100.0
James St W EB	10.0	14.0	14.0	14.0	25.8	11.0	7.0	7.0	7.0	100.0
James St W EB	6.5	14.0	14.0	14.0	40.0	13.0	14.0	14.0	14.0	100.0
James St W EB	3.0	3.0	3.0	3.0	80.4	8.0	12.0	12.0	12.0	100.0
James St W EB	5.5	10.0	7.0	12.0	31.8	8.0	12.0	12.0	12.0	100.0
James St W EB	6.0	12.0	12.0	12.0	30.1	10.0	15.0	15.0	15.0	100.0
James St W EB	17.0	12.0	12.0	12.0	39.9	0.0	0.0	0.0	0.0	100.0
James St W EB	8.5	8.0	7.0	9.0	5.0	7.0	8.0	8.0	8.0	100.0
James St W EB	6.0	10.0	8.0	12.0	59.5	7.0	8.0	8.0	10.0	100.0
James St W WB	8.0	12.0	12.0	12.0	59.1	13.0	12.0	12.0	12.0	100.0
James St W WB	6.0	7.0	7.0	7.0	40.8	15.0	14.0	14.0	14.0	100.0
James St W WB	9.5	14.0	14.0	14.0	9.9	10.5	14.0	14.0	14.0	100.0
James St W WB	5.0	12.0	12.0	12.0	70.3	6.0	3.0	3.0	3.0	100.0

Road	Left Side of Street Canyon					Right Side of Street Canyon				
	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)
James St W WB	4.3	12.0	12.0	12.0	36.5	9.0	10.0	7.0	12.0	100.0
James St W WB	6.0	15.0	15.0	15.0	20.0	10.0	12.0	12.0	12.0	100.0
James St W WB	0.0	0.0	0.0	0.0	100.0	21.0	12.0	12.0	12.0	100.0
Julian Rd Cres Ln EB	5.0	11.0	11.0	12.5	50.0	8.5	8.0	7.0	9.0	5.0
Julian Rd Cres Ln EB	5.0	12.5	12.5	13.2	61.9	8.5	9.0	7.0	9.0	10.0
Julian Rd Cres Ln WB	4.2	9.0	7.0	9.0	10.0	9.0	12.5	12.5	13.2	62.0
Julian Rd Cres Ln WB	4.2	8.0	7.0	9.0	5.0	9.0	11.0	11.0	12.5	50.0
Julian Rd EB	5.0	8.0	6.0	12.0	18.8	0.0	0.0	0.0	0.0	100.0
Julian Rd EB	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	100.0
Julian Rd EB	13.0	5.0	5.0	5.0	34.5	8.5	7.0	6.0	7.0	100.0
Julian Rd EB	7.0	12.0	10.0	15.0	17.8	8.5	13.0	13.0	13.0	100.0
Julian Rd EB	8.0	12.0	12.0	20.0	59.4	8.5	8.0	2.0	12.0	100.0
Julian Rd WB	0.0	0.0	0.0	0.0	100.0	8.0	8.0	6.0	12.0	100.0
Julian Rd WB	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	100.0
Julian Rd WB	5.0	7.0	6.0	7.0	6.3	18.0	5.0	5.0	5.0	100.0
Julian Rd WB	5.0	13.0	13.0	13.0	21.3	11.0	12.0	10.0	15.0	100.0
Julian Rd WB	5.0	8.0	2.0	12.0	64.1	11.5	12.0	12.0	20.0	100.0
Junction Rd NB	7.0	7.0	2.0	9.0	32.7	8.0	2.0	2.0	7.0	50.0
Junction Rd SB	5.0	2.0	2.0	7.0	50.0	10.0	7.0	2.0	9.0	32.0
King Edward Rd EB	10.0	6.5	2.0	10.0	38.7	14.0	8.0	2.0	12.0	32.7
King Edward Rd WB	11.0	6.5	3.5	6.5	62.1	13.0	6.5	6.5	6.5	69.6
Lansdown Rd EB	8.0	13.0	13.0	13.0	39.7	18.0	10.0	4.0	12.0	100.0
Lansdown Rd NB	5.0	10.0	8.0	15.0	36.5	10.0	13.0	13.0	15.0	32.9
Lansdown Rd NB	7.0	11.0	11.0	11.0	10.0	10.0	9.0	5.0	12.0	30.0
Lansdown Rd NB	9.0	13.0	13.0	13.0	14.8	12.0	10.5	3.8	15.0	37.2
Lansdown Rd NB	8.0	13.0	13.0	13.0	15.1	13.0	15.0	14.0	17.0	100.0
Lansdown Rd NB	8.0	13.0	13.0	13.0	27.1	14.5	14.0	14.0	14.0	0.0
Lansdown Rd NB	5.0	10.0	8.0	15.0	20.0	10.0	13.0	13.0	15.0	5.0
Lansdown Rd NB	7.0	10.0	4.0	12.0	5.2	12.0	13.0	13.0	13.0	100.0
Lansdown Rd NB	4.0	11.0	11.0	11.0	50.0	6.0	10.0	7.0	11.5	54.0
Lansdown Rd NB	3.0	3.0	3.0	15.0	60.0	13.5	8.0	7.0	10.0	60.0
Lansdown Rd SB	6.0	13.0	13.0	15.0	5.0	9.0	10.0	8.0	15.0	20.0
Lansdown Rd SB	6.0	9.0	5.0	12.0	30.0	11.0	11.0	11.0	11.0	10.0

Road	Left Side of Street Canyon					Right Side of Street Canyon				
	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)
Lansdown Rd SB	7.0	10.5	3.8	15.0	36.9	14.0	13.0	13.0	13.0	14.3
Lansdown Rd SB	9.0	15.0	14.0	17.0	10.0	12.0	13.0	13.0	13.0	100.0
Lansdown Rd SB	10.0	14.0	14.0	14.0	0.0	12.0	13.0	13.0	13.0	26.6
Lansdown Rd SB	6.0	13.0	13.0	15.0	32.1	9.0	10.0	8.0	15.0	35.6
Lansdown Rd SB	10.5	8.0	7.0	10.0	60.0	6.5	3.0	3.0	15.0	60.0
Lansdown Rd SB	3.8	10.0	7.0	11.5	53.8	7.0	11.0	11.0	11.0	50.0
Lansdown Rd SB	5.0	10.0	8.9	15.0	30.0	0.0	0.0	0.0	0.0	100.0
Lansdown Rd WB	0.0	0.0	0.0	0.0	100.0	9.0	10.0	8.9	15.0	30.0
Lansdown View NB	5.0	7.0	7.0	7.0	48.8	8.0	6.0	6.0	6.0	55.6
Lansdown View NB	5.0	6.5	3.0	7.5	66.8	12.0	6.5	6.5	6.5	58.6
Lansdown View NB	8.5	6.0	5.5	8.0	66.5	12.5	7.0	6.5	7.0	11.3
Lansdown View SB	5.0	6.0	6.0	6.0	56.9	8.0	7.0	7.0	7.0	50.3
Lansdown View SB	10.0	6.5	6.5	6.5	58.7	8.0	6.5	3.0	7.5	66.8
Lansdown View SB	10.0	7.0	6.5	7.0	11.7	10.0	6.0	5.5	8.0	66.7
Livingstone Rd NB	6.0	6.5	4.0	9.0	21.9	9.0	6.0	4.0	7.0	38.4
Livingstone Rd SB	6.0	6.0	4.0	7.0	39.8	9.0	6.5	4.0	9.0	23.6
Locksbrook Road EB	0.0	0.0	0.0	0.0	100.0	12.5	7.0	7.0	7.0	50.0
Locksbrook Road SB	8.5	7.0	7.0	7.0	50.0	0.0	0.0	0.0	0.0	100.0
London Rd EB	7.5	3.0	3.0	3.0	5.0	10.5	12.0	12.0	12.0	39.0
London Rd EB	7.0	10.0	7.0	15.0	11.0	15.0	12.5	7.0	13.5	11.0
London Rd EB	8.0	8.0	7.0	9.0	26.2	15.5	9.0	8.0	13.0	25.4
London Rd EB	12.0	12.5	5.0	12.5	14.4	16.0	11.5	10.0	12.0	26.6
London Rd EB	6.5	7.0	3.0	10.0	5.0	0.0	0.0	0.0	0.0	100.0
London Rd EB	10.0	8.0	5.0	10.0	24.1	0.0	0.0	0.0	0.0	100.0
London Rd EB	10.0	10.0	8.0	10.0	60.0	0.0	0.0	0.0	0.0	100.0
London Rd EB	12.0	18.0	18.0	18.0	0.0	0.0	0.0	0.0	0.0	100.0
London Rd WB	5.5	12.0	12.0	12.0	38.9	12.5	3.0	3.0	3.0	5.0
London Rd WB	0.0	0.0	0.0	0.0	100.0	10.2	7.0	3.0	10.0	5.0
London Rd WB	10.0	12.5	7.0	13.5	12.3	11.5	10.0	7.0	15.0	12.3
London Rd WB	10.0	9.0	8.0	13.0	25.1	14.0	8.0	7.0	9.0	26.0
London Rd WB	0.0	0.0	0.0	0.0	100.0	15.0	10.0	8.0	10.0	60.0
London Rd WB	0.0	0.0	0.0	0.0	100.0	15.0	8.0	5.0	10.0	24.6
London Rd WB	0.0	0.0	0.0	0.0	100.0	15.0	7.0	3.0	10.0	5.0

Road	Left Side of Street Canyon					Right Side of Street Canyon				
	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)
London Rd WB	0.0	0.0	0.0	0.0	100.0	18.0	18.0	18.0	18.0	0.0
London Rd WB	0.0	0.0	0.0	0.0	100.0	18.0	10.0	8.0	10.0	60.0
London Rd WB	7.6	11.5	10.0	12.0	25.1	21.0	12.5	5.0	12.5	12.7
Lower Bristol Rd EB	0.0	0.0	0.0	0.0	100.0	9.0	7.0	7.0	7.0	5.0
Lower Bristol Rd EB	6.0	12.0	10.0	14.0	15.0	10.0	7.0	7.0	7.0	5.0
Lower Bristol Rd EB	0.0	0.0	0.0	0.0	100.0	12.0	8.5	8.5	8.5	10.0
Lower Bristol Rd EB	14.0	7.0	6.5	7.0	11.0	12.0	8.0	7.0	10.0	15.1
Lower Bristol Rd EB	0.0	0.0	0.0	0.0	100.0	14.0	9.0	7.0	9.5	0.0
Lower Bristol Rd EB	9.0	7.0	4.0	7.0	61.6	14.0	8.0	5.0	10.0	50.0
Lower Bristol Rd EB	14.0	11.0	5.0	12.0	10.0	14.0	6.5	6.5	6.5	4.9
Lower Bristol Rd EB	14.0	5.0	5.0	5.0	15.5	14.0	6.0	6.0	6.0	13.5
Lower Bristol Rd EB	4.0	10.5	7.0	10.5	19.2	20.0	10.0	6.5	13.0	35.7
Lower Bristol Rd EB	4.0	18.0	17.0	18.0	100.0	0.0	0.0	0.0	0.0	100.0
Lower Bristol Rd EB	10.0	10.0	10.0	10.0	5.0	0.0	0.0	0.0	0.0	100.0
Lower Bristol Rd EB	0.0	0.0	0.0	0.0	100.0	12.0	6.0	6.0	6.0	20.0
Lower Bristol Rd WB	0.0	0.0	0.0	0.0	100.0	8.0	18.0	17.0	18.0	100.0
Lower Bristol Rd WB	15.0	10.0	6.5	13.0	35.8	8.0	10.5	7.0	10.5	19.3
Lower Bristol Rd WB	5.0	7.0	7.0	7.0	5.0	11.0	12.0	10.0	14.0	15.0
Lower Bristol Rd WB	14.0	7.0	7.0	10.0	60.0	10.0	9.0	9.0	9.0	51.3
Lower Bristol Rd WB	10.0	8.0	5.0	10.0	50.0	13.0	7.0	4.0	7.0	62.3
Lower Bristol Rd WB	0.0	0.0	0.0	0.0	100.0	15.0	10.0	10.0	10.0	5.0
Lower Bristol Rd WB	7.0	8.0	7.0	10.0	14.7	17.0	7.0	6.5	7.0	10.6
Lower Bristol Rd WB	9.5	6.5	6.5	6.5	4.9	19.0	11.0	5.0	12.0	10.1
Lower Bristol Rd WB	9.5	6.0	6.0	6.0	12.7	19.0	5.0	5.0	5.0	14.7
Lower Bristol Rd WB	5.0	7.0	7.0	7.0	5.0	0.0	0.0	0.0	0.0	100.0
Lower Bristol Rd WB	6.0	8.5	8.5	8.5	10.0	0.0	0.0	0.0	0.0	100.0
Lower Bristol Rd WB	8.0	9.0	7.0	9.5	0.0	0.0	0.0	0.0	0.0	100.0
Lower Bristol Rd WB	8.0	6.0	6.0	6.0	20.0	0.0	0.0	0.0	0.0	100.0
Lower Oldfield Pk EB	11.0	7.0	7.0	8.0	23.3	17.0	7.0	7.0	7.0	23.3
Lower Oldfield Pk EB	11.0	10.0	10.0	10.0	17.8	17.0	12.5	12.5	12.5	67.1
Lower Oldfield Pk SB	11.0	8.0	8.0	8.0	44.0	15.0	7.0	7.0	7.0	23.2
Lower Oldfield Pk WB	14.0	7.0	7.0	7.0	22.3	14.0	7.0	7.0	8.0	22.3
Lower Oldfield Pk WB	14.0	12.5	12.5	12.5	67.1	14.0	10.0	10.0	10.0	17.7

Road	Left Side of Street Canyon					Right Side of Street Canyon				
	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)
Lower Oldfield Pk WB	11.0	7.0	7.0	7.0	33.6	15.0	8.0	8.0	8.0	51.5
Little Stanhope St SB	5.5	8.0	7.0	9.0	5.1	5.5	9.0	8.0	10.0	5.1
Lyncombe Hill NB	2.0	3.0	3.0	3.0	60.0	15.0	2.0	2.0	2.0	20.0
Lyncombe Hill NB	2.0	2.0	1.5	2.0	30.0	15.0	10.0	9.0	11.5	15.0
Lyncombe Hill SB	12.5	10.0	9.0	11.5	16.0	5.0	2.0	1.5	2.0	30.0
Lyncombe Hill SB	12.5	10.0	9.0	11.5	50.5	5.0	2.0	1.5	2.0	30.0
Lymore Av EB	7.5	5.5	2.0	7.0	16.9	10.0	6.5	2.0	7.0	12.9
Lymore Av EB	6.5	6.0	5.5	6.5	27.3	0.0	0.0	0.0	0.0	100.0
Lymore Av SB	6.5	6.0	5.5	6.5	38.9	0.0	0.0	0.0	0.0	100.0
Lymore Av WB	0.0	0.0	0.0	0.0	100.0	10.0	6.0	5.5	6.5	40.0
Lymore Av WB	0.0	0.0	0.0	0.0	100.0	10.0	6.0	5.5	6.5	28.5
Lymore Av WB	8.0	6.5	2.0	7.0	13.1	10.0	5.5	2.0	7.0	16.9
Lymore Terrace NB	7.5	6.0	2.0	9.0	9.5	10.0	6.0	3.0	8.0	5.7
Lymore Terrace SB	7.5	6.0	3.0	8.0	5.6	10.5	6.0	2.0	9.0	9.5
Lyncombe Hill NB	2.0	3.0	3.0	3.0	5.0	6.0	11.5	2.0	14.0	44.4
Lyncombe Hill SB	3.3	11.5	2.0	14.0	43.4	4.0	3.0	3.0	3.0	5.0
Manvers St NB	6.5	15.0	15.0	15.0	20.0	10.5	15.0	15.0	15.0	10.0
Manvers St NB	7.0	15.0	15.0	15.0	10.0	10.5	12.0	12.0	13.0	5.0
Manvers St NB	6.0	14.5	14.5	14.5	0.0	11.0	12.0	12.0	12.0	0.0
Manvers St NB	6.0	13.0	13.0	14.0	50.0	11.0	13.0	13.0	14.0	50.0
Manvers St NB	7.5	15.0	14.0	16.5	5.0	0.0	0.0	0.0	0.0	100.0
Manvers St SB	6.5	15.0	15.0	15.0	10.0	10.5	15.0	15.0	15.0	20.0
Manvers St SB	7.0	12.0	12.0	13.0	5.0	10.5	15.0	15.0	15.0	10.0
Manvers St SB	0.0	0.0	0.0	0.0	100.0	11.0	15.0	14.0	16.5	5.0
Manvers St SB	6.0	12.0	12.0	12.0	0.0	11.0	14.5	14.5	14.5	0.0
Manvers St SB	6.0	13.0	13.0	14.0	50.0	11.0	13.0	13.0	14.0	50.0
Marlborough Rd NB	0.0	0.0	0.0	0.0	100.0	17.5	9.0	9.0	9.0	100.0
Marlborough Rd NB	8.5	12.0	12.0	12.0	5.0	6.5	4.0	3.0	6.0	20.0
Marlborough Rd NB	8.5	12.0	12.0	12.0	10.0	0.0	0.0	0.0	0.0	100.0
Marlborough Rd SB	14.0	9.0	9.0	9.0	29.4	0.0	0.0	0.0	0.0	100.0
Marlborough Rd SB	0.0	0.0	0.0	0.0	100.0	11.0	12.0	12.0	12.0	100.0
Marlborough Rd SB	3.5	4.0	3.0	6.0	20.0	12.0	12.0	12.0	12.0	5.0
Midland Bridge EB	5.0	6.0	6.0	8.0	50.0	13.0	12.0	12.0	12.0	43.3

Road	Left Side of Street Canyon					Right Side of Street Canyon				
	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)
Midland Bridge WB	8.0	8.0	6.0	12.0	40.9	10.0	6.0	6.0	8.0	50.0
Milsom St SB	9.0	13.0	13.0	13.0	5.0	9.0	13.0	13.0	13.0	100.0
Monmouth St NB	5.0	7.0	7.0	7.0	35.1	5.5	11.0	11.0	11.0	100.0
Monmouth St WB	8.0	11.0	11.0	11.0	6.5	7.0	11.0	11.0	11.0	100.0
Monmouth St WB	8.0	11.0	11.0	11.0	53.5	7.5	11.0	10.0	12.0	100.0
Monmouth St WB	15.0	13.0	13.0	13.0	80.0	6.0	12.0	12.0	12.0	100.0
Moorland Rd NB	8.0	6.5	6.5	8.0	20.0	9.0	7.0	6.0	8.0	20.0
Morford St NB	12.0	8.0	4.0	12.0	30.0	6.0	8.0	4.0	12.0	100.0
Morford St SB	4.0	10.0	7.0	12.0	15.0	15.0	12.0	12.0	12.0	100.0
New Bond St EB	6.0	13.0	13.0	13.0	26.9	0.0	0.0	0.0	0.0	100.0
New Bond St EB	7.0	13.0	13.0	13.0	4.9	6.0	13.0	13.0	13.0	100.0
New Bond St EB	6.5	13.0	13.0	13.0	5.1	6.5	13.0	13.0	13.0	100.0
New Bond St SB	7.0	13.0	13.0	13.0	20.1	10.0	13.0	13.0	13.0	100.0
Newbridge Hill SB	6.0	3.0	3.0	10.0	20.0	15.0	10.0	6.5	14.0	36.1
Newbridge Hill WB	11.0	0.0	0.0	0.0	100.0	10.0	3.0	3.0	10.0	20.0
Newbridge Rd EB	14.0	7.5	6.0	7.8	36.6	11.0	10.5	6.7	11.4	14.1
Newbridge Rd EB	12.0	7.3	6.5	9.6	25.1	12.0	8.6	6.7	11.8	5.0
Newbridge Rd EB	12.0	8.0	7.5	9.5	31.3	13.0	8.5	7.5	10.6	15.4
Newbridge Rd EB	12.0	8.5	8.4	11.2	17.7	16.0	8.6	6.7	11.8	10.0
Newbridge Rd EB	10.5	7.5	6.8	8.2	50.5	17.5	10.0	6.0	11.0	20.0
Newbridge Rd WB	13.0	10.0	6.0	11.0	20.0	14.5	7.5	6.8	8.2	59.3
Newbridge Rd WB	8.5	8.5	7.5	10.6	15.9	15.0	8.0	7.5	9.5	31.7
Newbridge Rd WB	8.0	8.6	6.7	11.8	5.0	15.5	7.3	6.5	9.6	25.1
Newbridge Rd WB	12.0	8.6	6.7	11.8	10.0	16.0	8.5	8.4	11.2	17.9
Newbridge Rd WB	7.0	10.5	6.7	11.4	14.2	18.0	7.5	6.0	7.8	36.7
Newton Rd EB	0.0	0.0	0.0	0.0	100.0	10.0	12.0	10.0	15.0	60.0
Newton Rd WB	6.0	12.0	10.0	15.0	60.0	0.0	0.0	0.0	0.0	100.0
North Parade EB	0.0	0.0	0.0	0.0	100.0	15.0	15.0	15.0	15.0	22.3
North Parade WB	10.0	15.0	15.0	15.0	22.3	0.0	0.0	0.0	0.0	100.0
North Rd EB	3.0	7.5	6.0	11.0	30.0	8.0	3.0	3.0	15.0	30.0
North Rd EB	3.0	2.0	2.0	15.0	60.0	8.8	7.0	7.0	9.5	31.7
North Rd WB	5.0	3.0	3.0	15.0	30.0	5.5	7.5	6.0	11.0	30.0
North Rd WB	4.0	7.0	7.0	9.5	32.9	7.0	2.0	2.0	15.0	60.0

Road	Left Side of Street Canyon					Right Side of Street Canyon				
	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)
Northgate St SB	20.0	15.0	15.0	15.0	16.4	5.0	10.0	8.0	11.0	100.0
Northgate St NB	3.0	12.0	12.0	14.0	80.0	13.0	12.5	10.0	14.0	0.0
Northgate St NB	3.0	13.0	13.0	15.0	39.1	11.0	12.5	12.0	14.0	0.0
Northgate St SB	6.5	12.5	12.0	14.0	0.0	7.0	13.0	13.0	15.0	36.6
Northgate St SB	5.0	20.0	20.0	20.0	5.0	5.0	25.0	25.0	25.0	100.0
Northgate St SB	10.0	14.0	14.0	14.0	15.1	15.0	13.0	13.0	13.0	100.0
Northgate St SB	8.0	12.5	10.0	14.0	0.0	7.0	12.0	12.0	14.0	80.0
Oldfield Pk EB	8.5	9.0	9.0	9.5	26.5	12.0	7.0	5.0	8.5	21.5
Oldfield Pk EB	0.0	0.0	0.0	0.0	100.0	14.0	7.0	6.5	10.0	50.4
Oldfield Pk WB	10.0	7.0	5.0	8.5	23.6	12.0	9.0	9.0	9.5	28.3
Oldfield Pk WB	10.0	7.0	6.5	10.0	51.4	0.0	0.0	0.0	0.0	100.0
Park Ln NB	4.0	9.0	7.0	10.0	5.0	7.0	5.0	5.0	5.0	60.0
Park Ln SB	3.8	5.0	5.0	5.0	60.0	7.0	9.0	7.0	10.0	5.0
Pierrepont St NB	7.5	15.0	15.0	15.0	23.1	11.0	15.0	15.0	15.0	18.0
Pierrepont St NB	7.5	15.0	15.0	15.0	18.7	11.0	13.0	13.0	13.0	55.8
Pierrepont St SB	7.5	15.0	15.0	15.0	18.3	11.0	15.0	15.0	15.0	23.4
Pierrepont St SB	7.5	13.0	13.0	13.0	55.7	11.0	15.0	15.0	15.0	18.5
Pines Way SB	8.0	9.0	9.0	9.0	46.1	15.0	14.0	14.0	14.0	34.3
Prior Park Rd NB	3.6	8.0	8.0	15.0	2.3	9.0	9.0	6.0	12.0	2.3
Prior Park Rd SB	6.0	9.0	6.0	12.0	1.6	6.5	8.0	8.0	15.0	1.6
Pulteney Bdg EB	7.0	8.0	6.0	13.5	5.0	8.0	8.0	6.0	13.0	5.0
Pulteney Bdg WB	5.0	8.0	6.0	13.0	5.0	10.0	8.0	6.0	13.5	5.0
Pulteney Rd EB	7.0	3.0	2.0	15.0	70.0	19.0	9.5	8.0	11.0	8.7
Pulteney Rd NB	7.5	7.5	6.0	8.0	19.4	14.0	7.0	6.5	11.5	18.5
Pulteney Rd SB	14.0	9.5	8.0	11.0	11.0	12.0	3.0	2.0	15.0	70.0
Pulteney Rd SB	9.5	7.0	6.5	11.5	18.3	13.0	7.5	6.0	8.0	19.2
Queen Sq East SB	10.0	13.0	13.0	13.0	16.6	0.0	0.0	0.0	0.0	100.0
Queen Sq North EB	14.0	13.0	13.0	13.0	9.7	0.0	0.0	0.0	0.0	100.0
Queen Sq Pl EB	3.5	6.0	3.0	15.0	46.1	9.0	8.0	8.0	8.0	100.0
Queen Sq Pl EB	0.0	0.0	0.0	0.0	100.0	8.2	5.0	3.0	14.0	100.0
Queen Sq Pl WB	5.0	8.0	8.0	8.0	23.0	7.0	6.0	3.0	15.0	100.0
Queen Sq Pl WB	4.5	5.0	3.0	14.0	20.0	0.0	0.0	0.0	0.0	100.0
Queen Sq South WB	9.0	12.0	12.0	12.0	7.0	0.0	0.0	0.0	0.0	100.0

Road	Left Side of Street Canyon					Right Side of Street Canyon				
	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)
Queen Sq West NB	9.0	13.0	13.0	14.0	20.1	0.0	0.0	0.0	0.0	100.0
Richmond Rd NB	3.0	2.0	2.0	15.0	70.0	4.0	3.0	3.0	15.0	70.0
Richmond Rd SB	1.5	3.0	3.0	15.0	70.0	5.5	2.0	2.0	15.0	70.0
Saracen St EB	8.0	7.0	7.0	10.0	21.1	10.0	10.0	8.0	12.0	100.0
Seymour St NB	0.0	0.0	0.0	0.0	100.0	18.0	12.0	10.0	14.0	100.0
Seymour St SB	12.0	12.0	10.0	14.0	32.8	0.0	0.0	0.0	0.0	100.0
Shaftesbury Rd EB	4.5	6.0	3.0	7.0	35.7	7.5	6.5	6.5	7.0	40.9
Shaftesbury Rd EB	4.5	4.0	4.0	8.0	40.0	8.0	5.0	3.7	7.0	32.4
Shaftesbury Rd EB	8.5	6.5	6.5	8.0	33.1	0.0	0.0	0.0	0.0	100.0
Shaftesbury Rd WB	4.5	6.5	6.5	7.0	39.4	7.5	6.0	3.0	7.0	34.1
Shaftesbury Rd WB	5.0	5.0	3.7	7.0	32.4	7.5	4.0	4.0	8.0	40.0
Shaftesbury Rd WB	0.0	0.0	0.0	0.0	100.0	11.0	6.5	6.5	8.0	32.3
Shophouse Rd NB	5.5	5.8	2.0	6.3	40.0	12.0	6.7	5.6	8.1	25.2
Shophouse Rd SB	8.0	6.7	5.6	8.1	24.0	9.0	5.8	2.0	6.3	40.0
Southdown Rd NB	8.0	6.0	2.0	7.0	37.4	13.0	6.0	3.0	6.5	10.6
Southdown Rd SB	9.5	6.0	3.0	6.5	10.1	12.0	6.0	2.0	7.0	37.1
St George St EB	13.0	12.0	12.0	12.0	11.6	10.5	12.0	8.0	15.0	11.6
St George St EB	10.0	12.0	12.0	12.0	4.4	15.0	12.0	12.0	12.0	4.4
St George St EB	6.8	12.0	12.0	15.0	19.5	10.0	12.0	8.0	12.0	19.5
St George St EB	13.0	15.0	15.0	15.0	5.1	10.5	12.0	8.0	20.0	5.1
St George St SB	9.5	12.0	12.0	12.0	25.0	15.0	12.0	12.0	12.0	25.0
St George St WB	6.0	12.0	8.0	15.0	25.7	17.5	12.0	12.0	12.0	25.7
St George St WB	5.0	12.0	8.0	12.0	7.7	10.5	12.0	12.0	15.0	7.7
St George St WB	6.0	12.0	8.0	20.0	17.9	17.0	15.0	15.0	15.0	17.9
St James's Parade SB	12.0	15.0	15.0	15.0	5.0	9.0	10.0	10.0	10.0	31.1
St James's Parade SB	18.0	15.0	15.0	15.0	50.0	0.0	0.0	0.0	0.0	100.0
St James's Parade NB	5.5	12.0	12.0	12.0	54.2	11.5	12.0	12.0	12.0	100.0
St James's Parade NB	5.0	12.0	12.0	12.0	22.9	11.0	12.0	12.0	12.0	100.0
St James's Parade NB	8.0	15.0	15.0	15.0	13.8	10.0	10.0	10.0	10.5	9.1
St James's Parade SB	7.5	12.0	12.0	12.0	17.4	10.0	12.0	12.0	12.0	100.0
St James's Parade SB	8.0	12.0	12.0	12.0	16.7	10.0	12.0	12.0	12.0	100.0
St Kildas Rd NB	7.0	6.5	6.5	6.5	5.0	10.0	6.5	6.0	6.5	10.0
St Kildas Rd WB	7.0	6.5	6.0	6.5	10.0	10.0	6.5	6.5	6.5	5.0

Road	Left Side of Street Canyon					Right Side of Street Canyon				
	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)
St Pauls Place WB	7.0	9.0	9.0	9.0	80.0	5.0	15.0	15.0	20.0	100.0
St Pauls Place WB	7.0	12.0	8.0	12.0	20.0	5.0	8.0	7.0	8.0	100.0
St Pauls Place WB	7.0	9.0	7.0	12.0	10.0	5.0	12.0	12.0	12.0	100.0
St Saviours Rd NB	4.0	5.0	3.0	6.0	10.0	3.5	6.0	6.0	6.0	10.0
St Saviours Rd NB	4.5	8.0	7.0	10.0	18.1	6.0	7.0	6.0	10.0	33.9
St Saviours Rd NB	6.5	7.0	6.0	7.5	15.0	8.8	6.5	4.0	10.0	20.0
St Saviours Rd NB	0.0	0.0	0.0	0.0	100.0	9.0	6.5	3.0	10.0	30.0
St Saviours Rd SB	3.0	7.0	6.0	10.0	34.8	7.5	8.0	7.0	10.0	19.1
St Saviours Rd SB	6.5	6.5	3.0	10.0	30.0	0.0	0.0	0.0	0.0	100.0
St Saviours SB	6.5	6.5	4.0	10.0	20.0	9.0	7.0	6.0	7.5	15.0
Stanhope Pl SB	6.0	4.0	2.0	11.0	10.1	8.0	9.0	7.0	11.0	100.0
Sydney Pl NB	12.0	16.0	16.0	16.0	20.8	12.0	18.0	18.0	18.0	60.0
Sydney Pl SB	6.0	18.0	18.0	18.0	60.0	18.0	16.0	16.0	16.0	18.6
The Paragon NB	10.0	14.0	14.0	17.0	21.6	13.5	12.0	12.0	12.0	100.0
The Paragon NB	0.0	0.0	0.0	0.0	100.0	9.0	10.0	3.0	10.0	100.0
The Paragon NB	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	100.0
The Paragon NB	6.0	12.0	12.0	12.0	5.1	12.0	12.0	12.0	12.0	100.0
The Paragon NB	8.5	14.0	12.0	17.0	10.0	13.0	12.0	12.0	12.0	100.0
The Paragon NB	7.0	12.0	12.0	12.0	52.7	15.0	12.0	12.0	12.0	100.0
The Paragon SB	10.0	12.0	12.0	12.0	5.0	13.5	14.0	14.0	17.0	100.0
The Paragon SB	5.0	10.0	3.0	10.0	18.2	0.0	0.0	0.0	0.0	100.0
The Paragon SB	8.0	12.0	12.0	12.0	5.0	10.0	12.0	12.0	12.0	100.0
The Paragon SB	9.5	12.0	12.0	12.0	5.0	12.0	14.0	12.0	17.0	100.0
The Paragon SB	9.5	12.0	12.0	12.0	1.0	12.0	12.0	12.0	12.0	100.0
Third Avenue NB	7.0	6.5	3.5	6.5	8.9	11.0	6.5	6.5	6.5	26.9
Third Avenue SB	8.0	6.5	6.5	6.5	26.9	10.0	6.5	3.5	6.5	9.0
Triangle N EB	10.0	6.0	5.5	6.5	59.9	9.0	6.0	2.0	7.5	30.7
Twerton High St EB	3.8	9.0	9.0	9.0	30.2	6.5	8.0	6.5	9.5	21.9
Twerton High St EB	6.5	6.0	6.0	9.0	27.0	8.0	6.8	5.3	9.9	55.2
Twerton High St EB	11.0	5.9	5.9	5.9	32.6	9.0	8.5	4.5	9.4	6.1
Twerton High St SB	6.0	6.7	6.7	6.7	40.0	8.0	6.6	4.0	9.4	31.0
Twerton High St SB	8.5	6.2	6.2	7.1	49.7	12.0	7.5	6.5	9.3	27.4
Twerton High St WB	4.0	8.0	6.5	9.5	23.1	7.0	9.0	9.0	9.0	31.3

Road	Left Side of Street Canyon					Right Side of Street Canyon				
	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)
Twerton High St WB	4.5	6.8	5.3	9.9	54.2	10.0	6.0	6.0	9.0	25.5
Twerton High St WB	8.0	7.5	6.5	9.3	29.2	12.5	6.2	6.2	7.1	50.9
Twerton High St WB	5.5	8.5	4.5	9.4	7.3	15.0	5.9	5.9	5.9	33.4
Upper Bloomfield Rd3	6.5	6.0	3.5	6.5	43.7	9.0	7.0	7.0	7.0	62.9
Upper Bloomfield Rd4	6.5	7.0	7.0	7.0	62.4	9.0	6.0	3.5	6.5	42.9
Upper Borough Walls1	6.0	12.0	11.5	13.0	22.9	5.0	14.0	14.0	14.0	50.5
Upper Borough Walls2	6.0	11.0	11.0	11.0	30.0	6.0	17.0	17.0	17.0	5.0
Upper Borough Walls3	5.0	12.0	12.0	12.0	25.0	6.0	13.0	7.0	15.0	15.0
Upper Bristol Rd EB	14.0	12.0	12.0	12.0	25.3	13.0	12.0	10.0	15.0	100.0
Upper Bristol Rd EB	12.0	12.0	12.0	12.0	9.9	12.0	11.0	11.0	11.0	100.0
Upper Bristol Rd EB	14.0	11.0	11.0	11.0	4.9	12.0	12.0	12.0	12.0	100.0
Upper Bristol Rd EB	14.0	9.0	9.0	11.0	10.0	13.0	9.0	7.0	12.0	100.0
Upper Bristol Rd EB	10.0	12.0	12.0	12.0	35.0	13.0	11.7	6.0	12.0	20.0
Upper Bristol Rd EB	14.0	10.0	10.0	10.0	10.0	11.5	11.0	11.0	11.0	100.0
Upper Bristol Rd EB	4.5	2.0	2.0	10.0	91.2	10.0	6.0	3.0	7.0	56.2
Upper Bristol Rd EB	5.0	8.5	6.5	12.0	13.1	10.0	2.0	2.0	2.0	20.0
Upper Bristol Rd EB	8.0	6.5	6.5	8.0	55.4	12.5	7.0	6.5	10.5	55.4
Upper Bristol Rd EB	11.0	7.0	3.5	7.0	23.2	13.0	8.0	6.0	14.0	24.9
Upper Bristol Rd EB	0.0	0.0	0.0	0.0	100.0	14.0	7.6	6.6	10.2	32.6
Upper Bristol Rd EB	5.5	2.0	2.0	10.0	82.3	14.5	7.2	6.9	9.0	73.5
Upper Bristol Rd EB	8.0	6.5	6.5	7.9	22.1	16.5	6.5	6.5	6.5	10.1
Upper Bristol Rd NB	11.0	6.5	6.5	6.5	9.1	13.0	6.5	6.5	7.9	21.2
Upper Bristol Rd SB	8.0	7.5	7.5	12.0	23.5	16.0	7.5	7.5	7.5	10.0
Upper Bristol Rd WB	6.0	12.0	10.0	15.0	5.5	19.0	12.0	12.0	12.0	100.0
Upper Bristol Rd WB	7.0	10.0	10.0	10.0	5.1	17.0	11.0	11.0	11.0	100.0
Upper Bristol Rd WB	6.5	12.0	12.0	12.0	10.0	20.0	12.0	12.0	12.0	100.0
Upper Bristol Rd WB	7.0	9.0	7.0	12.0	10.0	20.0	9.0	9.0	11.0	100.0
Upper Bristol Rd WB	8.0	9.0	6.0	12.5	20.0	15.0	12.0	12.0	12.0	35.0
Upper Bristol Rd WB	6.8	11.0	11.0	11.0	10.0	20.0	10.0	10.0	10.0	100.0
Upper Bristol Rd WB	4.0	2.0	2.0	2.0	20.0	10.0	8.5	6.5	12.0	14.4
Upper Bristol Rd WB	4.5	6.0	3.0	7.0	57.0	10.0	2.0	2.0	10.0	91.4
Upper Bristol Rd WB	9.5	7.2	6.9	9.0	74.4	11.0	2.0	2.0	10.0	82.9
Upper Bristol Rd WB	8.5	7.0	6.5	10.5	55.4	13.0	6.5	6.5	8.0	55.4

Road	Left Side of Street Canyon					Right Side of Street Canyon				
	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)
Upper Bristol Rd WB	11.0	7.5	7.5	7.5	16.7	13.5	7.5	7.5	12.0	29.2
Upper Bristol Rd WB	6.0	8.0	6.0	14.0	25.0	16.0	7.0	3.5	7.0	23.3
Upper Bristol Rd WB	8.8	7.6	6.6	10.2	33.6	0.0	0.0	0.0	0.0	100.0
Upper Church St NB	5.5	4.0	4.0	4.0	10.0	9.5	12.0	12.0	12.0	100.0
Upper Church St NB	0.0	0.0	0.0	0.0	100.0	9.0	12.0	12.0	12.0	100.0
Upper Church St SB	7.0	12.0	12.0	12.0	15.0	8.5	4.0	4.0	4.0	100.0
Upper Church St SB	6.0	12.0	12.0	12.0	38.8	0.0	0.0	0.0	0.0	100.0
Upper Lambridge St EB	7.0	4.0	3.0	9.7	50.0	4.0	7.0	3.0	9.7	40.0
Walcot St NB	3.0	5.0	3.0	15.0	81.0	10.0	11.0	10.0	12.0	100.0
Walcot St NB	5.0	7.0	6.0	8.0	4.9	12.0	9.0	8.0	12.0	100.0
Walcot St NB	6.0	10.0	6.0	10.0	4.9	12.0	11.0	11.0	11.0	100.0
Walcot St NB	3.0	10.0	10.0	10.0	5.0	10.0	12.0	10.0	12.0	100.0
Walcot St NB	3.0	10.0	3.0	12.0	5.0	9.0	8.0	3.0	10.0	100.0
Walcot St NB	6.5	10.0	5.0	10.0	25.2	9.0	10.0	10.0	10.0	100.0
Walcot St NB	3.5	8.0	7.0	8.0	4.9	0.0	0.0	0.0	0.0	100.0
Walcot St NB	6.0	10.0	10.0	12.0	19.0	0.0	0.0	0.0	0.0	100.0
Walcot St SB	5.8	11.0	10.0	12.0	19.0	7.0	5.0	3.0	15.0	100.0
Walcot St SB	9.5	9.0	8.0	12.0	10.1	8.0	7.0	6.0	8.0	100.0
Walcot St SB	9.0	11.0	11.0	11.0	4.9	8.0	10.0	6.0	10.0	100.0
Walcot St SB	7.0	12.0	10.0	12.0	20.0	6.0	10.0	10.0	10.0	100.0
Walcot St SB	6.0	8.0	3.0	10.0	10.1	6.0	10.0	3.0	12.0	100.0
Walcot St SB	5.0	10.0	10.0	10.0	25.2	9.5	10.0	5.0	10.0	100.0
Walcot St SB	0.0	0.0	0.0	0.0	100.0	7.0	8.0	7.0	8.0	100.0
Walcot St SB	0.0	0.0	0.0	0.0	100.0	10.0	10.0	10.0	12.0	100.0
Wellsway EB	5.0	9.5	8.6	10.0	0.0	9.0	12.0	10.0	15.0	60.0
Wellsway EB	8.5	6.0	5.5	6.5	9.8	9.0	6.5	6.0	6.8	5.0
Wellsway EB	9.0	7.0	6.0	10.0	39.3	10.0	2.0	2.0	2.0	40.0
Wellsway NB	5.0	5.5	2.0	8.0	80.0	10.0	7.0	5.0	10.5	30.0
Wellsway NB	6.0	3.0	3.0	3.0	5.0	12.8	7.9	2.0	10.0	20.0
Wellsway NB	4.0	3.0	2.5	5.0	50.0	15.0	7.0	7.0	7.0	15.0
Wellsway NB	7.5	7.0	6.0	9.3	18.6	15.0	10.2	10.2	10.2	25.6
Wellsway NB	8.0	4.0	3.5	4.5	30.0	16.0	7.2	7.0	7.5	19.3
Wellsway NB	9.0	6.0	3.4	6.4	22.0	18.0	7.5	7.5	7.5	14.6

Road	Left Side of Street Canyon					Right Side of Street Canyon				
	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)
Wellsway NB	12.0	8.0	7.5	8.5	27.8	20.5	7.3	3.7	8.0	16.9
Wellsway SB	11.0	7.0	7.0	7.0	15.0	8.0	3.0	2.5	5.0	50.0
Wellsway SB	5.0	7.0	5.0	10.5	30.0	10.0	5.5	2.0	8.0	80.0
Wellsway SB	6.8	7.9	2.0	10.0	20.0	12.0	3.0	3.0	3.0	5.0
Wellsway SB	12.5	7.2	7.0	7.5	19.7	12.0	4.0	3.5	4.5	30.0
Wellsway SB	8.5	10.2	10.2	10.2	25.1	14.0	7.0	6.0	9.3	17.9
Wellsway SB	11.0	7.5	7.5	7.5	13.9	17.0	6.0	3.4	6.4	21.4
Wellsway SB	12.0	7.3	3.7	8.0	15.9	20.0	8.0	7.5	8.5	26.9
Wellsway WB	5.0	12.0	10.0	15.0	60.0	9.0	9.5	8.6	10.0	0.0
Wellsway WB	5.5	6.5	6.0	6.8	5.0	11.0	6.0	5.5	6.5	9.3
Wellsway WB	6.0	2.0	2.0	2.0	40.0	13.0	7.0	6.0	10.0	39.3
West Ave WB	8.0	6.5	6.5	7.0	42.9	11.0	6.5	2.5	7.0	36.3
West Ave EB	5.0	3.5	2.0	7.0	48.4	9.0	6.5	2.5	7.0	45.5
West Ave SB	6.0	6.5	2.5	7.0	48.6	9.0	3.5	2.0	7.0	51.3
West Ave EB	7.5	6.5	2.5	7.0	5.8	11.0	6.5	2.0	7.0	30.9
West Ave SB	8.0	6.5	2.5	7.0	34.6	11.0	6.5	6.5	7.0	41.5
West Ave WB	7.0	6.5	2.0	7.0	29.8	11.0	6.5	2.5	7.0	4.2
Westgate Buildings NB	7.0	12.0	12.0	12.0	9.9	9.0	12.0	12.0	12.0	100.0
Westgate Buildings NB	8.0	12.0	12.0	12.0	5.1	7.0	12.0	12.0	12.0	100.0
Westgate St NB	9.0	12.0	10.0	13.0	32.9	8.0	13.5	13.5	13.5	36.5
Westgate St WB	7.0	10.5	9.0	13.0	29.7	5.0	11.0	10.0	14.0	5.7
Westgate St WB	5.0	12.0	11.5	13.0	10.0	5.5	13.0	12.5	13.5	10.0
Weston Ln EB	3.8	2.0	2.0	2.0	32.4	7.5	6.0	4.0	7.0	8.5
Weston Ln EB	0.0	0.0	0.0	0.0	100.0	8.0	3.0	3.0	3.0	5.0
Weston Ln EB	9.0	4.0	3.0	8.0	30.0	12.5	3.0	2.0	6.3	30.0
Weston Ln EB	9.0	10.0	10.0	10.0	50.0	12.5	10.0	10.0	10.0	50.0
Weston Ln NB	3.5	10.0	10.0	10.0	60.0	13.0	7.0	6.5	10.0	58.4
Weston Ln NB	4.0	3.0	3.0	3.0	5.0	0.0	0.0	0.0	0.0	100.0
Weston Ln SB	2.0	3.0	3.0	8.0	5.0	6.0	3.0	3.0	3.0	5.0
Weston Ln SB	9.5	7.0	6.5	10.0	58.6	8.0	10.0	10.0	10.0	60.0
Weston Ln WB	3.0	3.0	3.0	3.0	5.0	5.0	3.0	3.0	8.0	5.0
Weston Ln WB	4.0	6.0	4.0	7.0	11.8	7.0	2.0	2.0	2.0	34.8
Weston Ln WB	9.5	4.0	4.0	4.0	15.0	12.5	10.0	10.0	10.0	50.0

Road	Left Side of Street Canyon					Right Side of Street Canyon				
	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%)
Weston Ln WB	9.5	3.0	2.0	6.3	30.0	12.5	4.0	3.0	8.0	30.0
Whiteway Rd EB	7.0	2.0	2.0	7.5	40.0	7.0	3.0	2.0	8.0	42.7
Whiteway Rd WB	4.0	3.0	2.0	8.0	42.6	9.0	2.0	2.0	7.5	40.0
Widcombe Hill EB	3.5	9.0	9.0	9.0	5.0	9.0	4.0	4.0	6.5	11.4
Widcombe Hill EB	3.5	1.5	1.5	1.5	35.0	9.0	10.2	6.0	11.5	20.0
Widcombe Hill NB	6.0	10.2	6.0	11.5	20.0	6.5	1.5	1.5	1.5	35.0
Widcombe Hill WB	6.0	4.0	4.0	6.5	15.9	6.5	9.0	9.0	9.0	5.0
Wood St EB	6.0	11.0	11.0	14.0	18.3	6.0	14.0	14.0	14.0	15.0
Wood St NB	8.0	12.5	12.5	12.5	23.6	6.0	14.5	14.5	14.5	25.2

Appendix B. Technical Note on Train Emissions

Air Quality CONSULTANTS

Technical Note:
Diesel Train Emissions

June 2018

Experts in air quality management & assessment

Document Control

Client	CH2M	**Principal Contact**	Becky Lloyd

Job Number	J3145

Report Prepared By:	Dr Clare Beattie

Document Status and Review Schedule

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J3145A/N1/F3	3 June 2018	Final	Dr Ben Marner (Technical Director)

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Introduction

1.1 Modelling (based on the London Atmospheric Emissions Inventory, LAEI) suggests that diesel trains may be responsible for exceedances of the nitrogen dioxide annual mean air quality objective up to 200 m either side of the Great Western main line. This short note considers diesel trains in the context of air quality concentrations within Bath city centre, in particular in relation to the current feasibility work for the Clean Air Zone.

Evidence

1.2 The most comprehensive piece of evidence regarding the impacts of diesel trains on ambient concentrations is a Defra grant funded project undertaken by the Environmental Research Group of Kings College on behalf of the London Boroughs of Ealing and Islington in 2014. Monitoring was undertaken alongside the railway track[1] in order to test the modelled predictions using emissions from the London Atmospheric Emissions Inventory (LAEI). Two locations were selected, on the Great Western main line out of Paddington (Ealing) and on the East Coast Main Line out of Kings Cross (Islington).

1.3 Analysis of the monitoring data is complex because of the need to isolate railway emissions from other sources of pollution, especially road traffic. The researchers used a variety of techniques to overcome these difficulties. The report concluded that real world measurements were lower than the modelled predictions and a clear contribution from the diesel trains was difficult to detect.

1.4 The study also aimed to derive new emissions factors for diesel trains. However, the absence of a clear contribution from train emissions prevented the derivation of new emission information on diesel trains. Instead, alternative information about emissions from UK diesel trains[2] was used to adjust the emissions information in the LAEI and the resulting ambient pollution concentrations were modelled. The new results show good agreement with measured concentrations.

1.5 Studies have also been undertaken within enclosed stations such as Edinburgh Waverley and London Paddington[3]. The outcomes of these studies are not included in this note as they are not directly relevant for Bath Spa station, or for the Clean Air Zone feasibility study which is aimed at

[1] Fuller G, Baker T, Tremper A, Green D, Font A, Priestman M, Carslaw D, Dajnak D and Beevers S (2014) Air Pollution emissions from diesel trains in London. Available at: https://www.londonair.org.uk/london/reports/KCL_Air_pollution_emissions_from_diesel_trains_in_London.pdf

[2] Hobson and Smith (2001). Rail Emissions Model, AEA Technology , Culham. Available at: http://webarchive.nationalarchives.gov.uk/+/http:/www.dft.gov.uk/pgr/rail/researchtech/research/railemissionmodel.pdf

[3] Thornes, J E, Hickman A, Baker C, Cai X and Saborit JMD (2016) Air Quality in Enclosed Railway Stations. Institute of Civil Engineers Publishing. Transcript available at: http://pure-oai.bham.ac.uk/ws/files/27847822/ICE_paper_accepted_version.pdf

reducing concentrations in locations which are relevant for either the EU Limit Value or the annual mean air quality objective. Some of this work is summarised in a report setting out the air and health impacts of diesel emissions from trains[4], which concludes that "*the indication is that emissions … are significantly less than for major roads even from very busy diesel railways*".

Summary and Conclusions

1.6 Diesel trains will not be included in the modelling to be undertaken within the city of Bath for the Bath CAZ feasibility work. There are three main reasons for this:

- It is considered that using current Defra emissions factors will overstate the contribution from trains (and hence underestimate any modelled air quality impacts of the Clean Air Zone scenarios);
- Although emissions factors as published by Hobson and Smith (2001) could be used, there are no emissions factors published or endorsed by Defra which are considered to accurately reflect emissions from diesel trains; and
- Current evidence suggests that at locations relevant to the Limit Values or air quality objectives, the contribution from diesel trains is likely to be minimal.

1.7 Even though there is less contribution from diesel trains than current modelling would suggest, electrification of the Great Western main line will reduce the contribution from trains to nitrogen dioxide concentrations in the immediate vicinity of the railway line. Other mitigation measures are discussed in the report published by the Rail Safety and Standards Board (2016) as below.

[4] Rail and Safety Standards Board (2016) Air and Health Impacts of Diesel Emissions. Available at: https://www.rssb.co.uk/HealthAndWellbeingContent/HW008-2016-02-health-air-and-health-impacts-of-diesel-emission.pdf