Cardiff Council Clean Air Feasibility Study

September 2018

MOTT MACDONALD

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Executive Summary

Background

The European Union Ambient Air Quality Directive (2008/50/EC) sets legally binding limits for concentrations of certain air pollutants in outdoor air, termed 'limit values'. The Directive requires that Member States report annually on air quality within zones designated under the Directive and, where the concentration of pollutants in air exceeds limit values, to develop air quality plans that set out measures in order to attain the limit values. The only limit values that the UK currently fails to meet are those set in respect of nitrogen dioxide (NO_2).

In July 2017, the UK and devolved Governments published an Air Quality Plan (the 2017 Plan) for tackling roadside NO_2 concentrations. The 2017 Plan set out details of the authorities responsible for delivering air quality improvements including devolved administrations and Local Authorities.

In order to meet its requirements under the 2017 Plan, the Welsh Government Directed Cardiff Council to undertake feasibility study to bring forward compliance with NO_2 Limit Values in the shortest possible time.

The Direction requires the Council to undertake a feasibility study setting out the case for change and identifying, exploring, analysing and developing options for measures which the local authority will implement to deliver compliance in the shortest possible time, with indicative costs for those options. The Direction requires a report be submitted to Welsh Government no later than the **30th September 2018**.

A Final Plan, Identifying in detail the preferred option for delivering compliance in the shortest possible time, and including a full business case setting out value for money considerations and implementation arrangements and timings must be submitted to Welsh Government no later than the **30th June 2019.**

This report addresses the expected requirements outlined by the Direction deadline of the 30th of September 2018. It sets the case for change and identifies, explores, analyses and has developed options for measures which the local authority will implement to deliver compliance in the shortest possible time, with indicative costs for those options.

Baseline Modelling Results

The report has identified through localised modelling that the location of projected future non-compliance of the NO_2 limit value differs significantly from the national projected compliance issues undertaken by the Department for Environment, Food and Rural Affairs (DEFRA) using the Pollution Climate Mapping (PCM) model. The national PCM model showed exceedances on the A48 to the east of the city and the A4232 to the south west. The local model results indicate **only one** road link, **namely the A4161 Castle Street, (ID 30665)** to show non-compliance issues beyond 2021. The main reason for this exceedance relates to very high traffic flows, some 32,000 vehicles a day and accompanying slow speeds of around 11mph on this specific road link.

The main reasons for the differences between the local model results and the PCM results is primarily down to the fact that the local model has a far greater level of detail which is based on local data, and not national assumptions, and thus can be seen to be a better representation of local circumstances. The key aspects of the local model that influence the results are as follows:

- Traffic flows are based on a local traffic model;
- Traffic speeds are based on a local model and local traffic master;
- Local fleet data from the ANPR, not just national averages; and
- Local topology in terms of gradient, canyons, etc. which the PCM does not allow for.

Examining the baseline years of 2015 and 2021 source apportionment analysis has been undertaken for a number of road links in Cardiff to provide an indication of the key sources contributing to pollution levels. The analysis shows that the main source of air pollution is from road traffic, which accounts for **80 - 84 %,** while the remainder of the pollution is from background sources. Overall, diesel cars are the main contributor (36%) followed by buses (19%) and Heavy Goods Vehicles (HGVs 18%). Taxis account for approximately 7% of NOx

In 2021 the main contribution to pollution in Cardiff is still anticipated to be road traffic (73 – 78 %), with diesel cars still contributing the largest proportion of emissions (36%) to the total road NOx emissions. The proportion of emissions from HGVs and buses is expected to reduce to 10% and 11% respectively.

Development of Shortlist of Measures

A long list of measures has been developed as part of previous works developing a Clean Air Strategy & Action Plan. These measures have been qualitatively assessed against a primary objective of **achieving compliance with set air quality objectives in the shortest possible time**. Where measures were deemed as unlikely to achieve the primary objective they were not considered any further. The measures were considered against secondary objectives and were subjected to further qualitative assessments against the WelTAG Well-being Aspects. As a result of this analysis the following shortlist of measures was decided;

- **M8: Implement further speed restrictions and enhance already established 20mph Zones;**
- **M13: Development of Cycling Superhighways infrastructure and expansion of Nextbike Scheme;**
- **M14: Implement Zero Emission Buses on Cardiff Network;**
- **M21: Improvement of Taxi Licensing Policy, to set minimum vehicle emissions standards;**
- **M10: City Centre West and Central Interchange and Eastside City Centre Schemes;**
- **M11: Bus Programme- Strategic Bus Network to improve bus networks and efficiency of the services via increased and improved bus lanes;**
- **M12: Accelerate Park and Ride programme to increase Park and Ride along the A48 and new facility off Junction 33 of the M4;**
- **M18: Improve and promote the uptake of low emission vehicles by enhancing Cardiff's EV infrastructure;**
- **M23: Review car parking and car permit charges and allow for reduced rates for EV/OLEV, and increased rates for <Euro 6;**

It must be noted that the above shortlist of measures have initially been identified as measures that will likely have the greatest impact on the road links identified by the PCM modelling as being non-compliant, namely the A48 and A4232 near Cardiff Bay. However, the measures were also assessed in terms of their likely impact on improving air quality within the Councils existing Air Quality Management Areas (AQMAs). The results of the local modelling detailed in Section 3.3 have demonstrated that compliance issues are not forecasted to occur on the A48 or the A4232. Non-compliance issues are now predicted to only occur on Castle Street which is immediately adjacent to the boundary of the City Centre AQMA, and measures put forward to address air quality in this AQMA will likely have an impact on this road link.

As a requirement of the legal direction, the shortlist of measures will be benchmarked against a charging Clean Air Zone (CAZ) in terms of establishing whether the package of measures can achieve compliance in a timeframe equal or sooner than that of a CAZ.

Whilst the option of CAZ will be the benchmark against which the measures will be assessed it does not imply that the CAZ will become the preferred option. A fundamental point is that the Council needs to ensure that any proposals are proportionate to the scale of the problem and tailored to local circumstances, whilst ensuring compliance in the shortest time possible. A key aspect of this will be ensuring that there are no detrimental impacts on the economy of Cardiff and this will be assessed in detail as part of the full business case for the preferred option(s).

Funding

The Welsh Government has stated that it has allocated over £20 million for an Air Quality Fund through to 2021 to help accelerate compliance with NO_2 limits and improve air quality in Wales. Welsh Government have stated that this fund will primarily be used to provide on-going support, guidance and finance to enable Cardiff Council (and Caerphilly County Borough Council) to take action to achieve compliance in the shortest possible time.

Within the Minister's letter that accompanied the formal direction it was confirmed that finance would be made available for the production of the feasibility study and for the implementation of the chosen scheme.

In addition to the above funding mechanisms, the Council will continue to work collaboratively with Welsh Government officers to identify all available and an appropriate funding mechanisms including transportation funds, to maximise the financial contribution from Welsh Government towards the implementation of any measures.

Next Steps

Detailed quantitative assessment of the initial shortlist of measures will now be progressed and the impact of these measures on achieving compliance in the shortest possible time will be benchmarked against the need for a charging Clean Air Zone.

However it should be the noted that the previous assessments undertaken by DEFRA which demonstrate that a CAZ achieves compliance is based on the initial PCM modelling results. As discussed earlier the local modelling results have projected different results in terms of the road links showing non-compliance compared to the PCM modelling and therefore the impact of a CAZ in achieving compliance needs further assessment and review.

The further assessments will enable Cardiff Council to develop a preferred option(s) to progress to a full business case in order to produce a Final Plan by 30th June 2019.

Chapter 1 Introduction

1.1 Cardiff

As the capital city of Wales, Cardiff has a population of 346,100 people, and is a base for many of the country's political, cultural, sporting and commercial institutions. Principal destinations include the Principality Stadium in the City Centre, the St David's shopping centres, and the historic Cardiff Castle. To the south of the city, Cardiff Bay (in the Butetown and Grangetown Wards) houses the Senedd, Wales Millennium Centre, BBC studios. Cardiff City Football Club and rugby union side Cardiff Blues are also both based in the capital.

Cardiff is located within a well-defined landscape setting with prominent ridges to the west and north and Severn Estuary to the south. The Western, Northern and Eastern areas of the City are mainly residential, with the main commercial areas being in the City Centre and to the south.

Cardiff is currently the most populated Welsh local authority, with approximately 361,468 inhabitants and this is predicted to grow to between 395,000 and 413,000 by 2026. Therefore, the Local Development Plan [1] calls for 41,100 new dwellings and 40,000 new jobs to be created. Such population growth is likely to place additional strain on the transport network, exacerbating existing problems of congestion and harmful emissions across the urban area.

In 2013 around 217,600 commuters travelled to work in Cardiff daily, with 83,100 commuting from outside of the city and 134,500 Cardiff residents travelling within the city to their place of work[2]. The city's travel to work area extends to the whole of South East Wales with an increasingly significant number of people arriving from Rhondda Cynon Taf, the Vale of Glamorgan and beyond.

Moreover, although there has been an increase in the use of active and sustainable modes of travel in recent years, the most used mode of travel in Cardiff both within and into the city is by the private car. The dominance of the private car leads to congestion and the associated adverse impacts on the environment, including air quality, greenhouse gas (GHG) emissions and noise pollution.

The countryside and urban area contains a wealth of natural and historic interests. For example, there are almost 1,000 Listed Buildings, 27 Conservation Areas, 2 sites noted for their international biodiversity (Cardiff Beechwoods SAC and Severn Estuary SAC/SPA/RAMSAR)

The city has a particularly rich Victorian and Edwardian legacy.

Cardiff has over 400 hectares of recreational open space and 2000 hectares of amenity space. The four river valleys of the Ely, Taff, Rhymney and Nant Fawr provide extensive and continuous blue corridors running from the countryside and through the urban area.

[1] Cardiff Council Adopted Local Development Plan 2006-2026
[2] Annual Population Survey 2014
[3] https://www.gov.uk/government/publications/air-quality-plan-for-nitrogen-dioxide-no2-in-uk-2017

1.2 Overview of Study

The UK has in place legislation passed down from the European Union, to ensure that certain standards of air quality are met, by setting Limit Values on the concentrations of specific air pollutants. In common with many EU member states, the EU limit value for annual mean nitrogen dioxide is breached in the UK and there are on-going breaches of the nitrogen dioxide limit value in Cardiff. The UK and Welsh Government is taking steps to remedy this breach in as short a time as possible. Within this objective, the UK and devolved governments published a plan for tackling roadside nitrogen dioxide in July 2017. [3]

Due to modelled air quality exceedances Cardiff Council has been directed [4] by the Minister to produce a feasibility study, to identify the option which will deliver compliance with legal limits for nitrogen dioxide in the area for which the authority is responsible, in the shortest possible time.

The Direction specified that Cardiff Council was required to produce an Initial Scoping Proposal, which required the Council to set out its proposed approach to the feasibility study and included a scope of work, governance, resourcing, procurement approach, indicative costs and timings. This report was required to be submitted, to Welsh Government no later than the 31st March 2018. Cardiff Council submitted this proposal to Welsh Government in March 2018[5].

The Direction subsequently requires two further aspects of the feasibility study. Firstly an **Initial Plan,** setting out the case for change and identifying, exploring, analysing and developing options for measures which the local authority will implement to deliver compliance in the shortest possible time, with indicative costs for those options. The Direction requires this report be submitted to Welsh Government no later than the **30th September 2018.**

Secondly **a Final Plan**, Identifying in detail the preferred option for delivering compliance in the shortest possible time, and including a full business case setting out value for money considerations and implementation arrangements and timings. The Direction requires this report be submitted to Welsh Government no later than the **30th June 2019.**

The focus of the Feasibility Study is on achieving results in the shortest time possible, and in accordance with the High Court Order in November 2016[6] will only consider cost when comparing between two equally quick schemes.

1.3 Purpose of This Report

This report sets out the Initial Plan, and follows the requirements of Strategic Outline Case for a package of measures which will bring about compliance with the Limit Value for annual mean NO_2 in the shortest time possible in Cardiff.

It has been produced where feasible in line with the Inception, Evidence and Options Appraisal packages of Guidance issued by the Joint Air Quality Unit (JAQU) in 2017, and the

[3] https://www.gov.uk/government/publications/air-quality-plan-for-nitrogen-dioxide-no2-in-uk-2017

[4] Environment Act 1995 (Feasibility Study for Nitrogen Dioxide Compliance) Air Quality Direction 2018 14th Feb 2018

[5] Cardiff Council Initial Scoping Report for Feasibility Study

[6] November 2016 in R (Client Earth) (NO_2) V Secretary of State for Environment Food and Rural Affairs [2016] EWHC 2740 (Admin).

HM Treasury Green Book[7]. It also reflects the requirements of the Welsh Transport Appraisal Guidance (WelTAG).[8]

This report presents the findings of local air quality and transport modelling to establish local baseline conditions, compared against the results of the Pollution Climate Mapping (PCM) modelling results. Following this comparative exercise the report presents a shortlist of measures which have been developed from an initial long list of options to improve air quality.

In addition to the meeting the requirements of the Air Quality Directive, the study also supports s Well-being Objectives, identified within the Council's Well Being Plan 2018-2023[9]-:

- **A Capital City that Works for Wales –** this objective looks to reduce air pollution levels in Cardiff, and thus this Feasibility Study will be assessing measures that will look to achieve compliance with the Air Quality Directive in the shortest possible time.
- **Cardiff grows in a resilient way –** the study will ensure that Nitrogen Dioxide and air pollution in general will be managed in a way to ensure that Cardiff can grow in a sustainable way by identifying measures to achieve compliance in the shortest possible time.
- **Supporting people out of poverty** – poor air quality partially affects deprived areas, and thus by identifying measures that will improve air quality and achieve compliance those living in the most deprived areas of the City will benefit from improved air quality.

The remainder of this report is structured around the five cases, namely;

- **Strategic Case** – sets out the case for change and the objectives of the Plan;
- **Economic Case** – develops a long list of options to achieve the objectives and appraises them against the defined critical success factors;
- **Commercial Case** – details the possible routes to procurement, supplier capability and likely delivery solution;
- **Financial Case** - sets out the indicative costings for the Plan and available funding sources; and
- **Management Case** – provides the governance and management arrangements to deliver a successful project

Following the Initial Plan a Final Plan will be produced which will include a Full Business Case for the preferred option to achieve compliance in the shortest possible time.

[7] HM Treasury Green Book
[8] https://beta.gov.wales/welsh-transport-appraisal-guidance-weltag
[9] https://www.cardiffpartnership.co.uk/well-being-plan/

Chapter 2 Strategic Case

2.1 Introduction

The purpose of the Strategic Case within this report is to set out the case for change by comparing the existing conditions, statutory and regulatory obligations and the desired goals of this intervention. In accordance with the Inception package of JAQUs guidance this Strategic Case considers the following;

- An outline of the strategic context, in particular the national air quality plan for tackling roadside nitrogen dioxide, impact assessment and Clean Air Zone framework;
- An overview of the local situation and how the proposal fits with existing local authority's strategies;
- A local air quality assessment including reference to health impacts;
- A determination of the spending objectives; and
- Determination of the benefits, risks, constraints and dependencies related to address the identified issue;

2.2 Background and Strategic Context

2.2.1 Air Quality Policy and Legislation

UK Air Quality Strategy

The UK Air Quality Strategy[10] identifies nine ambient air pollutants that have the potential to cause harm to human health. These pollutants are associated with local air quality problems, with the exception of ozone, which is instead considered to be a regional problem.

The Air Quality (Wales) Regulations and subsequent amendments (National Assembly for Wales, 2000 and 2002) set objectives for the seven pollutants that are associated with local air quality. The objectives aim to reduce the health impacts of those pollutants to negligible levels as part of the Local Air Quality Management in Wales

Welsh Ministers have a responsibility to ensure air quality levels in Wales comply with air quality limit values in accordance with the Air Quality Standards (Wales) Regulations, 2010.

Cardiff Council has a statutory duty under Part IV of the Environment Act 1995 & Air Quality Strategy for England, Scotland, Wales and Northern Ireland 2007 to manage local air quality. The Local Air Quality Management (LAQM) process places an obligation on all local authorities to regularly review and assess air quality in their areas, and to determine whether or not air quality objectives are likely to be achieved.

The air quality objectives applicable to LAQM in Wales are set out in the Air Quality (Wales) Regulations 2000, No. 1940 (Wales 138) and Air Quality (Amendment) (Wales) Regulations 2002, No 3182 (Wales 298). Where the air quality reviews indicate that the air quality objectives may not be met the local authority is required to designate an Air Quality Management Area ('AQMA'). Action must then be taken at a local level which is outlined in a specific Air Quality Action Plan (AQAP) to ensure that air quality in the identified area improves.

[10] https://www.gov.uk/government/publications/the-air-quality-strategy-for-england-scotland-wales-and-northern-ireland-volume-1

2.2.2 European Air Quality Directives

Air Quality Framework Directive (96/62/EC) on ambient air quality assessment and management defines the policy framework for 12 air pollutants known to have a harmful effect on human health and the environment. The limit values for the specific pollutants are set through a series of Daughter Directives.

European Directive 2008/50/EC consolidates existing air quality legislation (apart from the 4th Daughter Directive) and provides a new regulatory framework for PM2.5.

The UK Air Quality Standards Regulations 2010 came into force on 11th June 2010, replacing the previous Air Quality Standards Regulations 2007, and consolidated and transposed into national legislation the requirements of the European Directives 2008/50/EC and 2004/107/EC – the 4th Daughter Directive.

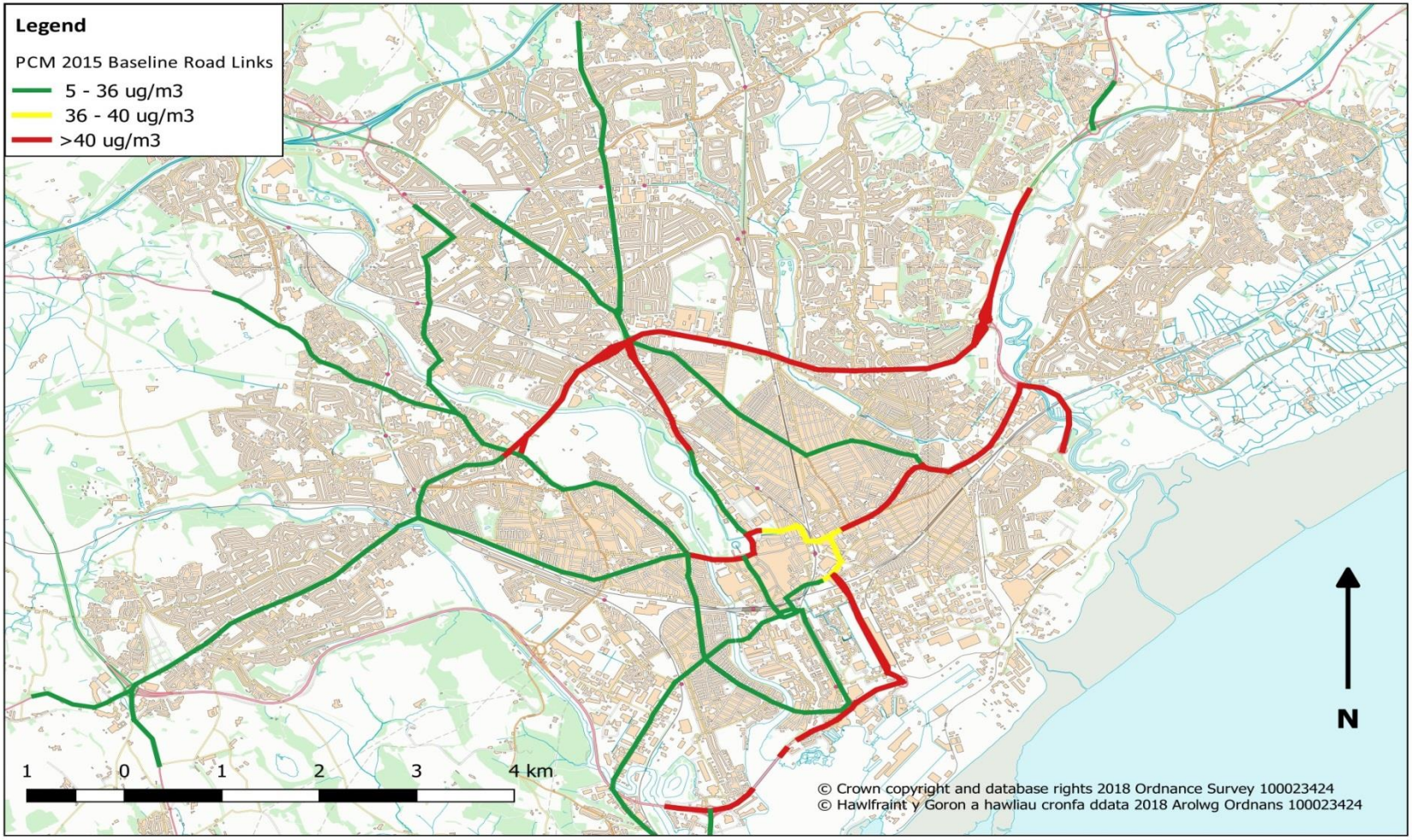
The UK and Welsh Governments have an obligation to achieve European Air Quality Limit Values (Directive 2008/50/EC, Annex III). The most relevant are limits for nitrogen dioxide (NO_2) and Particulate Matter smaller than 10 µm (PM10) which must not exceed 40 µg/m3 as an annual mean (i.e. measured over a calendar year). There are a number of requirements of the Directive, including that the Limit Value applies at locations which are accessible, including footpaths but excluding areas within 25m from major road junctions.

In 2015, 37 of the 43 monitored areas across the country were in exceedance of the annual mean Limit Value for NO_2. One of these 43 areas includes the Cardiff Urban Agglomeration where the Government has forecast that exceedances will remain beyond 2021.

The Government assesses air quality compliance with the European Directive in 43 areas across the country at single locations, using both monitoring and modelling. It uses Defra's Pollution Climate Mapping (PCM) model to forecast exceedances, which is adjusted based on the monitored data. This is the approved means of reporting air quality information to assess legal compliance with the European legislation.

Figure 1 below illustrates the 2015 PCM baseline NO_2 Results, with the red lines representing the road links with modelled exceedances.

Figure 1 - Updated Baseline NO2 PCM Modelling Results Identifying Exceeding Road Links in Cardiff 2015



2.2.3 Air Quality Objectives and Limit Values

The air quality objectives and limit values currently applicable to the UK can be split into two groups. UK air quality objectives set down in regulations for the purposes of local air quality management which are targets; and EU Limit Values transcribed into UK legislation which are mandatory.

A summary of the UK Air Quality Objective and EU Limit Values for NO_2 and particulate matter (PM10 and PM2.5) is given in Table 1.

Furthermore, the UK has a target to reduce average concentrations of PM2.5 at urban background concentrations by 2 µg/m3 by 2020.

Table 1 - UK and EU Air Quality Objectives for NO_2, PM10 and PM2.5

	Pollutant	Standard/ Concentration	Measured As	Date to be achieved and maintained thereafter
UK Air Quality Objectives	Nitrogen Dioxide	200 µg/m3 not to be exceeded more than 18 times per annum 40 µg/m3	1 Hour Mean Annual Average	31.12.2005 31.12.2005
	Particulate Matter (PM 10)	50 µg/m3 not to be exceeded more than 35 times per annum 40 µg/m3	24 Hour Mean Annual Average	31.12.2004 31.12.2004
	Particulate Matter (PM 2.5)	25 µg/m3	Annual Average	2020
EU Limit Values	Nitrogen Dioxide	200 µg/m3 not to be exceeded more than 18 times per annum 40 µg/m3	1 Hour Mean Annual Average	
	Particulate Matter (PM 10)	50 µg/m3 not to be exceeded more than 35 times per annum 40 µg/m3	24 Hour Mean Annual Average	01.01.2010 01.01.2010
	Particulate Matter (PM 2.5)	25 µg/m3	Annual Average	2015

2.3 Air Quality in Cardiff

2.3.1 Monitoring

In line with the Council 's statutory duties under Part IV of the Environment Act 1995, undertakes regular air quality monitoring at specifically allocated locations across Cardiff using automated and non-automated principles for ambient air Nitrogen Dioxide (NO_2), Particulate Matter (PM_{10} & $PM_{2.5}$), Sulphur Dioxide (SO_2), Carbon Monoxide (CO) & Ozone (O_3).

Currently there are 75 locations across Cardiff where monitoring for annual nitrogen dioxide (NO_2) concentrations is undertaken with the use of passive diffusion tubes. In addition, automated AURN monitoring stations are located on Frederick Street in the City Centre and Newport Road, which provide continuous monitoring for Nitrogen Dioxide (NO_2), Particulate Matter (PM_{10} & $PM_{2.5}$), Sulphur Dioxide (SO_2), Carbon Monoxide (CO) & Ozone (O_3).

2.3.2 Air Quality Management Areas

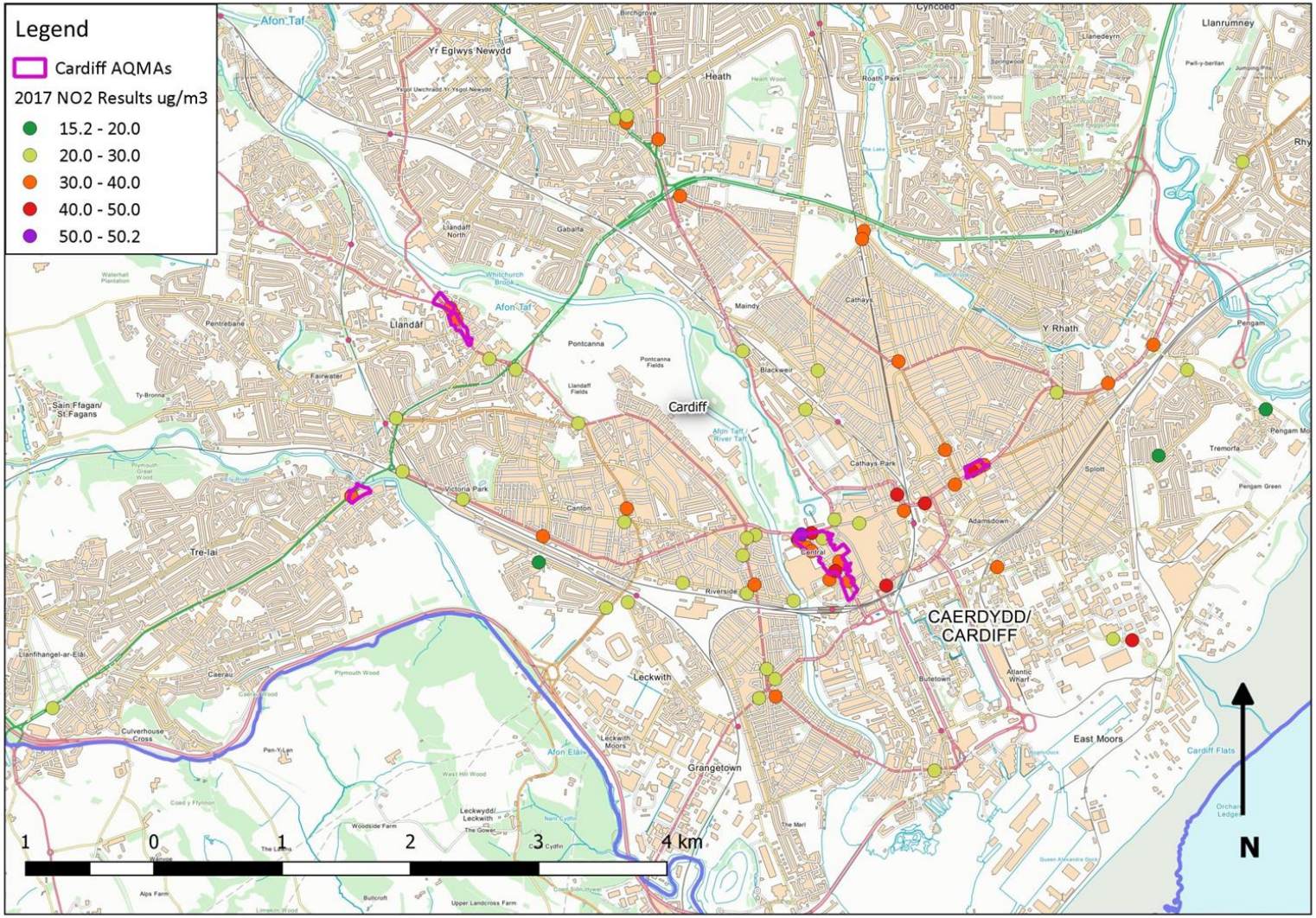
Based on monitoring results and further detailed assessments there are currently 4 Air Quality Management Areas (AQMAs) declared across the authority which were all declared due to exceedances of the annual mean NO_2 Air Quality Standard (40ug/m^3), known to be derived from road transport.

Two AQMAs are primarily focused in Cardiff City Centre (Cardiff City Centre AQMA established: 01/04/2013 & Stephenson Court AQMA established: 01/12/2010).

North of the City Centre, lies the Llandaff AQMA established: 01/04/2013 and to the west of Cardiff is the Ely Bridge AQMA established: 01.02.2007.

Figure 2 details the location of the AQMAs and the results of the latest 2017 monitoring for NO_2 monitoring across Cardiff.

Figure 2 – 2017 Monitored NO_2 Results and Existing AQMAs in Cardiff



2.3.3 Pollution Climate Mapping Model Results

The methods used to model and monitor air quality to assess compliance with NO_2 limits and to model future concentrations have been developed by Defra and comply with the EU AAQD.

In brief, emissions from the National Atmospheric Emissions Inventory (NAEI)[11] are mapped across the UK within a Geographic Information System (GIS). Deterministic dispersion models specific to each pollutant are used to simulate atmospheric mixing and to generate background concentrations for different pollutants. The modelled results are then calibrated against measured concentrations from the national monitoring network and then verified. This modelling provides an estimate of the distribution of atmospheric pollutants including NO_2 on a 1km x 1km grid and **for individual roads**. Collectively, this is known as the Pollution Climate Mapping (PCM) model and is operated on behalf of Defra by Ricardo Energy & Environment.

The results of the PCM modelling identified 16.3 km of road length that would exceed the annual limit value. The roads which have been modelled as exceeding the annual limit value for the baseline year of 2015 are the A4161, the A4232, the A4234, the A470 and the A48 as detailed in Figure 1. The A48, which extends out of the Cardiff Urban Area agglomeration zone and into the South Wales non-agglomeration zone, is not projected to achieve compliance until 2023 without further measures. The results of the PCM modelling are summarised in Table 2 below.

Table 2 – PCM Modelling Results Cardiff Urban Area

Road Name	ID No	PCM 2015 Baseline Results for NO_2	PCM 2021 Baseline Results for NO_2
A4161	50660	43.7	33.8
A4232	80898	47.3	37.7
A48	20527	48.8	39.1
A4161	40656	40.9	33.4
A470	40549	40.8	32.5
A48	50527	45.3	37.1
A4232	80899	43.1	34.3
A48	50524	59.6	**45.4**
A4232	74101	52.5	**40.7**
A4161	30665	41.2	31.9
A4234	99956	44.6	36.8
A4232	70056	42.2	29.9

[11] National Atmospheric Emissions Inventory: http://naei.defra.gov.uk

A target determination assessment and full assessment of the PCM results and local modelling/ monitoring has been undertaken as part of this study, and is detailed in Section 3.3.

This assessment provides finer resolution than is possible with the national PCM model. Input parameters are more localised including measured speed assumptions, local emission sources and fleet composition captured as part of an Automatic Number Plate Recognition (ANPR) study. The results of this assessment are presented for 2015 and 2021, with the 2021 results representing a Business As Usual (BAU) scenario where only measures currently implemented to improve air quality have been modelled. The results of this assessment are presented in detail in Chapter 3.

2.3.4 Improvements to Air Quality -Progress to Date

The Council has a statutory requirement to produce an Air Quality Action Plan (AQAP) for each identified AQMA within the local authority area. However previous experience in implementing singular actions plans in Cardiff has not proven to be sufficiently successful. The main issue with this particular approach is that the AQAP focuses on introducing local measures to individual road links/ areas, which only targets at improving air quality within the identified AQMA itself.

Whilst such measures have been successful in improving air quality within the individual AQMA (High Street/ St Mary's Street Action Plan) such localised measures can ,and have led, to an adverse impacts on air quality in surrounding areas and result in more widespread air quality issues. These plans have not been sufficient enough in looking at the primary cause of the problem, this being road traffic derived emissions, resulting in air quality levels being detrimentally increased in neighbouring areas.

The Council recognises that in order to tackle these known pockets of poor air quality, it is deemed a more suitable and constructive approach to target the whole of Cardiff, improving overall air quality. With the implementation of correct long term measures all highlighted road networks and identified AQMAs should be able to benefit from improved air quality. The absence of an AQMA in parts of Cardiff does not means there is no public health problem from air pollution. The recent Welsh Government guidance on local air quality management recommended two clear goals

> (1) Achieve compliance with the national air quality objectives in specific hotspots and:
>
> (2) To reduce exposure to pollution more widely, so as to achieve the greatest public health benefit

Collective efforts, therefore, should look beyond targeted action in localised air pollution hotspots and do this in parallel with universal action to reduce risks for everyone.

It has been highlighted that any formal AQAP needs to be devised via the involvement and input of various influencing sectors across local authority bodies and partner agencies. The Council acknowledges this approach which will allow for increased awareness within the authority and fundamentally will produce an effective action plan, supporting the desirable outcome of reaching lowest levels reasonably practicable, and maximising health benefits to the residents of Cardiff and commuters to the Capital.

It is important to note the recent report by National Institute for Health and Care Excellence (NICE) [12] suggests that small-scale actions on their own are unlikely to lead to the significant reductions in air pollution needed to protect health. Rather, it is recommended that multiple interventions are driven forwards in parallel; with each producing a small benefit, a multiple-intervention approach would likely act cumulatively to produce significant change (both in terms of air pollution mitigation and population health adaptation and improvement).

The Council recognise that there is no defined "safe level" when describing levels of NO_2 [13]. The Council is committed to achieving NO_2 levels as low as reasonably practicable.

Datasets for annual average NO_2 levels recorded at relevant public exposure locations within the AQMAs do display signs of improvement. However, levels are consistently elevated and are seen to be either exceeding or encroaching on the annual average NO_2 objective. Table 3 draws upon ratified NO_2 datasets monitored via passive diffusion tubes at most relevant sensitive receptor locations, i.e., residential facades within each AQMA.

Table 3- Five Year Dataset For Monitored Annual Average NO_2 Levels At Residential Facades.

AQMA	Site ID	Bias Adjusted Annual Average NO_2 Concentration (µg/m^3)					
		2012	2013	2014	2015	2016	2017
City Centre	143	**41.5**	**42.1**	**42.1**	38.2	38.7	38.2
Stephenson Court	131	**47.9**	**43.9**	**41.2**	39.5	39.6	36.7
Ely Bridge	117	**42.6**	**44.9**	**42.3**	39.5	**41.3**	38
Llandaff	161	**43.0**	39.1	37.2	32.3	35.0	32.5

Bold -= exceedance of the Air Quality Standard for NO_2 as an annual average (40 µg/.m^3)

As displayed by Table 3, although it can be suggested that compliance is being met in the existing AQMAs, the Council do not consider these levels as low as reasonably practicable. With Cardiff's expected future growth and approved development works already in progress, further work is needed to ensure compliance with the air quality objectives and EU Limit Values is of a greater magnitude.

In order to monitor the Council's identified strategic measures and their effectiveness, the Council will continue to monitor levels of NO_2 at various relevant exposure locations citywide. The Council will look at improving the network of monitoring across the city by examining ways of increasing monitoring capabilities, for example looking at personal air quality monitoring for the public and purchasing automatic monitoring equipment to provide a further understanding of air quality trends. The Council will also design a transport monitoring programme which will look to examine different modes of transport trends, undertaken on a yearly basis. The scope for such a transport study would include examining figures for cycle trips, school journey mode determination, bus patronage, trends in peak traffic flow times and fleet composition analysis using routes through AQMAs and surrounding tributary road networks.

[12] NICE (2017). Air pollution: outdoor air quality and health. NICE Guideline NG70
[13] Local air quality management in Wales Policy guidance June 2017

2.4 Public Health Impacts

There is clear scientific evidence which shows that air pollution exposure reduces life expectancy by increasing mortality and morbidity risk from heart disease, and strokes, respiratory diseases, lung cancer and other conditions[14]. Public Health Wales have stated that poor air quality is probably the second greatest health concern after smoking and is the most significant environmental determinant of health.

In the UK it has been estimated that an equivalent of **29,000** deaths are attributed to long term exposure to fine particulate air pollution exposure each year and an equivalent of **23,500** deaths are attributed to long term exposure to nitrogen dioxide (NO_2) exposure each year[15]. There is an overlap between the effects of both pollutants; as such, it has been estimated that the equivalent of **40,000 deaths** occur each year in the UK as a result of exposure to outdoor pollution[16]. On average, exposure reduces the life expectancy of every person in the UK by 7 to 8 months[17]. It has been estimated that reducing particulate air pollution by 10 µg/m3 in the UK would extend lifespan by five times more that eliminating casualties on the roads or three times more that eliminating passive smoking[18].

In Wales, based on data for the period 2011-2012, it has been estimated that an equivalent of **1,604** deaths can be attributed to fine particulate exposure each year, and **1,108** deaths can be attributed to nitrogen dioxide exposure each year[19]. Accounting for the pollutant effect overlap, it is estimated that an equivalent of around **2,000** deaths occur each year in Wales as a result of exposure to fine particulate and NO_2 exposure each year.

A study undertaken in 2014 published by Public Health England estimated that in **Cardiff 143** deaths were attributable to exposure to fine particulate air pollution.[20] More recent work by Public Health Wales estimates that the equivalent of over 220 deaths each year among people aged 30 and over in the Cardiff and Vale area that can be attributed to NO_2[21] with many more citizens suffering ill health as a consequence of poor air quality.

In 2012, the International Agency for Research on Cancer listed diesel exhaust pollution as a Class 1 carcinogen and extended this to all ambient air pollution in 2013.

For particulate air pollution and nitrogen dioxide there is no safe level of exposure and any initiatives to reduce air pollution will have positive health benefits. Welsh Government have indicated that the national air quality objectives used to identify Air Quality Management Areas (AQMAs) should not be seen as 'safe' levels and impacts are observed below levels permitted by current legal limits. Air pollution can cause adverse effects on health and quality of life at lower exposures, depending on the circumstances of the exposed individual. As a consequence, the majority of the avoidable health burden associated with air pollution in Wales is the result of population exposures outside AQMAs.

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[14] WHO. Review of evidence on health aspects of air pollution-REVIHAAP. 2013. Copenhagen: WHO. From: http://www.euro.who.int/__data/assets/pdf_file/0004/193108/REVIHAAP-Final-technical-report.pdf

[15] Defra. Draft plans to improve air quality in the UK: tackling nitrogen dioxide in our towns and cities. UK overview document. 2015. London: Defra.

[16] Royal College of Physicians and Royal College of Paediatrics and Child Health (2016). Every breath we take: the lifelong impact of air pollution. From: https://www.rcplondon.ac.uk/projects/outputs/every-breath-we-take-lifelong-impact-air-pollution

[17] Defra. The air quality strategy for England, Scotland, Wales and Northern Ireland (vol. 1). 2007.

[18] Defra (2017) Air Quality: Public Health Directors briefing. From https://laqm.defra.gov.uk/assets/63091defraairqualityguide9web.pdf

[19] Brunt., H and McCarthy J., (2017). Estimating the mortality burden of air pollution in Wales

[20] Gowers., A. M, Miller., BG, Stedman., JR. Estimating local mortality burdens associated with particulate air pollution. 2014. London: Public Health England

[21] Estimating the mortality burden of air pollution in Wales, Public Health Wales

Although air pollution is a public health priority in Wales, its management needs to be a collaborative approach between public bodies, private companies, third sector partners and the public, all whom have important roles to play in addressing this pressing issue.

Poor air quality does not only have a significant health impact but it also has a wider societal cost. Accounting for health service costs and reduced productivity through lost work-days in the UK this is significant, standing at around £20b every year.[22]

Widespread air pollution is associated with routine car use for journeys within, into and out of, Cardiff. Well-designed measures to reduce air pollution will also increase active travel rates. Reducing reliance on the car as the primary mode of transport will have co-benefits of increased physical activity, mental well-being, and improved productivity and reduced stress, and will play a vital role in reducing carbon emissions which contribute to climate change.

The Director of Public Health's Annual Report 2017 highlights how our built environment has become increasingly shaped around car use over the last 50 years, with journeys made by car across the UK increasing from 27% to 83% over that period, while journeys made by bus have fallen from 42% to 5%, and by cycling from 11% to 1%. Over half of adults in our area are overweight or obese. To help reduce these levels, as well as levels of cardiovascular disease and type 2 diabetes, we need active travel to become the default for short journeys once again.

2.5 Well-being of Future Generations (Wales) Act 2015

The Well-being of Future Generations (Wales) Act 2015 (WFG) is a significant enabler to improve air quality as the Act calls for sustainable cross-sector action based on the principles of long-term, prevention-focused integration, collaboration and involvement. It intends to improve economic, social, environmental and cultural well-being in Wales to ensure the needs of the present are met without compromising the ability of future generations to meet their own needs. The Act places responsibilities on public bodies in Wales to work in new ways (including via Public Services Boards) towards national Well-being goals. Progress is measured against a suite of well-being and Public Health Outcomes Framework indicators; there is one specifically concerned with air pollution.

As Figure 3 illustrates, the Act is the legislative vehicle for "Health in all Policies in Wales" and provides the underpinning principles for all policy and decision making, including economic development, in Wales. Reducing air pollution, health risks and inequalities can help contribute to most, if not all, of the well-being goals. As such, the Act presents excellent opportunities to change policy and practice to enhance air quality management arrangements across Cardiff (and wider).

The feasibility study will ensure that future decision making in terms of air quality will comply with the WFG in terms of ensuring that meets the five ways of working

• **Long term** – The feasibility study will balance short-term needs of achieving compliance with the limits values in the shortest time possible, with the need to safeguard the ability to ensure longer term continued improvement in air quality within Cardiff.

• **Prevention** –By implementing the preferred option identified in the Final Plan, should ensure improvements in air quality are achieved and will be able to prevent air quality getting worse in the future thus protecting public health and the wider environment.

[22] Royal College of Physicians and Royal College of Paediatrics and Child Health (2016). Every breath we take: the lifelong impact of air pollution.

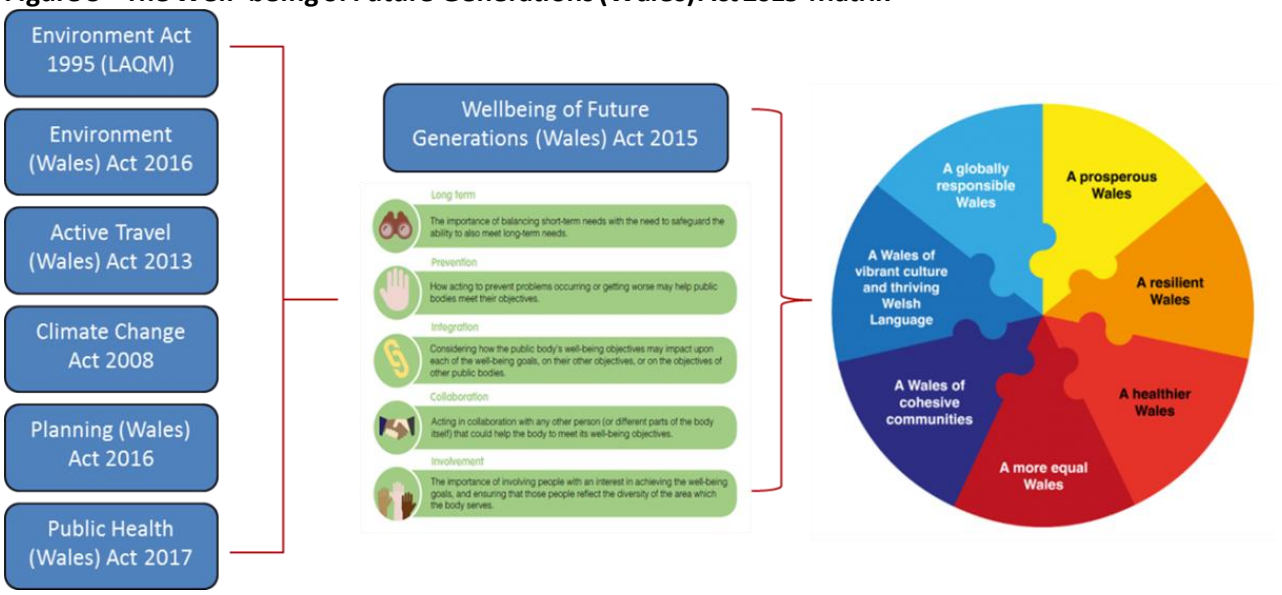
•**Integration** – The development of a preferred option in the Final Plan will take into consideration other public body's well-being objectives and will assess how the preferred option may impact upon each of the well-being goals, or on the objectives of other public bodies.

•**Collaboration** –The development of the shortlist of measures detailed in this report has been done so in collaboration with many departments within the Council and other external organisations, e.g., Public Health Wales. This collaborative approach will be taken forward in the development of the preferred option in the Final Plan.

• **Involvement** –Prior to developing the Final Plan the preferred measures will be subject to an appropriate level of consultation, and will ensure that those who have a strong interest in improving air quality will be fully involved and their ideas considered .

Overall, improving air quality and developing a preferred option to achieve compliance with the NO_2 limit value, contributes significantly to the majority of the well-being goals.

Figure 3 - The Well- being of Future Generations (Wales) Act 2015 Matrix



2.6 Consistency with Local Transport Plan

Cardiff Council's longstanding vision for transport in the city is for:

"An integrated transport system that offers safe, efficient and sustainable travel for all, where public transport, walking and cycling provide real and desirable alternatives to car travel, which contributes to making Cardiff Europe's most liveable capital city."

Our priorities to achieve this are:

1. Widening travel choices making it practical for most daily trips to be made by alternatives to the car, such as public transport, walking and cycling;
2. Demand management taking steps to reduce the demand for travel overall, and particularly by car ; and
3. Network management using technology to make best use of the existing highway network, rather than building new roads that would generate more traffic.

As a result, it is necessary to assess how the various options considered to improve the air quality in Cardiff will align with, and support, the realisation of the strategic objectives contained within the emerging policy documents.

The key strategic themes and principles of the existing policies overlap with several of the critical success factors used in the economic assessment, including those related to air quality improvements, benefits to the economy, social inclusion and public health benefits.

2.6.1 Local Transport Plan

Cardiff is growing and changing, and this brings more journeys and more pressures on Cardiff's transport network. Reducing the number of car journeys made in the city, and promoting the use of active and sustainable modes of travel, is central to Cardiff Council's Transport Strategy and in improving air quality in the city. Our Local Development Plan (LDP) provides for 41,000 new homes and up to 40,000 new jobs up to 2026. The LDP sets the target of achieving a 50:50 modal split – this means that 50% of all journeys need to be made by sustainable transport by 2026 in order to accommodate the future development set out in the LDP. Our policies set out in the LDP support the need to secure significant improvements to the public transport and active travel networks in combination with new developments.

Cardiff's Local Transport Plan (LTP) was approved by the Welsh Government in May 2015. The LTP sets out our main transport infrastructure proposals which will support this significant modal shift. The Local Transport Plan recognises the need to improve air quality and in doing so its programme prioritises:

- development of active travel networks to increase walking and cycling for local journeys
- the provision of cycling infrastructure
- the bus network
- reduced speed limits
- reducing congestion
- improving transport efficiency and reliability
- bus based park and ride

The LTP has been used to help develop a number of the measures which have been assessed by this study.

2.7 Stakeholder Engagement

Owing to the timeframes required to complete this report it has not been feasible for the Council to undertake a public consultation on the shortlist of measures that have been developed as detailed in Chapter 3.

However, earlier in 2018 the Council launched a Green Paper on Transport and Clean Air[23]. The paper set out a number of proposals/ ambitions on measures to improve transport and air quality in Cardiff. Fundamentally the paper focused on the need to tackle congestion and offer active travel options to discourage unnecessary private car use, keeping the city moving and ensuring the health of citizens. The paper enabled members of the public, businesses and

[23] https://www.cardiff.gov.uk/ENG/resident/Parking-roads-and-travel/transport-and-clean-air-green-paper/Documents/Cardiff%27s%20Transport%20and%20Clean%20Air%20Green%20Paper.pdf

other organisations a chance to score the proposals in terms of preference of them being implemented in Cardiff. At the time of writing this report work is still on going to assess the results of the Green Paper Consultation. A number of the measures assessed later in this report were included, as part of the Green Paper.

As the feasibility study progresses the Council will undertake appropriate consultation with stakeholders on the preferred measure(s).

2.8 The Case for Change

2.8.1 Primary Objective

The primary objective of the feasibility study is to deliver a scheme that leads to compliance with the EU AAQD annual average NO2 limit value in the shortest possible time.

2.8.2 Secondary Objectives

JAQU's Options Appraisal Package [24]document states that while the primary CSF allows appraisers to test whether an option meets the minimum requirements, other secondary CSFs are needed to undertake a comparative assessment of the options. The guidance states that these may include factors such as value for money, distributional impacts, wider strategic air quality policy alignment, affordability and achievability.

Following this guidance, a number of secondary CSFs have been defined for the Plan for which options that have been assessed as achieving the Primary CSF have been further assessed against. Further, this study contributes to the strategic priorities for Cardiff Council, including that of the Well-being of Future Generations (Wales) Act 2015. As such, based on the Future Generations Act and the further recommendations within The National Institute for Health and Care Excellence (NICE)[25] on air quality guidelines and health, the following are considered as **secondary objectives** in the appraisal process:

- Will the measure deliver an overall reduction in NO_2 emissions to air;
- Will the measure result in additional benefits or other environmental improvements;
- Will the measure contribute to well-being goals:
  - Will the measure impact equally across multiple vehicle classes and journey types;
  - Will the measure have a positive impact on wider public health;
  - Mitigate financial impact on low income households and reduce inequalities;
- Does the option fit or compliment other local policies;
- Value for Money - Do the likely benefits of this option exceed the costs; and
- Are there constraints that prevent/ impact on the implementation of the measure

[24] Joint Air Quality Unit - OPTIONS APPRAISAL GUIDANCE 2017
[25] NICE (2017). Air pollution: outdoor air quality and health. NICE Guideline NG70

Chapter 3 Economic Case

3.1 Introduction

The Strategic Case outlines the case for change by comparing the existing conditions, statutory and regulatory obligations, and the desired goals of this Local Government intervention. Within this context the purpose of the Economic Case in the Strategic Outline Case document, as outlined in the Joint Air Quality Unit's (JAQU) Inception Package, is to identify a long list of options and refine them to a short-list of options / packages which will be appraised in greater detail as part of the Full Business Case.

The Inception Package document states that shortlisting of the long list of options requires an early appraisal of options against Critical Success Factors as well as the intervention's spending objectives and benefit assessment criteria. The document also states that the options' other strengths, weaknesses, opportunities and threats may also need to be considered for the shortlisting process. Finally, the Inception Package document states that this multi-criteria analysis should be used to short list approximately four options to be explored further.

Within the above context, this Economic Case chapter includes the following:

- Identify a long-list of options for delivering the desired goal;
- Establish the Critical Success Factors, including the primary Critical Success Factor and other secondary Critical Success Factors as identified in the JAQU's Options Appraisal Package document;
- Establish the multi-criteria appraisal framework, including the Critical Success Factors, and the process for appraising the long list of options;
- Determination of a short list of options / packages, which will be appraised in greater detail as part of the Outline Business Case and the Full Business Case.

3.2 Baseline Local Transport Modelling

The section outlines the transport modelling work undertaken by Mott MacDonald to develop the evidence base to progress this study. Transport modelling has been undertaken using the South East Wales Transport Model (SEWTM) using methods that are appropriate for a high-level feasibility study. The full details of the transport modelling are included in Appendix B of this Report.

3.2.1 South East Wales Transport Model (SEWTM) Summary

SEWTM is a disaggregate multi-modal transport model of South East Wales. The model comprises separate highway and public transport assignment models linked together with a variable demand model. The model was developed for Welsh Government with a 2015 base year, validated to WebTAG Unit M3.1 guidance. It has been designed to:

- Understand the current travel patterns in South East Wales and the performance of the transport system;
- Monitor changes in travel patterns over time;
- Predict future travel patterns and conditions on the transport network;
- Assess the impacts of possible interventions in the transport system in a consistent manner;

- Assess the impacts of land use changes such as new housing developments and employment locations in a consistent manner; and
- Provide inputs required for transport appraisals and business cases.

The model represents an average weekday and for most purposes outputs are divided into four time periods:

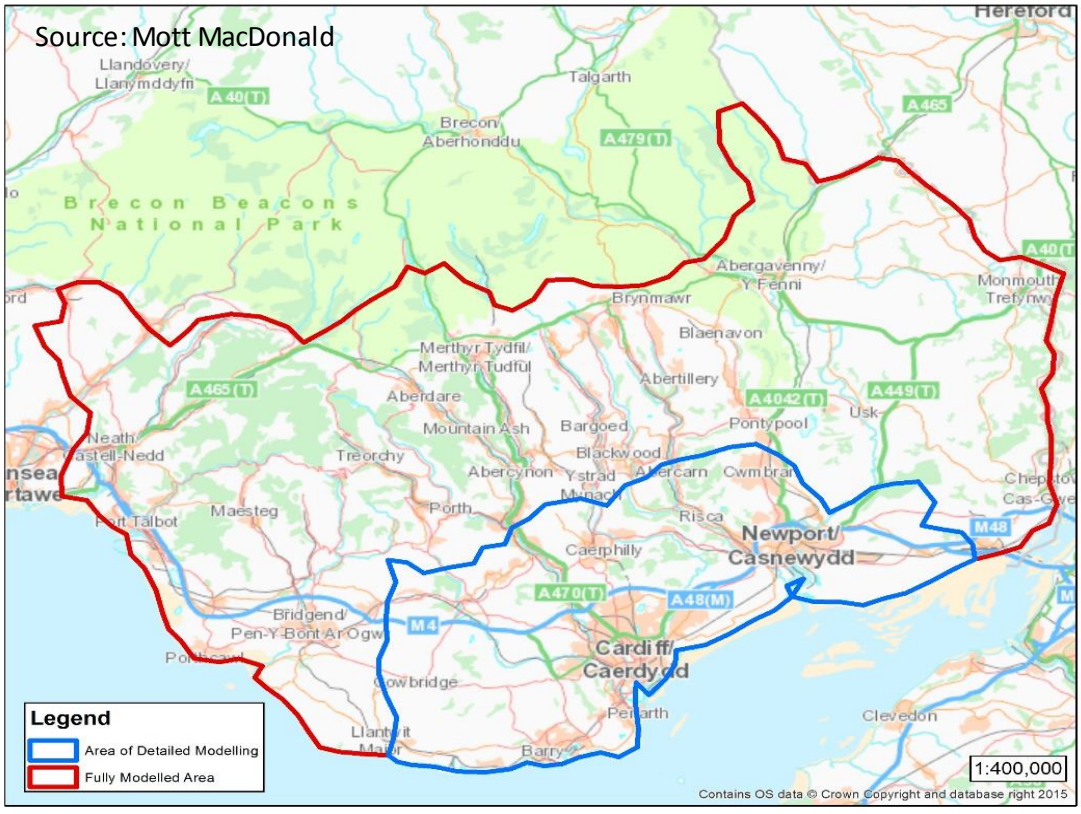
- AM peak between 0700 and 0930; peak hour assignment representing 0745-0845;
- Inter-peak (IP) between 0930 and 1530; average hour assignment;
- PM between 1530 and 1800; peak hour assignment representing 1630-1730; and Off-peak (OP) between 1800 and 0700; average hour assignment.

The following assignment user classes are included in the highway model:

- Car commute;
- Car business;
- Car other;
- HGV and
- LGVs

The SEWTM geographical coverage is shown in Figure 4 . The Cardiff local authority area is within the Area of Detailed Modelling. This is the area of the transport model within which significant impacts of interventions are more certain. Within this area the model will represent all trips (demand), model zones are generally smaller than LSOAs, the transport network is detailed, and junction modelling is included.

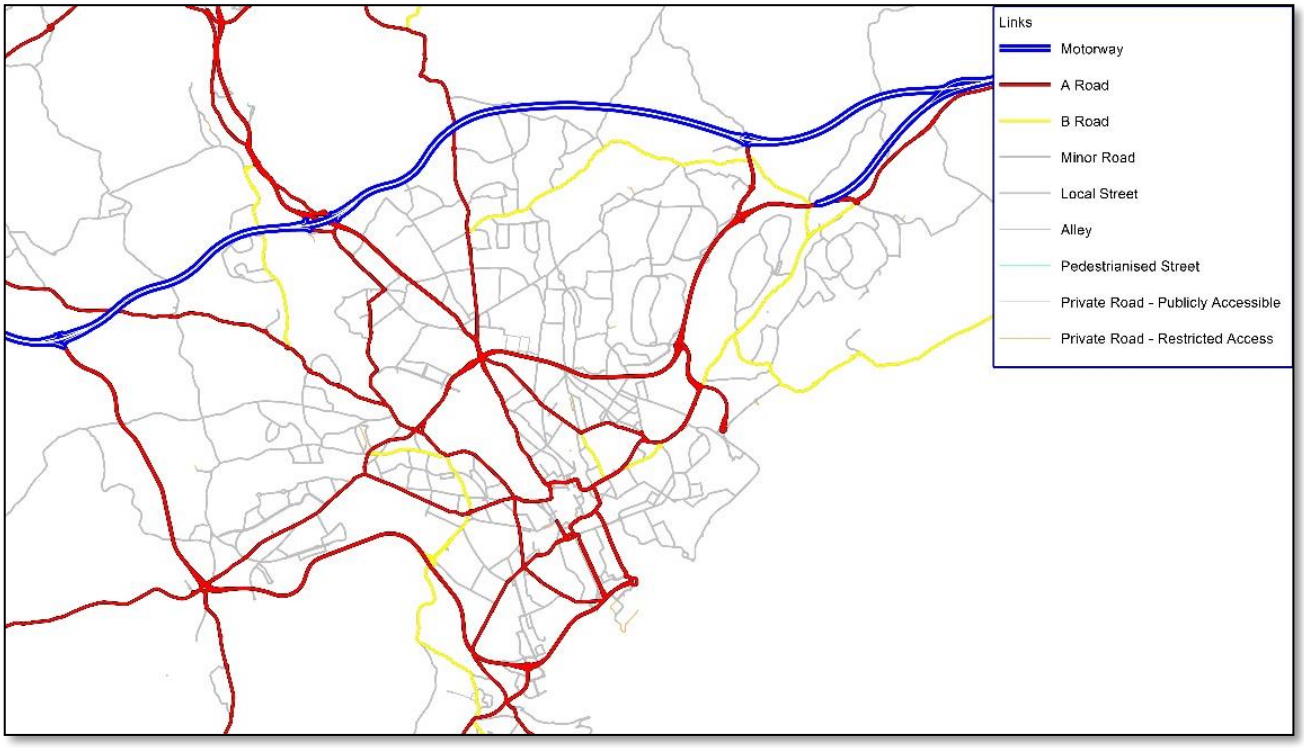
Figure 4 - SEWTM Modelled Area



3.2.2 Method Overview

The transport modelling approach that has been adopted for this study balances the need to forecast the highway network impacts of a range of interventions with the need to maintain a proportionate approach to appraisal, taking account of the high-level nature of the study and the associated time and budget constraints. The full multi-modal Variable Demand Model (VDM) has been used to forecast the 2021 baseline situation given expected changes to population, employment and the highway/public transport networks. The highway assignment user classes have been split by vehicle emissions class using information provided by Ricardo, determined from Automatic Number Plate Recognition (ANPR) surveys. The highway network level of detail contained in SEWTM for the Cardiff area is shown in Figure 5.

Figure 5 - SEWTM Highway Network in Cardiff Area



3.3 Baseline Local Air Quality Modelling Results for 2015 and 2021

A detailed modelling exercise has been carried out to provide an initial estimate of NO_2 concentrations across Cardiff for a base year of 2015 and a target year of 2021. The area modelled extended to 1km beyond the city's boundary and covered the PCM links of concern in the national modelling and local AQMAs. This model domain is illustrated in Figure 6.

There are three main components of the model:

- ***The South East Wales Traffic Model (SEWTM)*** – this is a strategic traffic model developed for the Welsh Government that covers the Cardiff area. This model provided traffic data in terms of traffic flows (AADT[26]) and speeds. The traffic flows are provided for cars, LGVs, HGVs and buses. In addition, for the 2021 model year the vehicle categories have been split further into compliant and non-compliant vehicles. Compliant vehicles are those that meet the CAZ emission standards set out in the UK Government's Clean Air Zone Framework and non-compliant vehicles are those that don't[27]. It should be noted that for the purposes of the traffic modelling, taxis are included within the car flows and coaches are not included in the modelling at all (in line with standard practice).
- ***Local ANPR fleet data*** – a set of ANPR data was collected in May 2018. This data comprised of seven main sites covering each of the AQMAs in the city and the two stretches of road that the PCM modelling showed would be exceeding NO_2 thresholds in 2021 (A48 and A4232). The data was collected over a 1-week period and provided a detailed breakdown of the fleet composition in these areas. This data was used to provide fleet descriptions for seven distinct zones in the model domain, as illustrated in, Figure 7 detailing:
    - The split of compliant and non-compliant vehicles, that would feed back into the transport model;
    - The breakdown of vehicles by fuel type and Euro standard;
    - The split of vehicles between rigid and artic HGVs;
    - The proportion of car traffic which was estimated to be taxis.

- ***Ricardo's emissions and dispersion modelling suite RapidAir*** – the emission component of this takes the traffic activity data and fleet data and provides emission results for each 'link'[28] in the traffic model. The dispersion component of the modelling suite then takes these emissions and generates a 1m x 1m grid of NOx concentrations. This is combined with the national background maps to provide NO_2 concentration results. The model is calibrated against monitoring data in the 2015 base year.

[26] Annual average daily traffic
[27] For details of the standards, see Annex A at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/612592/clean-air-zone-framework.pdf. For example, this shows that for petrol cars and diesel cars, compliant cars are those that are Euro 4 and above or Euro 6 and above respectively.
[28] A 'link' in this context being a stretch of road where air pollution is estimated within the PCM model.

Figure 6 - Air Quality Modelling Domain

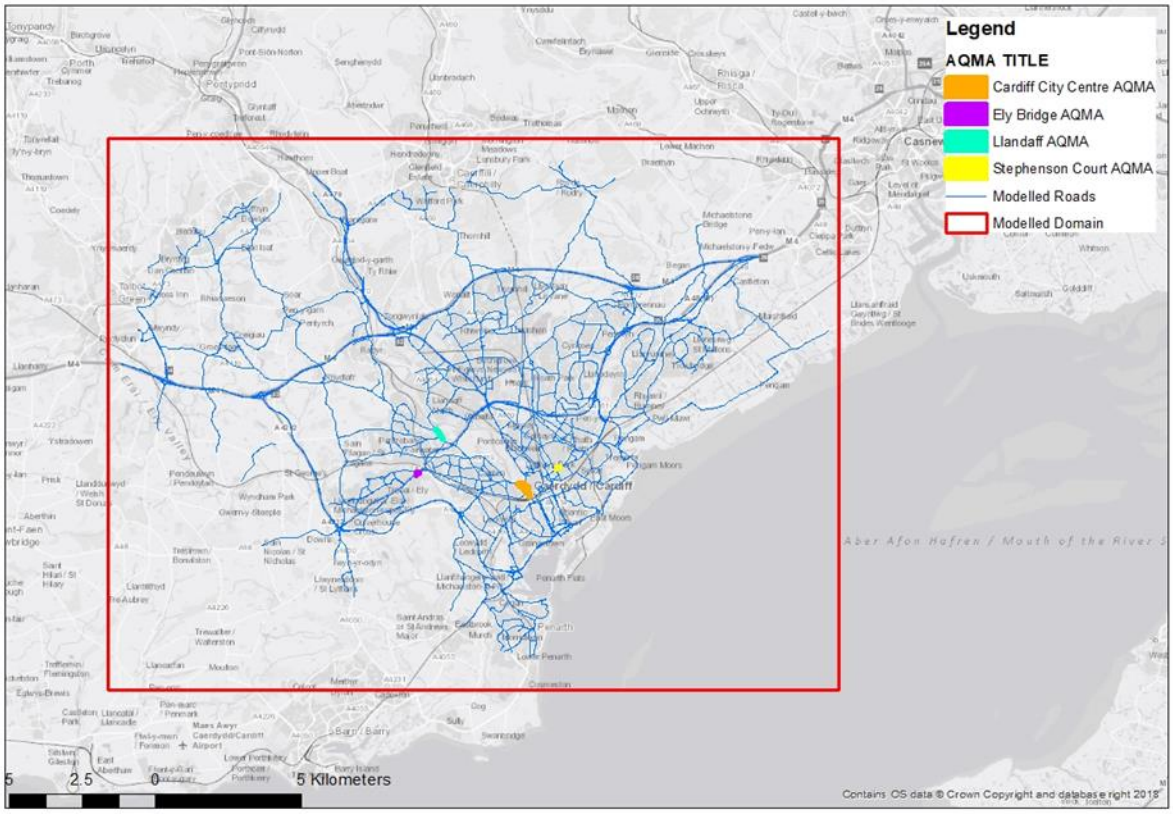
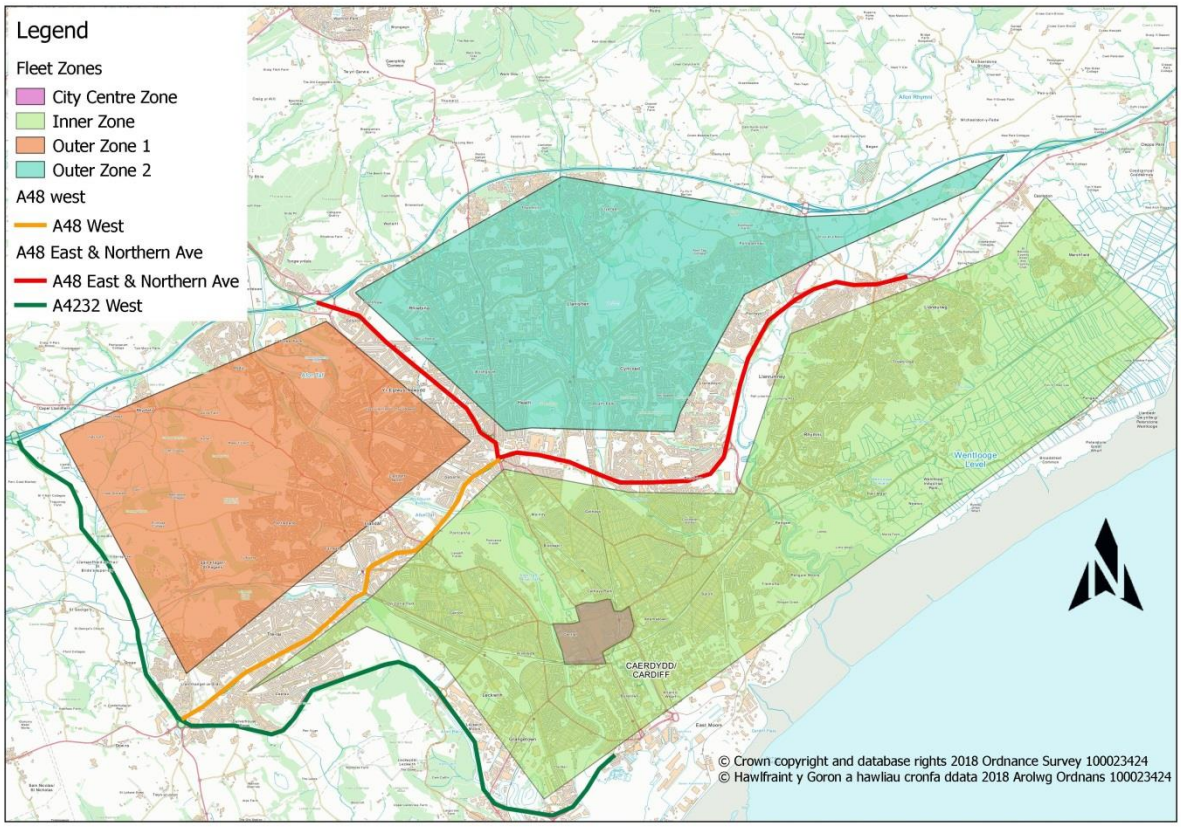


Figure 7- Fleet Zones Used In the Air Quality Model



The initial baseline results from this model for 2015 and 2021 are described in the sections below. Section 3.3.3 below explains the inherent modelling uncertainty and when reviewing the initial results below it should be borne in mind that further work will be carried out in coming months that may impact on the results.

3.3.1 Comparison with PCM Results

For comparison with PCM model results, annual mean NO_2 concentrations at the roadside locations assessed in the national compliance PCM model have been extracted from the RapidAir dispersion model results; the results have been presented in both tabular form and graphically as maps of the study area.

Roadside receptor locations in the PCM model are at a distance of 4m from the kerb and at 2m height. To represent this in our city scale modelling, a subset of the OS Mastermap GIS dataset provided spatially accurate polygons representing the road carriageway. Receptor locations were then placed at 10m intervals along relevant road links using a 4m buffer around the carriageway polygons.

Each PCM link has a unique Census ID number and a grid reference assigned which is typically the co-ordinates describing the location of the DfT traffic count points on each link; this location may not however be where the highest roadside concentrations are occurring along the entire link length when using a more detailed local scale modelling method with observed average vehicle speeds on shorter road sections. The PCM links within our model domain range in length from approximately 120m to 3.25km; we have therefore reported the highest of the modelled concentrations for each link, from the city scale model receptors spaced at 10m intervals, 4m from the carriageway.

A full list of tabulated results comparing the PCM baseline results with the local modelled results from 2015 to 2021 is shown in Table 4. This shows estimated NO_2 concentration for each PCM link and is colour coded as green for less than 35µgm^{-3}, amber between 35µgm^{-3} and 40 µgm^{-3} and red for greater than 40µgm^{-3} (the compliance threshold[29]). For the local model only the baseline 2015 and future year 2021 results have been directly modelled, the intervening years have simply been interpolated between these two results.

Mapped results are shown in Figure 8 to Figure 11. These show two types of maps; one with the PCM links colour coded with the local results in the same way as the tabulated results (i.e. a whole link is colour coded to match the highest concentration along that link) and a second showing point locations of any local modelled receptors along the PCM links greater than 35 µgm^{-3}. It should be noted that the compliance limit is 40µgm^{-3}, but is formally defined as a whole number and so only results equal or greater than 40.5µgm^{-3} are considered non-compliant, and are colour coded as such in both the table and maps.

[29] The compliance limit is 40µgm^{-3}, but is formally defined as a whole number and so any result less than 40.5µgm^{-3} which rounds down to 40µgm^{-3} is considered compliant.

Looking first at the local model results overall, they show a somewhat different pattern to the PCM results. A difference is to be expected as the local and PCM modelling are done in different ways; for example road gradients and street canyons[30] are considered in the local model and not in the PCM model, which would tend to lead to higher concentrations in the local model.

Focusing on areas of exceedance in 2021, the national PCM model showed exceedances on the A48 to the east of the city and the A4232 to the south west. The local model however suggests that both these locations would be comfortably within compliance. The differences between the PCM and local model will be explored further at these locations, but one possible reason is that the PCM model uses generic urban speeds for these links whereas the local model uses local speeds from the traffic model. Since these are major dual carriageways the local speeds are likely to be higher than that seen in the PCM model and hence would generate lower emission rates.

The local model results are showing only one exceedance on PCM link ID30665 – the A4161 Castle Street. This exceedance is related to high traffic flows of some 32,000 vehicles a day, slow speeds of around 11mph and being located in a canyon.

Section3.3.3 below looks at the inherent uncertainty in modelling of this kind. This shows that whilst all efforts have been made to reduce the uncertainty, it is still possible that results could be higher or lower by around 5 µgm-3.

It should be noted that the NO_2 concentrations in the table and maps below only show the maximum concentrations for each PCM modelled road link. Certain roads in the modelling domain are not modelled in PCM and hence no concentrations are shown (e.g. M4).

The main reasons for the differences between the local model results and the PCM results is primarily down to the fact that the local model has a far greater level of detail which is based on local data, and not national assumptions, and thus can be seen to be a better representation of local circumstances. The key aspects of the local model that influence the results are as follows:

- Traffic flows are based on a local traffic model;
- Traffic speeds are based on a local model and local traffic master;
- Local fleet data from the ANPR, not just national averages; and
- Local topology in terms of gradient, canyons, etc. which the PCM does not allow for.

[30] A street canyon is where buildings create a canyon effect, concentrating air pollution levels in a specific area.

Table 4- Comparison of PCM and Local Model NO_2 Concentration Results 2015- 2021 (NO_2 In µgm-3)

CensusID	Road Name	LA Name	PCM Baseline						Local Baseline						
			2015	2017	2018	2019	2020	2021	2015	2016	2017	2018	2019	2020	2021
30660	A4119	Cardiff City Council	22.4	21.3	20.5	19.8	18.9	17.9	37.1	36.0	34.9	33.9	32.8	31.8	30.7
10629	A4054	Cardiff City Council	19.1	18.1	17.4	16.7	15.8	15.0	25.3	24.3	23.4	22.4	21.4	20.5	19.5
50647	A4119	Cardiff City Council	29.9	28.7	27.7	26.7	25.4	24.0	34.4	32.7	31.0	29.4	27.7	26.0	24.4
10660	A4161	Cardiff City Council	40.3	38.7	37.4	36.2	34.5	32.7	34.9	33.4	32.0	30.5	29.1	27.6	26.2
522	A48	Cardiff City Council	27.9	26.8	25.8	24.8	23.7	22.3	32.9	31.6	30.4	29.2	27.9	26.7	25.4
30659	A4119	Cardiff City Council	27.2	26.2	25.2	24.3	23.1	21.8	23.8	23.0	22.2	21.3	20.5	19.6	18.8
77018	A470	Cardiff City Council	31.1	29.8	28.7	27.7	26.4	25.2	45.4	42.9	40.5	38.0	35.5	33.0	30.6
99955	A4160	Cardiff City Council	32.2	30.7	29.6	28.5	27.1	25.7	36.7	35.1	33.5	31.8	30.2	28.5	26.9
50660	A4161	Cardiff City Council	43.7	41.4	39.6	37.9	35.9	33.8	42.2	40.3	38.4	36.5	34.6	32.7	30.8
70055	A4161	Cardiff City Council	37.5	35.9	34.5	33.1	31.5	29.7	43.9	41.7	39.4	37.1	34.9	32.6	30.4
99671	A469	Cardiff City Council	33.1	32.2	31.1	30.1	28.7	27.1	27.2	26.2	25.3	24.4	23.4	22.5	21.5
10659	A4160	Cardiff City Council	30.4	29.3	28.3	27.3	26.2	25.0	30.4	29.3	28.2	27.0	25.9	24.8	23.7
10655	A4119	Cardiff City Council	31.9	30.8	29.8	28.8	27.4	25.9	36.6	35.4	34.1	32.8	31.6	30.3	29.0
80898	A4232	Cardiff City Council	47.3	45.2	43.5	42.0	39.9	37.7	34.3	33.5	32.7	31.9	31.1	30.3	29.5
20527	A48	Cardiff City Council	48.8	46.9	45.2	43.6	41.5	39.1	40.0	38.4	36.9	35.3	33.7	32.2	30.6
40655	A4160	Cardiff City Council	28.2	27.1	26.1	25.1	24.0	22.7	24.2	23.4	22.6	21.7	20.9	20.1	19.3
50580	A469	Cardiff City Council	28.5	27.1	26.1	25.0	23.8	22.4	33.0	31.8	30.6	29.4	28.2	27.0	25.8
50657	A4161	Cardiff City Council	29.5	28.3	27.2	26.1	24.8	23.3	26.5	25.5	24.4	23.4	22.4	21.4	20.3
10661	A4161	Cardiff City Council	24.9	23.9	23.1	22.2	21.2	20.1	26.6	25.6	24.5	23.4	22.3	21.3	20.2
10527	A48	Cardiff City Council	31.9	30.8	29.6	28.6	27.2	25.7	29.4	28.3	27.2	26.1	24.9	23.8	22.7
40582	A469	Cardiff City Council	31.8	30.5	29.5	28.4	27.0	25.5	32.2	30.9	29.7	28.4	27.2	25.9	24.7
50651	A4119	Cardiff City Council	28.4	27.3	26.4	25.5	24.2	22.9	31.6	30.4	29.2	28.0	26.9	25.7	24.5
40656	A4161	Cardiff City Council	40.9	39.3	38.0	36.8	35.1	33.4	43.7	41.4	39.0	36.6	34.3	31.9	29.6
40549	A470	Cardiff City Council	40.8	39.1	37.7	36.3	34.5	32.5	38.1	36.3	34.6	32.8	31.1	29.3	27.6
50527	A48	Cardiff City Council	45.3	44.0	42.6	41.2	39.3	37.1	37.1	35.7	34.3	32.9	31.5	30.2	28.8

CensusID	Road Name	LA Name	PCM Baseline						Local Baseline						
			2015	2017	2018	2019	2020	2021	2015	2016	2017	2018	2019	2020	2021
642	A4160	Cardiff City Council	38.3	37.1	36.1	35.0	33.6	32.1	*40.0*	*38.1*	*36.2*	*34.4*	*32.5*	*30.7*	*28.8*
80899	A4232	Cardiff City Council	43.1	41.1	39.5	38.1	36.3	34.3	*32.1*	*31.3*	*30.6*	*29.8*	*29.0*	*28.3*	*27.5*
99960	A4055	Cardiff City Council	34.9	33.7	32.6	31.5	30.0	28.4	*31.4*	*30.4*	*29.5*	*28.5*	*27.5*	*26.5*	*25.5*
50541	A470	Cardiff City Council	35.6	34.1	32.9	31.8	30.2	28.5	*37.3*	*35.9*	*34.5*	*33.2*	*31.8*	*30.5*	*29.1*
20548	A470	Cardiff City Council	31.3	29.8	28.6	27.5	26.1	24.6	*41.3*	*39.4*	*37.6*	*35.7*	*33.8*	*31.9*	*30.0*
50524	A48	Cardiff City Council	59.6	56.2	53.7	51.4	48.5	45.4	*36.4*	*35.0*	*33.6*	*32.1*	*30.7*	*29.3*	*27.9*
74101	A4232	Cardiff City Council	52.5	49.7	47.6	45.7	43.3	40.7	*30.1*	*29.2*	*28.3*	*27.4*	*26.5*	*25.6*	*24.8*
638	A4119	Cardiff City Council	27.5	26.1	25.0	24.0	22.8	21.6	*28.8*	*27.7*	*26.6*	*25.6*	*24.5*	*23.4*	*22.3*
30665	A4161	Cardiff City Council	41.2	39.0	37.3	35.7	33.9	31.9	*55.7*	*53.2*	*50.8*	*48.4*	*46.0*	*43.5*	*41.1*
73233	A4055	Cardiff City Council	35.8	34.6	33.4	32.3	30.8	29.1	*31.6*	*30.4*	*29.3*	*28.1*	*26.9*	*25.7*	*24.5*
99956	A4234	Cardiff City Council	44.6	43.1	41.8	40.5	38.7	36.8	*38.2*	*36.2*	*34.2*	*32.3*	*30.3*	*28.3*	*26.3*
78439	A4232	Cardiff City Council	33.6	32.0	30.7	29.5	28.1	26.4	*21.7*	*21.0*	*20.3*	*19.6*	*18.9*	*18.2*	*17.5*
70056	A4232	Cardiff City Council	42.2	38.2	36.0	34.0	32.0	29.9	*35.3*	*34.2*	*33.2*	*32.1*	*31.0*	*30.0*	*28.9*
73232	A4160	Cardiff City Council	26.9	25.6	24.6	23.6	22.5	21.2	*21.0*	*20.6*	*20.1*	*19.6*	*19.1*	*18.6*	*18.1*
80896	A470	Cardiff City Council	26.5	25.3	24.5	23.8	22.9	22.2	*26.9*	*26.0*	*25.2*	*24.3*	*23.5*	*22.6*	*21.8*
80726	A470	Cardiff City Council	35.4	32.6	30.9	29.1	27.2	25.3	*34.8*	*33.2*	*31.6*	*30.0*	*28.4*	*26.8*	*25.2*
78435	A4050	Cardiff City Council	30.2	28.5	27.2	26.0	24.6	23.1	*32.5*	*31.2*	*30.0*	*28.7*	*27.5*	*26.3*	*25.0*

Note: local results are colour coded as green for less than 35µgm^{-3}, amber between 35µgm^{-3} and 40 µgm^{-3} and red for greater the 40µgm^{-3} (the compliance threshold). Numbers are rounded to the nearest integer, hence any values less than 40.5 µgm^{-3} are not counted as exceedances.

Figure 8- PCM Links Local Model Results For 2015

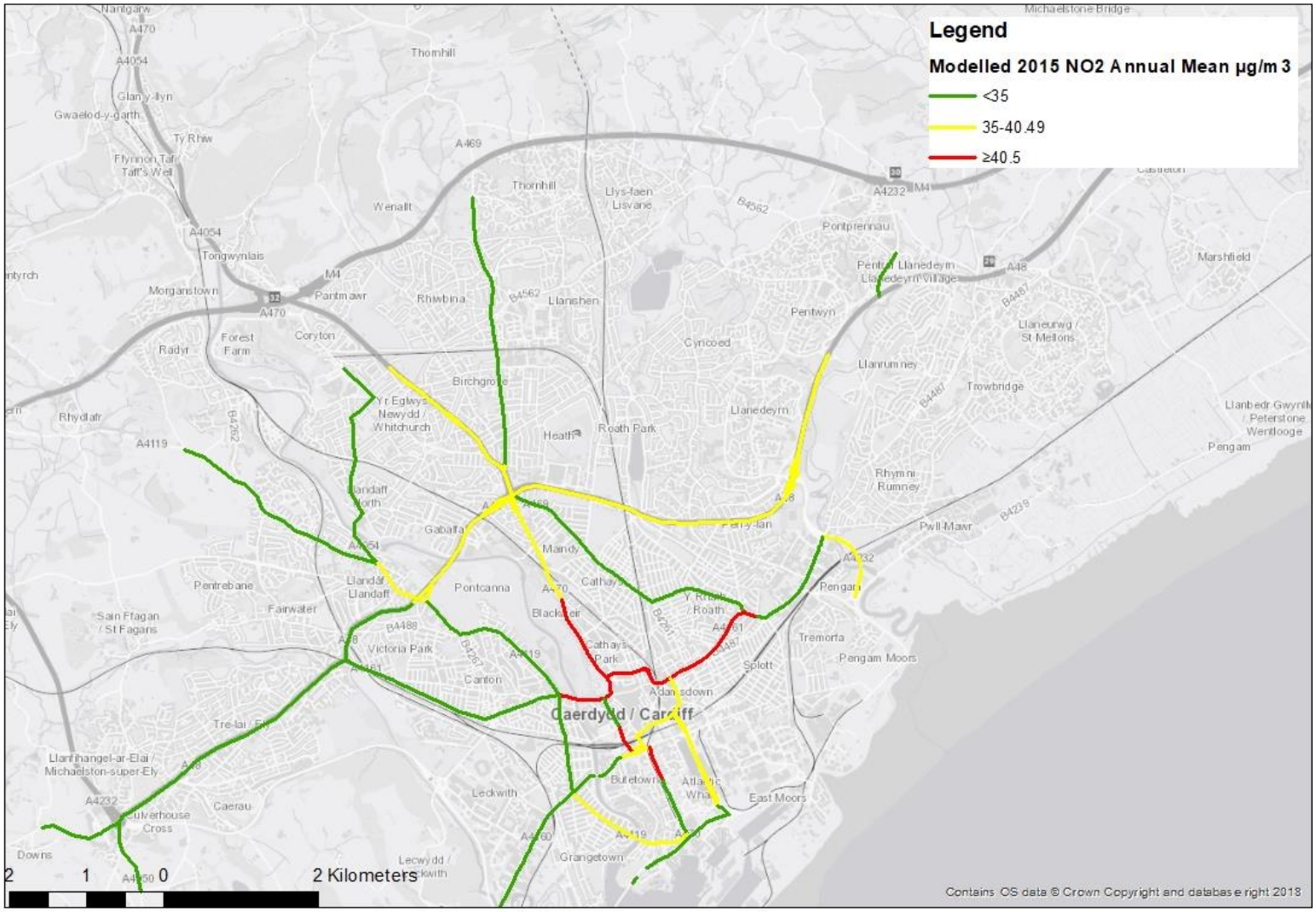


Figure 9- Sampled NO_2 Results along the PCM Links > 35 µgm-3 in 2015

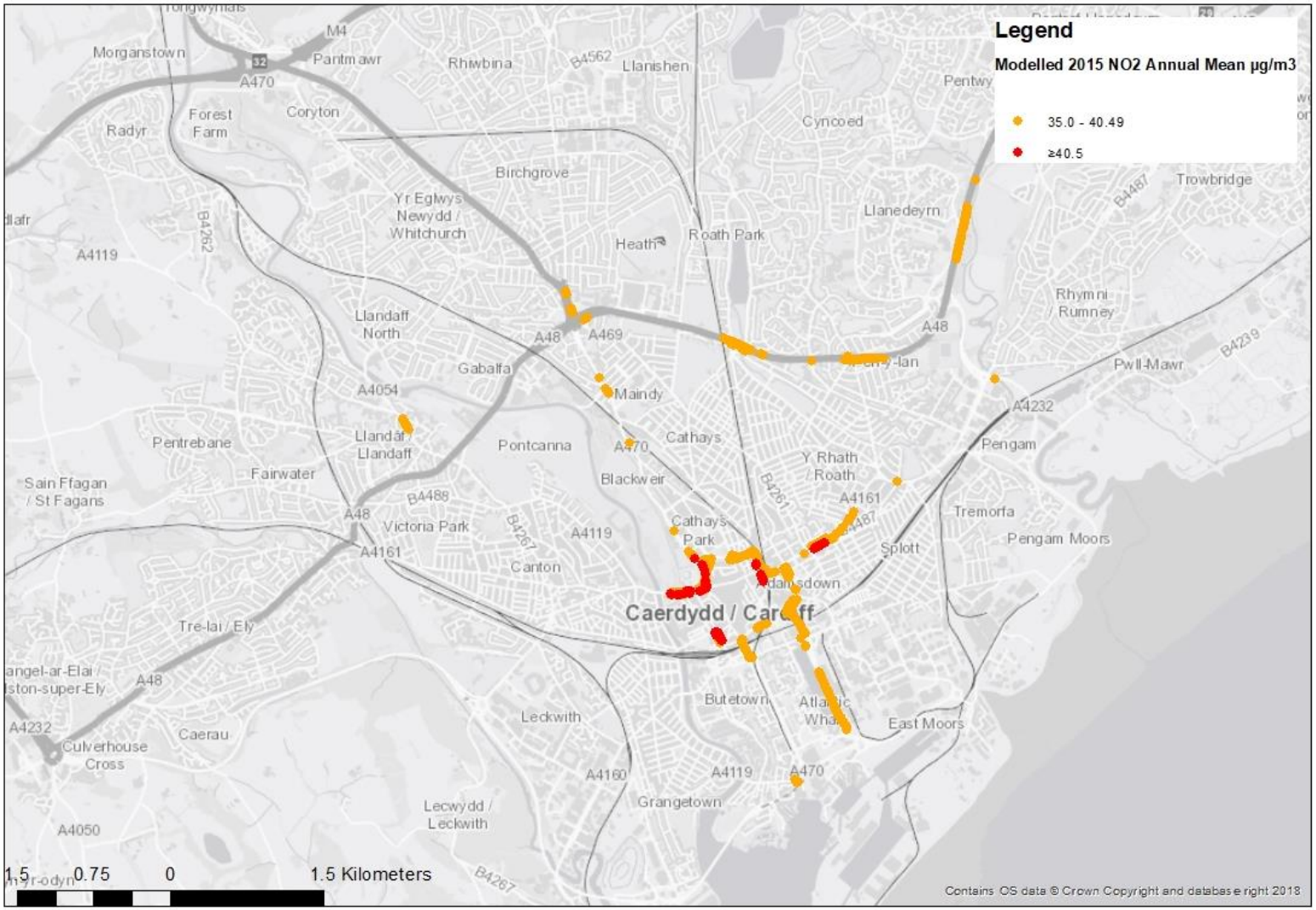


Figure 10 - PCM Links Local Model Results For 2021

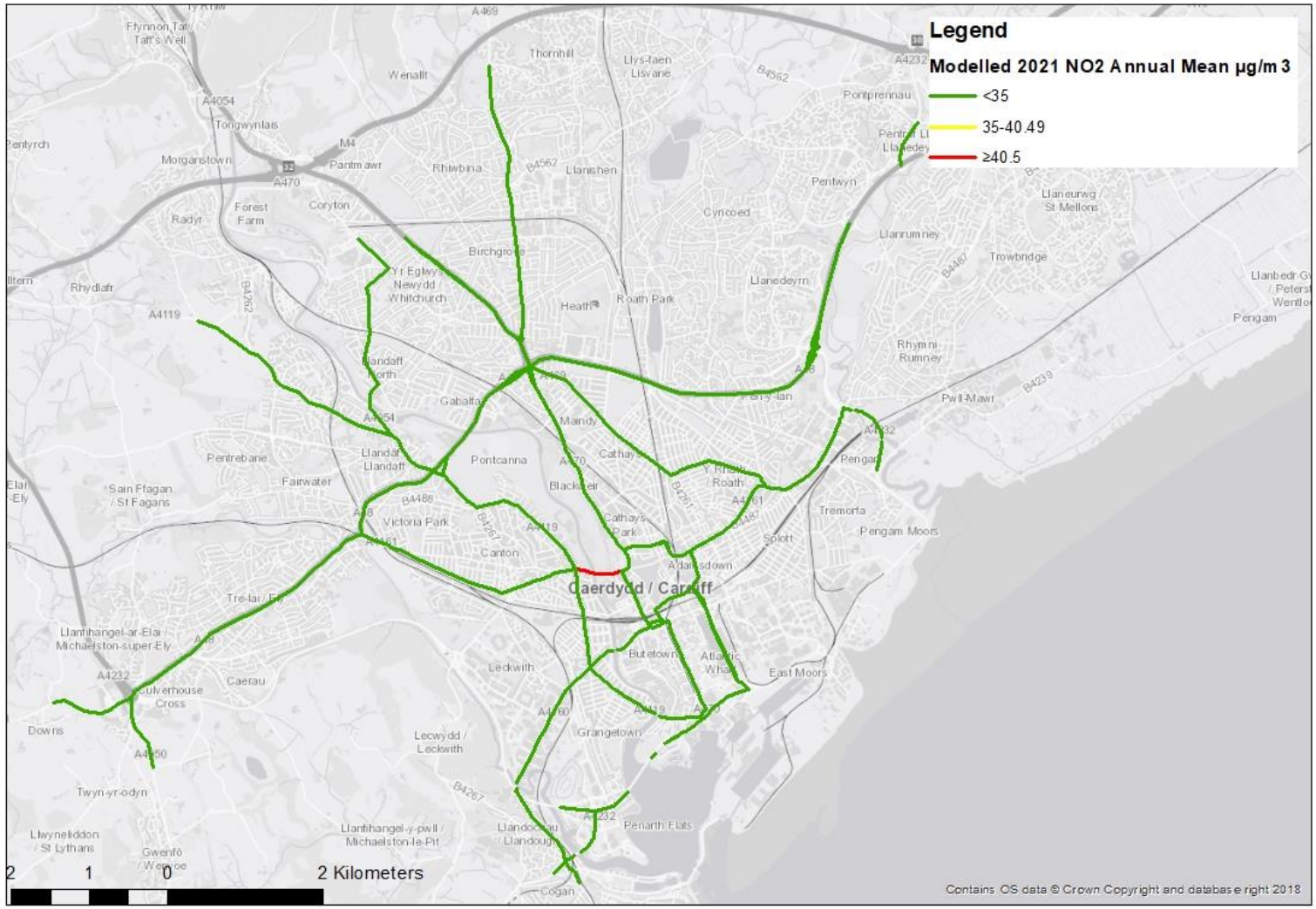
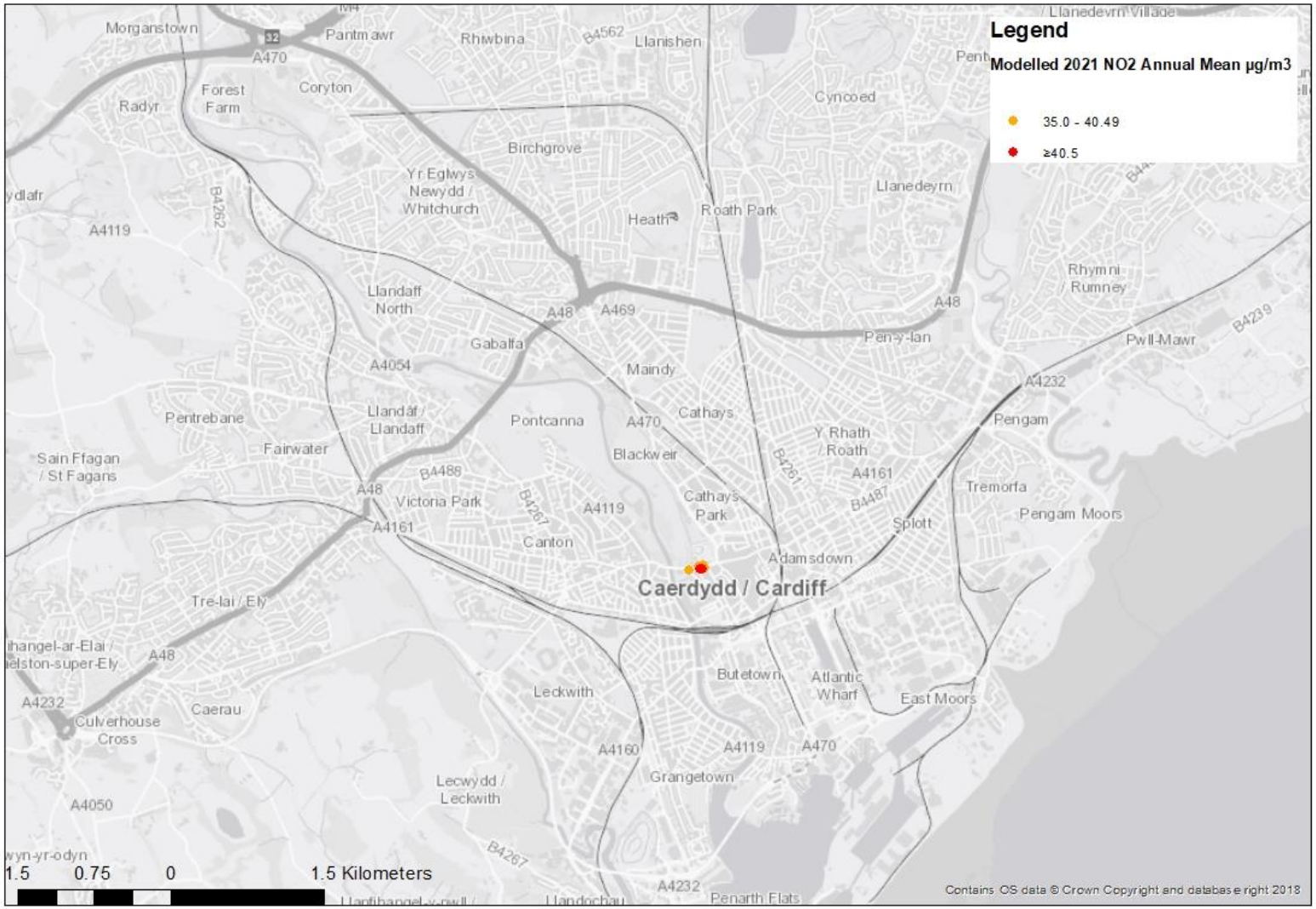


Figure 11- Sampled NO_2 Results along the PCM Links > 35 µgm-3 in 2021



3.3.2 Results at Local Monitoring Locations

Modelled 2015 and 2021 NO_2 concentration results have been produced for the all the 2015 monitoring location used in model verification. The results are presented in Table 5 below and show:

- Measured data for 2015 and 2018;
- Modelled data for 2015 and 2021 using the global model adjustment factor;

These results provide an indication of whether compliance is predicted at monitoring locations in 2021. One monitoring location, 176 Castle Arcade, is predicated to exceed the 40 µg/m3 limit value in the 2021. This result correlates well with the PCM results reported above, which reports non-compliance in the same locality.

Table 5 - Predicted NO2 Annual Mean Concentrations at Monitoring Site Locations in 2015 & 2021

Monitoring site name	Site ID	NO_2 annual mean (µg.m^{-3})		
		Measured	Modelled	
		2015	2015	2021
Ninian Park Road	16	27.9	18.8	14.2
Mitre Place	33	46.9	39.7	31.5
City Road	44	27.1	26.8	20.4
Mackintosh Place	45	32.1	30.4	23.4
Penarth Road	49	29.4	21.6	17.1
Birchgrove Village	56	29.6	22.0	17.1
Westgate Street	58	48.3	41.7	30.3
Stephenson Court	81	35.3	36.5	25.3
104 Birchgrove Road	82	23.8	23.4	18.0
497 Cowbridge Road West	85	22.4	19.5	15.2
19 Fairoak Road	86	34.9	24.5	19.0
Manor Way Junction	96	31.1	30.5	23.2
Newport Road (premises)	97	30.5	29.4	21.4
Western Avenue (premises)	98	25.4	22.9	18.2
Cardiff Road Llandaff	99	29.8	35.2	27.8
Cardiff AURN	101	20.3	24.9	18.4
Cardiff AURN	102	21.1	24.9	18.4
Cardiff AURN	103	20.7	24.9	18.4
30 Caerphilly Road	106	29.4	31.3	24.6
Lynx Hotel	107	30.7	29.0	21.6

Monitoring site name	Site ID	NO_2 annual mean ($\mu g.m^{-3}$)		
		Measured	Modelled	
		2015	2015	2021
98 Leckwith Road	111	21.3	19.6	15.3
17 Sloper Road	112	27.1	21.9	17.2
21 Llandaff Road	115	32.5	19.1	15.2
25 Cowbridge Road West	117	39.5	26.6	20.0
Havelock Street	119	27.7	32.2	22.3
287 Cowbridge Road East	124	22.5	18.7	14.4
Westgate Street Flats	126	36.0	37.9	27.6
117 Tudor Street	128	29.6	21.4	16.1
Stephenson Court 2	129	31.5	34.4	23.9
Burgess Court	130	35.2	35.3	24.5
Dragon Court	131	39.5	35.6	24.7
St Mark's Avenue	133	31.9	35.8	28.1
Sandringham Hotel	134	32.1	26.5	18.8
Lower Cathedral Road	139	29.4	26.1	19.8
Clare Street	140	36.3	27.7	21.2
Fairoak Road 2	141	32.3	24.1	18.9
Windsor House	143	38.2	38.6	27.9
Marlborough House	144	37.2	38.2	26.6
Tudor Street Flats	145	29.9	35.5	24.3
Neville Street	146	26.6	25.5	19.8
211 Penarth Road	147	27.7	22.2	17.5
161 Clare Road	148	27.5	22.7	18.0
10 Corporation Road	149	33.6	20.9	16.5
James Street	152	27.6	26.3	22.0
Magic Roundabout	153	29.0	29.7	21.6
2a/4 Colum Road	156	25.9	24.2	18.5
47 Birchgrove Road	157	27.2	26.7	20.8
64/66 Cathays Terrace	158	25.5	23.2	18.0
IMO façade replacement	159	34.0	31.6	22.6
High Street Zizzi	160	27.0	28.2	20.6
52 Bridge Road	161	32.3	24.3	18.9
58 Cardiff Road	162	24.5	22.7	18.0

Monitoring site name	Site ID	NO_2 annual mean (µg.m^{-3})		
		Measured	Modelled	
		2015	2015	2021
118 Cardiff Road	163	23.2	24.9	19.4
725 Newport Road	164	20.3	20.9	16.6
6 Heol Tyrrell	165	15.1	16.7	13.2
163 Lansdowne Road	166	32.1	21.3	16.9
359 Lansdowne Road	167	28.3	22.0	17.0
570 Cowbridge Road East	168	24.3	24.3	18.7
11 Pengam Green	170	19.1	23.0	17.6
23 Tweedsmuir Road	171	18.1	22.2	17.9
Ocean Way 1	172	**44.5**	28.6	18.9
Ocean Way 2	173	28.4	29.5	19.6
76 North Road	174	28.7	32.8	23.9
Castle Arcade	176	**47.8**	**57.8**	**42.7**
Angel Hotel	177	**48.1**	**44.8**	33.1
Park Street/Westgate Street	178	**45.4**	**52.7**	32.0

3.3.3 Modelling Uncertainty

The city-wide model used to predict NO_2 concentrations is a large and complex model comprising many thousands of road links, a large amount of input data and a number of modelling assumptions. Both the transport and air quality modelling teams have followed all the appropriate guidance to produce as robust a model as possible. However, it needs to be recognised there is always inherent uncertainly in such models and this needs to be taken in consideration when interpreting the results.

Both the transport and air quality models have been validated. In terms of the air quality model a direct assessment of uncertainty is carried out for the baseline model year (2015) as part of the validation process against monitored air quality data. In this process model performance and uncertainty is assessed using the Root Mean Square Error (RMSE) for the observed vs. predicted NO_2 annual mean concentrations, as detailed in Technical Guidance LAQM.TG (16). In this case the RMSE was calculated at 5.1 µg.m-3. This can then be used as a measure of error on forecast results for future years. This error metric has been used when considering the results by considering locations over 35 µg.m^{-3} as being at risk of exceedance. More details on this validation exercise can be found in Appendix A.

However, when assessing future years there will also be uncertainty related to the forecast assumptions we have made in modelling future years. The key assumptions relate to:

- The forecast of traffic activity in the traffic model which is related to local development factors and national growth factors;
- Forecasting the local fleet composition from the ANPR data to future years, this has been done using national trends.

One particular area of forecasting that bears further exploration is the use of the split transport model in 2021 with compliant and non-compliant vehicles. This split is not used for the 2015 traffic modelling. As such we are not strictly comparing like with like going from 2015 to 2021. However, going forward an assessment of additional scenarios taking account of expected policy options will be carried out, and for this we will need to use the split matrix transport model. It will therefore be more robust to compare these option results with the baseline 2021 results using the split model as well. Splitting the transport model in this way can influence both the traffic flows and speeds and the fleet composition on individual links when comparing with an un-split model. To assess the impact of this we plan to do a sensitivity test by running the un-split 2021 transport model results through the air quality model and comparing this with the current 2015 and 2021 results.

Another area of uncertainly is the emissions data used in the modelling. We have used the latest COPERT emission factors available in line with guidance, however, we are aware that these do not always reflect 'real world' vehicle performance accurately. For example, remote sensing work carried out by Ricardo has shown that LGV emissions, particularly for Euro 5 vehicles, can be significantly higher than the standard emission factors. There is also significant variation within a Euro class. This uncertainty also relates to the primary NO_2 fraction (fNO_2) which can have implications for the NOx to NO_2 conversion process used in the modelling as it can be quite sensitive to fNO_2. Again, we have followed the current guidance on this and used a link-specific fNO_2 derived from modelled primary NO_2 and NOx concentrations at each location.

Lastly, the PCM results have been extracted using the 4m buffer as described above, as per guidance. However, in defining relevant receptors along the 4m buffer we also have to account for several other key criteria:

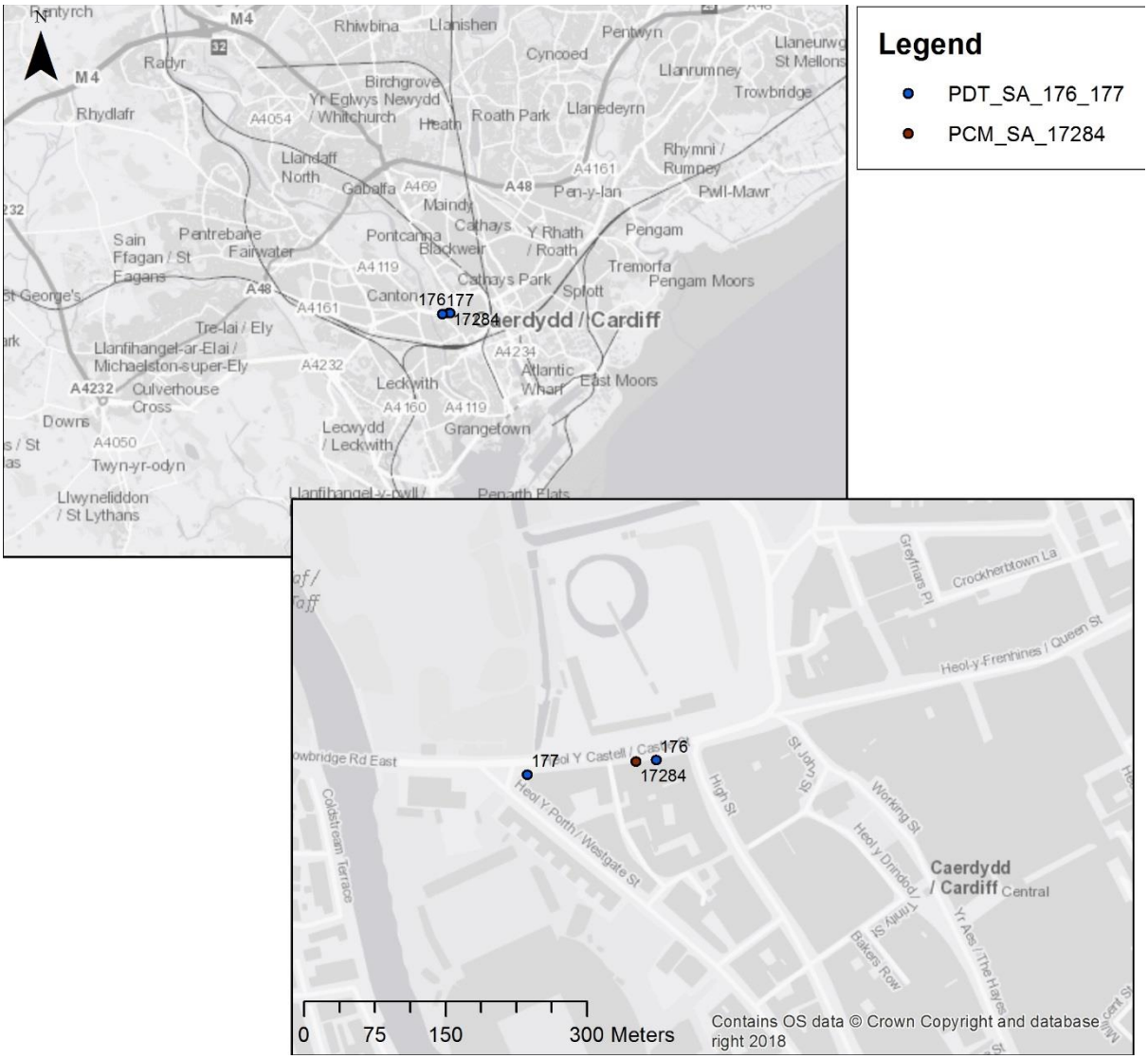
- The receptor location should be representative of 100m length of road;
- It should not be closer than 25m to a major road junction;
- There must be public access – such as a footpath or building.

The sampling is done automatically in a GIS system and the above exceptions removed manually. However, there is some subjectivity around these exceptions such as what constitutes a major junction and how publicly accessible are certain locations. The final results allocated to any given PCM link can be quite sensitive to the final selection of receptors. However, we have taken all endeavours to ensure the final set of receptors used is a reasonable interpretation of the criteria given in the guidance.

3.4 Source Apportionment

For 2015 and 2021 base years we have carried out source apportionment for a number of locations in Cardiff to provide an indication of the key sources contributing to pollution levels. The locations selected for source apportionment are the PCM receptor showing continued exceedance in 2021 on Castle Street, along with monitoring locations close to this location. The locations for which source apportionment have been calculated are indicated in Figure 12.

Figure 12 Location of Source Apportionment Results



3.4.1 2015 Baseline Source Apportionment

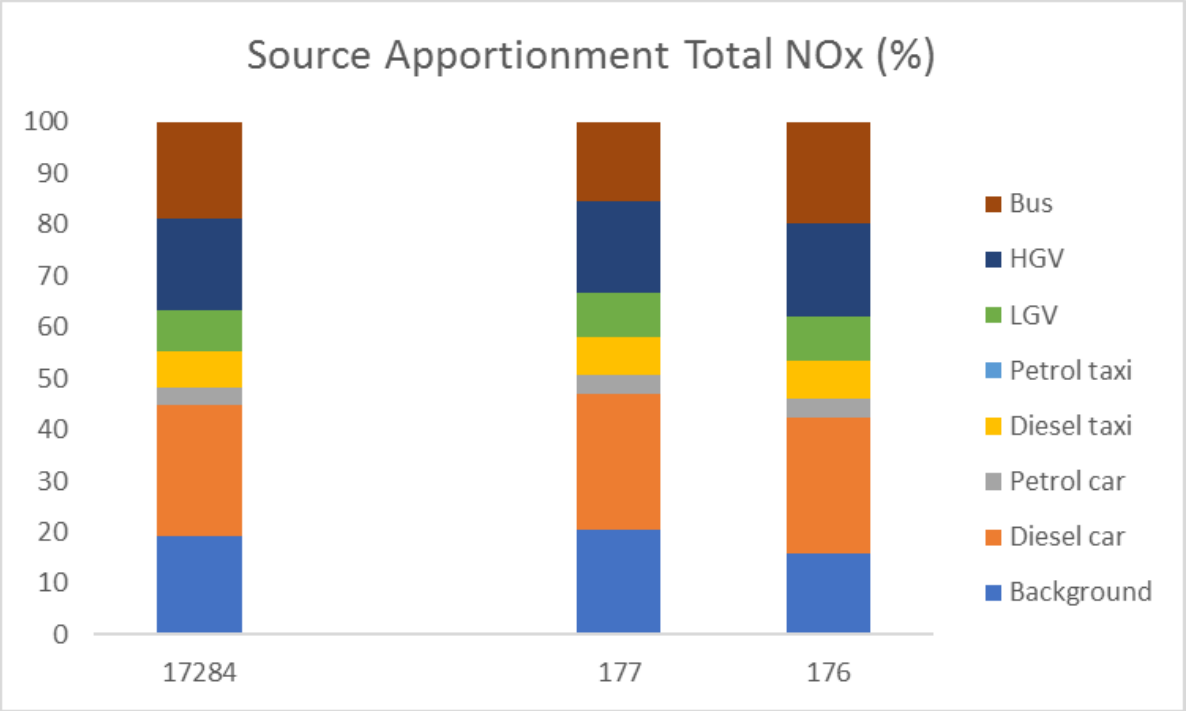
The source apportionment results (in terms of NOx concentrations) for 2015 are shown in Table 6. These show that the main source of air pollution is from road traffic, which accounts for 80 - 84 %, while the remainder of the pollution is from background sources.

Table 6 - NOx Concentrations in 2015 (µg/m3)

Site name	PCM census link	Background µg/m³	Background %	Roads µg/m³	Roads %	Total
PCM_17284	30665	21.7	19.1%	91.7	80.9%	113.4
DT176	30665	16.3	20.3%	63.7	79.7%	80.0
DT177	30665	16.9	15.8%	90.0	84.2%	106.9

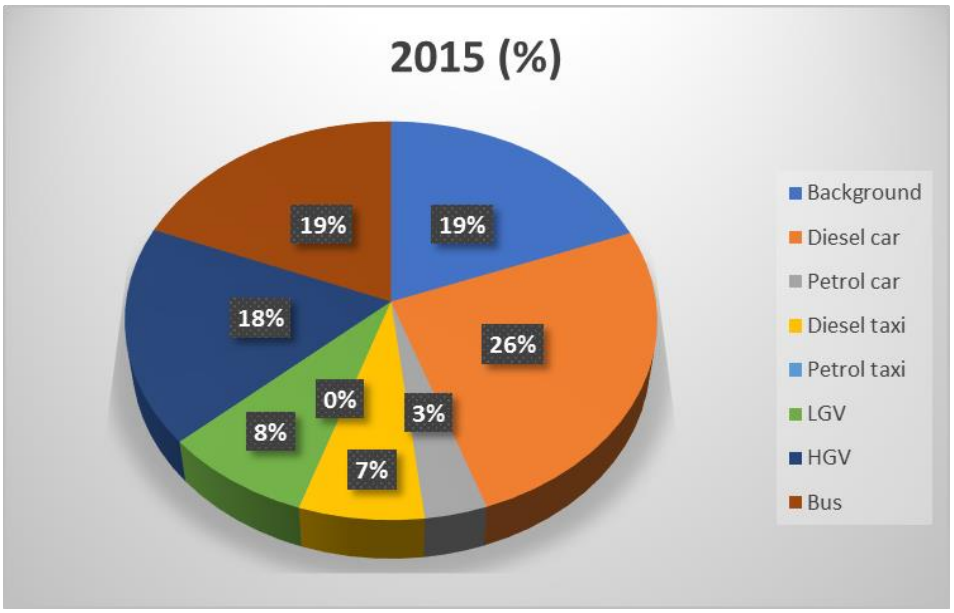
The road contribution can be broken down further to show the contribution from each vehicle type, as illustrated in Figure 13. Overall, diesel cars are the main contributor followed by buses and HGVs. Taxis account for between 5 and 10 % of NOx emissions, while buses on account for between 8 and 10 % of NOx.

Figure 13 - Source Apportionment of Total NOx (%) at each of the Locations along PCM link 30665



The source apportionment for the three locations on 30665 is similar, therefore for the remainder of the report the source apportionment for 17284 only will be presented. Figure 14 presents the results of 17284 in form of a pie chart to aid comparison between 2015 and the future year results presented.

Figure 14 - Breakdown of NOx Contribution in 2015



3.4.2 2021 Baseline Source Apportionment

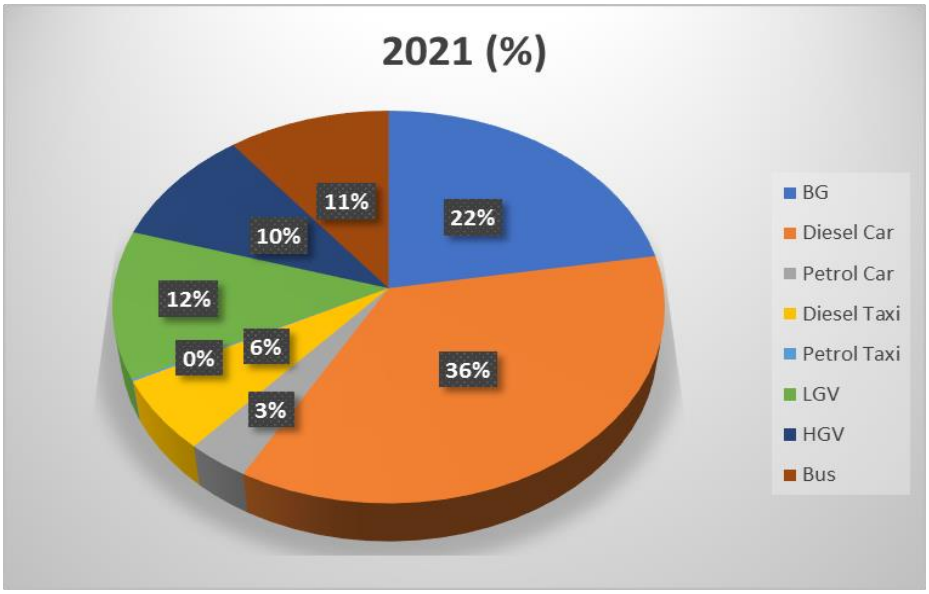
The 2021 source apportionment results for NOx are shown in Table 7. In 2021 the main contribution to pollution in Cardiff is still anticipated to be road traffic (73 – 78 %).

Table 7 - NOx Concentrations in 2021 (µg/m3)

Site name	PCM census link	Background		Roads		Total
		µg/m^3	%	µg/m^3	%	
PCM_17284	30665	16.9	22.3%	58.8	77.7%	75.7
DT176	30665	16.3	27.3	43.0	72.7%	59.3
DT177	30665	17.0	22.8	57.5	77.2%	74.5

The breakdown of the projected 2021 road NOx concentrations by vehicle type is given in Figure 15. In 2021 diesel cars still contribute the largest proportion of emissions to the total road NOx emissions while the proportion of emissions from HGVs and buses has reduced.

Figure 15 - Breakdown of NOx Contribution in 2021



3.5 Assessment of Local Modelling Results

As a result of the localised detailed assessment the Council needs to develop a list of measures that can be assessed against the Primary and Secondary objectives, (Critical Success Factors), in order to assess whether the implementation of said measures will deliver firstly against the Primary Objective of achieving compliance in the shortest possible time. The following sections provide the overall assessment of a long list of measures and the development of a shortlist of measures that will be fully modelled to assess their performance against the Primary and Secondary Objectives. The results of these assessments will enable the Council to develop a preferred option to achieve compliance in the shortest possible time which will be fully assessed in the Final Plan to be published no later than the 30th June 2019.

3.6 Development and Assessment of Long List of Measures

Prior to receiving the direction Cardiff Council started work on developing a Clean Air Strategy (CAS) & Action Plan , as the Council had recognised the increase public health concerns related to poor air quality. The Council's Capital Ambition programme recognised Cardiff as one of the UK's fastest growing cities, and that it is crucial that this growth be well planned and sustainable. A priority to achieve this was to address Cardiff's transportation system to tackle congestion and improve air quality in Cardiff. The purpose of the strategy was therefore to be an overarching document to identify, implement and deliver strategic measures with a preliminary aim to improve air quality to protect and improve public health. The strategic measures appointed by the CAS and Action Plan were identified to address the health impacts of air pollution in Cardiff would play a critical role in supporting other priorities such as active travel, health inequalities, integrated care, sustainability, growth and regeneration, localism and community engagement. The measures detailed in the CAS and Action Plan were assigned based on source apportionment exercises undertaken in accordance with Cardiff's 4 Air Quality Management Areas, as well as the exceeding two stretches of road network identified by Defra's PCM modelling (A48 and A4232).

Owing to the Direction to undertake a feasibility study to address exceedances of NO_2, the Council has not yet been able to finalise and publish its Clean Air Strategy. However it is felt that the work undertaken in developing the strategic measures provides the feasibility study its long list of measures. The strategic measures have been grouped as follows with each measure having more detailed measures, which form the long list of measures;

- **Enhance Local Planning Policy**
- **Enhance Cardiff's Transportation System**
- **Increase the Uptake of Sustainable and Active Travel**
- **Implement a Renewable Fuels Strategy and Improve EV/ 0EV Infrastructure**
- **Regulatory Interventions**
- **Public Information and Behaviour Change Initiatives**

The long list of measures is detailed in the following sections.

3.6.1 Enhance Local Planning Policy

M1: Implementation and consideration of existing Local Development Plan (LDP) policies (KP18 & EN13) during any planning application process.

M2: Development of a Supplementary Planning Guidance (SPG) for Planning for Health and Well-being .The SPG is supplementary to Policies KP14 and C6 of the adopted LDP.

M3: Develop Supplementary Planning Guidance (SPG) to provide a specific guidance for air quality in accordance with new developments.

M4: Develop Supplementary Planning Guidance (SPG) "Managing Transport Impacts & Parking Standards.

M5: Publish Green Infrastructure SPG

3.6.2 Enhance Cardiff's Transportation System

M6: Freight and Delivery Management- Assess and improve where necessary strategic routes for freight timings of planned journeys for in and around City Centre.

M7: Establishment of a freight quality partnership to provide a forum for discussion with HGV operators.

M8: Implement further speed restrictions and enhance those already established "20mph Zones.

M9: Cardiff Capital Region Metro*

M10: City Centre West and Central Interchange and Eastside City Centre Schemes**;**

M11: Bus Network Programme- Strategic Bus Network to improve bus networks and efficiency of the services via increased and improved bus lanes.

M12: Accelerated Park and Ride programme in NW & NE Cardiff; NW delivery of P&R in North West of Cardiff – J33/ Llantrisant Road – 750 P&R at J33 and 250 P&R off Llantrisant Rd & NE expansion of P & R on the A48.

*** Metro not considered further owing to the fact this is a Transport for Wales Project.**

3.6.3 Increase the Uptake of Sustainable and Active Travel

M13: Development of Cycling Superhighways infrastructure with Integrated Network Map (INM). Minimum of Two cycle superhighways proposed.

M14: Implement Zero Emission Buses on Cardiff Network.

M15: Development of further School Travel Plans, by continued engagement with 'Living Streets' charity who have developed a 'WOW' (Walk Once a Week) scheme, which is currently undertaken in 7 schools in Cardiff.

M16: Development of Car Clubs in Cardiff, to encourage car sharing schemes.

M17: Promotion and Communication of the benefits surrounding active travel.

3.6.4 Renewable Fuels Strategy and Improve EV/ 0EV Infrastructure

M18: Roll out EV charging locations or identify alternative fuel supplies.

M19: Ensure that procurement for Councils fleet considers alternative fuelled vehicles.

M20: Through the Public Service Board encourage procurement of alternative fuelled vehicles.

3.6.5 Regulatory Interventions

M21: Improvement of Taxi Licensing Policy, to set minimum vehicle emissions standards.

M22: Implement and **Enforce** non vehicles idling areas

M23: Review car parking and car permit charges and allow for reduced rates for EV/OLEV, and increased rates for <Euro 6.

M24: Explore increasing the monitoring capabilities of the Council with investment in more real time monitoring.

M25: Implementation of a Charging Clean Air Zone

3.6.6 Public Information and Behaviour Change Initiatives

M26: Increase air quality awareness campaigns in Cardiff, such as Car Free Day.

M27: Collaborative working with key stakeholders, such as Public Service Boards (PSBs) & WG.

M28: Increase public's capabilities to access air quality data via the integration of a smart cities approach.

M29: Implement a Green Infrastructure/ Living Wall Installation Programme

3.7 Development of a Shortlist of Measures

The development of the long list of measures within the CAS, as detailed above in Section 3.6, is considered too large a list to asses in detail and many of the measures would unlikely meet

the primary objective of achieving compliance in the shortest possible time. Therefore a working group consisting of officers from Transportation, Planning, Highways Shared Regulatory Services, and Public Health Wales, along with appointed external consultants undertook a qualitative assessment of the long list of measures through a series of workshops and meetings.

The approach of this qualitative assessment was intended to screen and test the measures against the primary and secondary objectives of this study to ensure that measures could address the problem identified.

This assessment considered each of the measures initially against the identified Primary objective using a simple screening system of a pass or fail. This assessment was based on professional judgement and an understanding of the success of similar measures elsewhere in the UK and further afield. Only those measures that passed the Primary Objective were assessed against the secondary objectives and taken forward as a shortlisted measure for detailed air quality and transportation modelling to identify a preferred option. The summary appraisal of the long list of options is presented in Table 8.

Table 8 - Summary Appraisal of the Long List of Measures

Measure Description	**Primary Objective Achieved (Pass- expected year of compliance)**	**Secondary Objectives (Scores 1. Low, 2. Medium, 3. High 4. V. High)**							**Judgement**
		Will the measure deliver an overall reduction in NO_2 emissions to air.	**Will the measure result in additional benefits or other environmental improvements.**	**Will the measure contribute to well-being**			**Does the option fit or compliment other local policies.**	**Value for Money - Do the likely benefits of this option exceed the costs**	**Constraints on Implementation of Measure**	
				Will the measure impact equally across multiple vehicle classes and journey types	**Positive impact on wider public health.**	**Mitigate financial impact on low income households and reduce inequalities**				
M1: Implementation and consideration of existing Local Development Plan (LDP) policies (KP18 & EN13) during any planning application process	Fail	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Primary Objective not met, measure should be considered as part of a longer term AQ action plan.
M2: Development of a Supplementary Planning Guidance (SPG) for Planning for Health and Well-being .	Fail	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
M3: Develop Supplementary Planning Guidance (SPG) to provide a specific guidance for air quality in accordance with new developments.	Fail	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
M4: Develop Supplementary Planning Guidance (SPG) "Managing	Fail	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Primary Objective not met, measure should be considered as part

Measure Description	Primary Objective Achieved (Pass-expected year of compliance)	Secondary Objectives (Scores 1. Low, 2. Medium, 3. High 4. V. High)								Judgement
		Will the measure deliver an overall reduction in NO_2 emissions to air.	Will the measure result in additional benefits or other environmental improvements.	Will the measure contribute to well-being			Does the option fit or compliment other local policies.	Value for Money - Do the likely benefits of this option exceed the costs	Constraints on Implementation of Measure	
				Will the measure impact equally across multiple vehicle classes and journey types	Positive impact on wider public health.	Mitigate financial impact on low income households and reduce inequalities				
Transport Impacts & Parking Standards.										of a longer term AQ action plan.
M5: Publish Green Infrastructure SPG	Fail	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
M6: Freight and Delivery Management- Assess and improve where necessary strategic routes for freight timings of planned journeys for in and around City Centre.	Fail	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
M7: Establishment of a freight quality partnership to provide a forum for discussion with HGV operators	Fail	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
M8: Implement further speed restrictions and enhance already established 20mph Zones.	Pass (2021)	2	1	4	3	2	4 – LTP	3	1	Potentially Feasible 20 MPH zones have also been demonstrated as being effective at reducing some air pollution.

Measure Description	Primary Objective Achieved (Pass-expected year of compliance)	Secondary Objectives (Scores 1. Low, 2. Medium, 3. High 4. V. High)								Judgement
		Will the measure deliver an overall reduction in NO_2 emissions to air.	Will the measure result in additional benefits or other environmental improvements.	Will the measure contribute to well-being			Does the option fit or compliment other local policies.	Value for Money - Do the likely benefits of this option exceed the costs	Constraints on Implementation of Measure	
				Will the measure impact equally across multiple vehicle classes and journey types	Positive impact on wider public health.	Mitigate financial impact on low income households and reduce inequalities				
M10: City Centre West and Central Interchange and Eastside City Centre Schemes;	Pass (2021)	4	2	2	2	3	4 – LTP, Capitol Ambition	1.	1.	Potentially Feasible targeted bus priority measures could simultaneously reduce capacity for general traffic and improve bus journey times/reliability transferring trips from private cars to buses.
M11: Bus Programme- Strategic Bus Network to improve bus networks and efficiency of the services via increased and improved bus lanes.	Pass (2021)	3	2	2	2	3	4. LTP	2	2.	
M12: Accelerated delivery of P&R in north west of Cardiff and expansion of P&R on A48 –	Pass (2021)	3	2	2	2	2	4. LTP/LDP	2	2	
M13: Development of Cycling Superhighways infrastructure with Integrated Network Map (INM) and expansion of	Pass (2021)	1.	1	4	3	3	3. LTP	2	2	Potentially Feasible a number of cycle schemes being developed through other work streams which could be fast

Measure Description	Primary Objective Achieved (Pass-expected year of compliance)	Secondary Objectives (Scores 1. Low, 2. Medium, 3. High 4. V. High)								Judgement
		Will the measure deliver an overall reduction in NO_2 emissions to air.	Will the measure result in additional benefits or other environmental improvements.	Will the measure contribute to well-being			Does the option fit or compliment other local policies.	Value for Money - Do the likely benefits of this option exceed the costs	Constraints on Implementation of Measure	
				Will the measure impact equally across multiple vehicle classes and journey types	Positive impact on wider public health.	Mitigate financial impact on low income households and reduce inequalities				
Nextbike Scheme										tracked to support this project
M14: Implement Zero Emission Buses on Cardiff Network	Pass (2021)	4	1	1	3	2	3. LES	2	2	**Potentially Feasible** Significant impact on identified routes and could lead to increase in bus patronage as service improvement made.
M15: Development of further School Travel Plans, by continued engagement with 'Living Streets'	Fail	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Primary Objective not met, measure should be considered as part of a longer term AQ action plan
M16: Development of Car Clubs in Cardiff, to encourage car sharing schemes.	Fail	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
M17: Promotion and Communication of the benefits surrounding active travel.	Fail	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	

Measure Description	Primary Objective Achieved (Pass-expected year of compliance)	Secondary Objectives (Scores 1. Low, 2. Medium, 3. High 4. V. High)								Judgement
		Will the measure deliver an overall reduction in NO_2 emissions to air.	Will the measure result in additional benefits or other environmental improvements.	Will the measure contribute to well-being			Does the option fit or compliment other local policies.	Value for Money - Do the likely benefits of this option exceed the costs	Constraints on Implementation of Measure	
				Will the measure impact equally across multiple vehicle classes and journey types	Positive impact on wider public health.	Mitigate financial impact on low income households and reduce inequalities				
M18: Improve and promote the uptake of low emission vehicles by enhancing Cardiff's EV infrastructure.	Pass (2021)	2	1	2	2	4	1	1.	4	Possibly Feasible – however significant investment and installation of infrastructure would be required. Cannot guarantee switch to EVs .
M19: Ensure that procurement for Councils fleet considers alternative fuelled vehicles.	Fail	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Primary Objective not met, measure should be considered as part of a longer term AQ action plan.
M20: Through the Public Service Board encourage procurement of alternative fuelled vehicles in public services	Fail	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
M21: Improvement of Taxi Licensing Policy, to set minimum vehicle emissions standards.	Pass (2021)	3	1	1	2	2	2	4	3	Potentially Feasible as taxi drivers eventually required to upgrade to Euro 6 or to EVs.

Measure Description	Primary Objective Achieved (Pass-expected year of compliance)	Secondary Objectives (Scores 1. Low, 2. Medium, 3. High 4. V. High)								Judgement
		Will the measure deliver an overall reduction in NO_2 emissions to air.	Will the measure result in additional benefits or other environmental improvements.	Will the measure contribute to well-being			Does the option fit or compliment other local policies.	Value for Money - Do the likely benefits of this option exceed the costs	Constraints on Implementation of Measure	
				Will the measure impact equally across multiple vehicle classes and journey types	Positive impact on wider public health.	Mitigate financial impact on low income households and reduce inequalities				
M22: Implement and Enforce non idling areas	Fail	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Primary Objective not met, measure should be considered as part of a longer term AQ action plan
M23: Review car parking and car permit charges and allow for reduced rates for EV/OLEV, and increased rates for <Euro 6.	Pass (2021)	3	2	4	2	4	2	3	2	Potentially Feasible could encourage car and LGV drivers to upgrade to Euro 6 or to EVs.
M24: Increase the monitoring capabilities of with investment in more real time monitoring.	Fail	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Primary Objective not met, measure should be considered as part of a longer term AQ action plan
M25: Implementation of a Charging Clean Air Zone	Pass (2021)	4	1	1	2	3	1	3	2	Possibly Feasible- Scale of compliance will be dependent on size of CAZ and Class of Vehicles to be included.

Measure Description	Primary Objective Achieved (Pass- expected year of compliance)	Secondary Objectives (Scores 1. Low, 2. Medium, 3. High 4. V. High)								Judgement
		Will the measure deliver an overall reduction in NO_2 emissions to air.	Will the measure result in additional benefits or other environmental improvements.	Will the measure contribute to well-being			Does the option fit or compliment other local policies.	Value for Money - Do the likely benefits of this option exceed the costs	Constraints on Implementation of Measure	
				Will the measure impact equally across multiple vehicle classes and journey types	Positive impact on wider public health.	Mitigate financial impact on low income households and reduce inequalities				
M26: Increase air quality awareness campaigns in Cardiff,	Fail	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Primary Objective not met, measure should be considered as part of a longer term AQ action plan.
M27: Collaborative working with key stakeholders, such as Public Service Boards (PSBs) & WG.	Fail	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
M28: Increase public's access air quality data via the integration of a smart cities approach.	Fail	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
M29: Implement Green Infrastructure/ Living Wall Installation Programme	Fail	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Objective not met, a study[31] shows ineffective for NO2. Measure should be considered as part of a longer term AQ action plan

[31] AIR QUALITY EXPERT GROUP Impacts Of Vegetation On Urban Air Pollution

The above qualitative assessment has enabled a shortlist of measures to be developed. However the working group felt that in order for the study to provide a robust assessment of the impacts of these measures that they should be modelled as a package of measures rather than individual measures. Therefore the initial shortlist of measures has been grouped into two packages as follows:

Clean Air Strategy & Action Plan (CASAP) 1 – measures where a funding application has been made but the funding has not yet been confirmed/ or the measures can be implemented with minimal cost to authority.

CASAP 2 – measures which the Council may introduce but where no funding is in place or an application has yet to be made for funding.

The packages are detailed below:

CASAP 1

- Zero/lower emission buses – ULEB application submitted for 36 Electric Buses – would result in cascade effect of E6 busses replacing E3s; **M14**
- Active travel package –expansion of 20mph limit areas (beyond what is the baseline) and expansion of Nextbike Scheme, reduction of speed limit on A4232; **M13 and M8**
- Cycling programme up to end of 2020 - application for funding of segregated cycle networks to be installed in Cardiff; **M13**
- Taxi licensing - from 31/1/2019, all new hackney and PHV licenses to be Euro 6 (both petrol and diesel) **M21**

CASAP 2

- City Centre West Transport Improvement Scheme - Adjustment to road network and vehicle access; Part of East side city centre scheme (Station Terrace) – Adjustment to road network and access in Eastern central area of City; **M10/M11**
- A48 package - **M11**
- Accelerated delivery of P&R in north west of Cardiff and expansion of P&R on A48–; **M12**
- Installation of EV charging infrastructure - EV infrastructure programme to support uptake of Low Emission Vehicles (LEVs); **M18**
- Parking charges and controls - Emission related parking charges for Council managed on street parking – circa 3K spaces **M23.**

The assessment of the above packages in terms of achieving compliance in the shortest possible time will be benchmarked against a CAZ, as required by the Direction and thus this option is also taken forward and has been appraised in Section 3.8. However it should be the noted that the previous assessments undertaken by Defra which demonstrate that a CAZ brings compliance by 2020, is based on the initial PCM modelling results. As discussed earlier the results of the local modelling have produced different results, and thus the impact of a CAZ in achieving compliance in a shorter time will need further assessment and review.

3.8 Appraisal of WelTAG Impact Areas

A qualitative appraisal, using professional judgment and local understanding has been undertaken in order to assess the expected impact each of the short listed measure will likely have in terms of its Environmental, Social and Cultural and Economic Impacts

The following section provides a further appraisal of the shortlist of measures to examine in greater detail the measures for tackling the problem under consideration. The short list of measures has been appraised against the key three WelTAG areas.

- Economy
- Environment
- Social and Cultural

The measures that have been appraised against the WelTAG Aspect of Well-being are outlined in Table 9. As detailed modelling of the measures is undertaken it will be necessary to re-evaluate the assessment and quantify the effectives of the measures as data becomes available.

Table 9– WelTAG Well-being Aspects

Environment	Social and Cultural	Economy
Air Quality	Physical Activity	Journey time changes and journey time reliability
Noise	Journey Quality	Capital Costs
Landscape	Accidents	Land
Townscape	Access to employment and services	
Historic Environment		
Biodiversity		
Water Environment		

3.8.1 Environmental Appraisal

In accordance with Section 3.3 air quality modelling has been undertaken to establish a detailed understanding for NO_2 concentrations for the baseline years of 2015 and 2021. The 2021 projections enable an understanding for a do minimum scenario whereby no additional measures are implemented. At this stage of the assessment it has not been possible to fully model the shortlist of measures to enable a quantitative assessment of their environmental impact in terms of reducing NO_2 concentrations. However based on professional judgement and local understanding a further qualitative assessment has been completed to assess the likely improvements to air quality of the shortlisted measures.

Further qualitative appraisals have also been undertaken to assess the other environmental impacts areas namely:

- Noise
- Landscape
- Townscape;
- Historic Environment;
- Biodiversity;
- Water Environment

3.8.2 SOCIAL AND CULTURAL APPRAISAL

3.8.2.1 Physical Activity

A qualitative appraisal has been undertaken in order to assess the amount of walking, cycling and other physical exercise that is undertaken as a result of the measure.

3.8.2.2 Journey Times

A qualitative appraisal has been undertaken in order to assess the extent of impact of each of the measures on journey quality, taking into consideration the following aspects:

Traveller care: aspects such as cleanliness, level of facilities, information and the general transport environment;

Travellers' views: the view and pleasantness of the external surroundings throughout the duration of the journeys; and

Traveller stress: frustration, fear of accidents and route uncertainty.

3.8.3 Accidents

A qualitative appraisal has been undertaken in order to assess the extent of potential anticipated change which occurs in the number and severity of injuries as a result of the measure.

3.8.3.1 Access to Employment and Services

A qualitative appraisal has been undertaken in order to assess how many jobs people can reach, the respective journey times, and the impact on journeys to key services such as health facilities and schools which occurs as a result of the measure.

Whilst the WelTAG 2017 guidance outlines access to employment and access to services as two separate appraisal areas, both areas have been combined within this assessment, as the appraisals will be proportionate to one another, with little to no difference in appraisal outcomes between the two considered likely to take place.

3.8.4 Economic Appraisal

3.8.4.1 Journey Time and Journey Time Reliability Changes

A qualitative appraisal has been undertaken in order to assess changes in journey times across all affected modes both for users and non-users of the measure. The appraisal also takes into account changes in the variation in journey times between times of day and between journeys made at the same time each day i.e. morning and evening peak periods.

Whilst the WelTAG 2017 guidance outlines journey time and journey time reliability changes as two separate appraisal areas, both areas have been combined within this assessment, as the appraisals are proportionate to one another, with little to no difference in appraisal outcomes between the two considered likely to take place.

3.8.4.2 Capital Costs

The measures have been assigned within the following cost bands:

- Low – up to £500k
- Medium – £500k – £2m
- High – £2m+

Cost banding has been used to denote the costs of each measure in order to differentiate between more cost effective measures which could be implemented within a shorter timeframe, and those which will require more funds and longer lead-in periods. The banding takes into account the capital costs of each measure, and does not take account of revenue costs.

3.8.4.3 Land

A qualitative appraisal has been undertaken to assess the extent to which the measure will potentially reduce the amount of agricultural land, and open up development sites.

3.8.5 Value for Money

The value for money assessment categorises measures within banded ranges. Categorisation has been determined based on the banding of capital costs and broad benefits which have been weighted as far as possible in favour of the objective. Whilst all benefits have been taken into account, the final value for money score has taken into the impact on air quality as the primary consideration. Value for money will be presented in line with anticipated Benefit to Cost ratios as per the following:

- Poor: BCR of 0 – 1
- Fair: BCR of 1 – 2
- Good: BCR of 2+

3.8.6 Summary Appraisal Tables

Individual Summary Appraisal Tables for each of the shortlisted measures are presented below. Table 10 provides an overall summary of these assessments.

CASAP 1 Options

Name of Measure :		M8: Implement further speed restrictions and enhance already established 20mph Zones.	
Timescales		**2018-2020**	
Feasibility		**Yes – Cardiff Council can implement the Further 20 MPH zones.**	
Objective		Summary of Key Impacts	Assessment Qualitative
Environment	Air Quality	The main purpose is to create safer environments to enhance and encourage further uptake of active travel measures. 20 MPH zones have also been demonstrated as being effective at reducing some levels of air pollution.	Slightly Beneficial +1
	Noise	Research has shown a positive impact that 20 mph zones can have on noise pollution.	Moderately Beneficial +2
	Landscape	The expansion of 20 mph zone will not have a negative direct impact on designated landscapes in Cardiff. The zones could be combined with street furniture and planting, which could have a beneficial impact on landscape.	Slightly Beneficial +1
	Historic Env	The scheme will not have any impact on the historic environment of Cardiff.	Neutral 0
	Biodiversity	The scheme will not negatively impact on biodiversity nor will it impact any protected sites.	Neutral 0
	Water Environment	It is unlikely that the measure will impact the River Taff, River Ely or Rhymney River or the Severn Estuary and thus there will be no negative impact to the water environment.	Neutral 0
	Townscapes	No impact upon townscape features is anticipated to occur as a result of the scheme.	Neutral 0
Economy	Journey Time Changes	Journey Times have the potential to slightly increase in the 20 mph zones.	Slightly Adverse -1
	Capital Costs	Medium £500K-£2M, as little infrastructure changes would be proposed	Medium £500K-£2M
	Land	No loss of land is anticipated from this measure.	Neutral 0
Social and Cultural	Journey Quality	Limiting the maximum permitted speed is not envisaged to have a significant impact on the journey quality and, therefore, is considered to be neutral.	Neutral 0
	Physical Activity	The main purpose of 20mph zones is to improve the safety of pedestrians and cyclists in order to promote the increase in active travel.	Moderately Beneficial +2
	Accidents	The main purpose of 20mph zones is to improve the safety of pedestrians and cyclists and reduce the risk of accidents.	Significantly Beneficial +3
	Access	It is not anticipated that the introduction of this measure will have an impact on access to services, employment, or healthcare within Cardiff. There could be increased access for some members of society by encouraging walking and cycling.	Slightly Beneficial +1
Value for Money	Value for Money	It is anticipated that the Benefit to Cost ratio for this option would be within the range of + 2.	Good- Expected BCR >+2

Name of Measure :		M13: Development of Cycling Superhighways infrastructure and Expansion of Next bike Scheme	
Timescales		**2018-2020**	
Feasibility		**Yes – Cardiff Council can implement the Cycling Network.**	
Objective		Summary of Key Impacts	Assessment
			Qualitative
Environment	Air Quality	It would be anticipated that the introduction of the two segregated cycle highways could lead to a modal shift and thus reduce emissions. However as this programme is a limited area of overall proposed network its initial benefits in reducing NO_2 will be restricted	Slightly Beneficial +1
	Noise	This measure may see the reduction of vehicles on the road, and thus lead to a decrease in road traffic noise..	Slightly Beneficial +1
	Landscape	The introduction of this measure will have no impact on landscape as it will replaced existing road infrastructure.	Neutral 0
	Historic Env	The scheme will not have any impact on the historic environment of Cardiff.	Neutral 0
	Biodiversity	The scheme will not negatively impact on biodiversity nor will it impact any protected sites.	Neutral 0
	Water Environment	It is unlikely that the measure will impact the River Taff, River Ely or Rhymney River or the Severn Estuary and thus there will be no negative impact to the water environment.	Neutral 0
	Townscapes	No impact upon townscape features is anticipated to occur as a result of the scheme.	Neutral 0
Economy	Journey Time Changes	It is possible that cycle journeys times will be decrease through the segregated network and priority signals, and will increase the attractiveness for cycling in Cardiff.	Moderately Beneficial +2
	Capital Costs	High >£2M– the development of the segregated network and full expansion of Next bike, will require significant funding. However, Active Travel Fund is available and applications made.	High>-£2M
	Land	No loss of land is anticipated from this measure.	Neutral 0
Social and Cultural	Journey Quality	The creation segregated cycle network will make cycling a more attractive mode of transport.	Significantly Beneficial +3
	Physical Activity	The increase in cycling/ attractive travel will have a direct increase in physical activity of the citizens and visitors to Cardiff.	Significantly Beneficial +3
	Accidents	The measure will segregate cyclist from other road users which overall should reduce road traffic accidents involving cyclists.	Significantly Beneficial +3
	Access	It is not anticipated that the introduction of this measure will have an impact on access to services, employment, or healthcare within Cardiff. There could be increased access for some members of society.	Slightly Beneficial +1
Value for Money	Value for Money	It is anticipated that the Benefit to Cost ratio for this option would be within the range of 1 to 2.	Fair - Expected BCR between 1 and 2

Name of Measure :	M14: Implement Zero Emission Buses on Cardiff Network		
Timescales	**2019-2021**		
Feasibility	**Yes. Dependent on Success of ULEB Fund Bid made to the DfT**		
Objective		Summary of Key Impacts	Assessment Qualitative
Environment	Air Quality	In accordance with the proposals made to the DfT for the grant funding to support the uptake of 36 fully electric bus vehicles, the envisaged designated routes, as well as the cascade programme managed by Cardiff bus would anticipate positive improvements to air quality levels, especially on major routes in the City Centre. These anticipated improvements to air quality levels may be further enhanced by combining the proposed scheme with other city centre measures.	Significantly Beneficial +3.
	Noise	The introduction of 36 electric buses will lead to an overall reduction in noise from the Cardiff Bus fleet, especially in targeted residential street and thus potential lead to a slight decrease in noise levels.	Moderately Beneficial +2
	Landscape	The introduction of fully electric buses would have no impact on landscaped as they would utilise existing road infrastructure	Neutral 0
	Historic Env	The scheme will not have any impact on the historic environment of Cardiff	Neutral 0
	Biodiversity	The scheme will not negatively impact on biodiversity nor will it impact any protected sites.	Neutral 0
	Water Environment	It is unlikely that the measure will impact the River Taff, River Ely or Rhymney River or the Severn Estuary and thus there will be no negative impact to the water environment.	Neutral 0
	Townscapes	The scheme is not expected to impact upon townscape features.	Neutral 0
Economy	Journey Time Changes	It is not anticipated that journey time improvements will be made as a result of this measure.	Neutral 0
	Capital Costs	High >£2M. However ULEB Grant funding applied for.	High >£2M
	Land	There is no anticipated loss of land expected with the proposal.	Neutral 0
Social and Cultural	Journey Quality	The measure will introduce state of the art buses, with improved facilities.	Slightly Beneficial +1
	Physical Activity	May encourage increase in use of Public transport and thus increase in physical activity in walking to and from bus stop/ stations	Slightly Beneficial +1
	Accidents	There is no evidence to suggest the proposal will result in an increase in accidents.	Neutral 0
	Access	This measure is not expected to impact on access to services, employment, or healthcare in Cardiff.	Neutral 0
Value for Money	Value for Money	It is anticipated that the Benefit to Cost ratio for this option would be within the range of 1 to 2 Fair if ULEB Bid is successful	Fair - Expected BCR between 1 and 2

Name of Measure :	M21: Revision to Taxi Licensing Policy to include emissions standards		
Timescales	**2019**		
Feasibility	**Yes – Cardiff Council can implement a revised licensing.**		
Objective		Summary of Key Impacts	Assessment Qualitative
Environment	Air Quality	The majority of PHV and HC in Cardiff are diesel vehicles, and only small percentage are currently Euro 6 compliant. By introducing this policy there is a potential for more than 250 vehicles to be replaced per year.	Moderate Beneficial +2
	Noise	This measure may see the introduction of quieter vehicles, if older vehicles are replaced.	Moderate Beneficial +2
	Landscape	The introduction of this measure will have no impact on landscape as it will utilise existing road infrastructure.	Neutral 0
	Historic Env	The scheme will not have any impact on the historic environment of Cardiff.	Neutral 0
	Biodiversity	The scheme will not negatively impact on biodiversity nor will it impact any protected sites.	Neutral 0
	Water Environment	It is unlikely that the measure will impact the River Taff, River Ely or Rhymney River or the Severn Estuary and thus there will be no negative impact to the water environment.	Neutral 0
	Townscapes	No impact upon townscape features is anticipated to occur as a result of the scheme.	Neutral 0
Economy	Journey Time Changes	It is not anticipated that the measure will impact on journey times	Neutral 0
	Capital Costs	Low > there is no direct capital cost to the authority in implementing this measure.	Low <£500k
	Land	No loss of land is anticipated from this measure.	Neutral 0
Social and Cultural	Journey Quality	Improving the age of the taxi fleet in Cardiff by introducing minimum emission standards will have a positive effect on the quality of the journey provided.	Moderately Beneficial +2
	Physical Activity	The requirement for minimum taxi emission standards would not affect the rate of physical activity in Cardiff.	Neutral 0
	Accidents	The measure will unlikely lead to a decrease in accidents, although newer vehicles would inherently provide some additional safety assurances compared to some of the very oldest vehicles in the fleet.	Neutral 0
	Access	This measure is not expected to impact on access to services, employment, or healthcare in Cardiff.	Neutral 0
Value for Money	Value for Money	It is anticipated that the Benefit to Cost ratio for this option would be >2 and thus Good as there are no direct capital costs from to the Council, unless an incentive scheme is introduced. However there will be costs to the taxi industry to replace vehicles.	Good Expected to be ->2

CASAP 2 Options

Name of Measure :	**M10: City Centre West and Central Interchange and Eastside City Centre Schemes;**		
Timescales	**2019-2021**		
Feasibility	**Yes. Dependent on Success of Cardiff Council's Transport Team WelTAG Stage 1 & 2 Proposals to WG**		
Objective		Summary of Key Impacts	Assessment Qualitative
Environment	Air Quality	In accordance with the Council's WelTAG Stage 2 proposals to WG, supporting Air Quality Assessment (AQA) has projected an overall beneficial impact to air quality levels with marked improvements for NO_2 concentrations at sensitive receptor locations in and around the City Centre AQMA. The AQA focuses upon the City Centre, therefore further analysis is required to encapsulate the additional non-compliant road links identified by the 2021 baseline projections cited by the modelling in accordance with the given Direction.	Moderate Beneficial +2
	Noise	There are a number of sensitive receptor dwellings located in the vicinity of the proposed scheme. The proposed scheme may generate a slight decrease to the levels of noise in and around Cardiff City Centre.	Slightly Beneficial +1
	Landscape	The introduction of the Central Interchange Scheme would have no impact on landscape as will utilise existing road infrastructure.	Neutral 0
	Historic Env	The scheme will not have any impact on the historic environment of Cardiff.	Neutral 0
	Biodiversity	The scheme will not negatively impact on biodiversity nor will it impact any protected sites.	Neutral 0
	Water Environment	It is unlikely that the measure will impact the River Taff, River Ely or Rhymney River or the Severn Estuary and thus there will be no negative impact to the water environment.	Neutral 0
	Townscapes	The scheme is expected to provide a visual enhancement to the area, in particular for townscape and public realm.	Moderately Beneficial +2
Economy	Journey Time Changes	It is anticipated that the scheme will lead to slight improvements in journey times for buses and pedestrians.	Slightly Beneficial +1
	Capital Costs	High >£2M	High >£2M
	Land	No loss of land is anticipated from this measure.	Neutral 0
Social and Cultural	Journey Quality	It is expected that journey time reliability would have little or no variation due to restriction of traffic.	Neutral 0
	Physical Activity	The proposed scheme would provide pedestrian improvements. Also cyclists could share the space or be segregated.	Slightly Beneficial +1
	Accidents	The scheme is anticipated to reduce collisions between cyclists and pedestrians.	Slightly Beneficial +1
	Access	The full impact of this measure in terms of access to services, employment and businesses can only be understood following detailed design.	Neutral 0
Value for Money	Value for Money	It is anticipated that the Benefit to Cost ratio for this option would be within the range of 0-1 owing to the high capital costs.	Poor - Expected BCR between 0 and 1

Name of Measure :	M11: Bus Network Programme- Strategic Bus Network to improve bus networks and efficiency of the services via increased and improved bus lanes		
Timescales	**2019**		
Feasibility	**Yes. Road network is managed by the Council Highways Operations.**		
Objective		Summary of Key Impacts	Assessment
			Qualitative
Environment	Air Quality	The proposed scheme does have the potential to influence a modal shift and therefore generate positive improvements to air quality levels, especially in known areas of poor air quality, such as the Cardiff City Centre AQMA. The scheme will have the potential to provide improvements along road links which have predicted exceedences. These anticipated improvements to air quality levels may be further enhanced by combining the proposed scheme with other bus orientated measures.	Moderately Beneficial +2
	Noise	Sensitive receptor dwellings located in the vicinity of road links impacted via the proposals may expect a slight decrease in noise levels due to fewer private vehicles on the network.	Slightly Beneficial +1
	Landscape	The introduction of proposed schemes would have no impact on landscape as will utilise existing road infrastructure	Neutral 0
	Historic Env	The scheme will not have any impact on the historic environment of Cardiff.	Neutral 0
	Biodiversity	The scheme will not negatively impact on biodiversity nor will it impact any protected sites.	Neutral 0
	Water Environment	It is unlikely that the measure will impact the River Taff, River Ely or Rhymney River or the Severn Estuary and thus there will be no negative impact to the water environment.	Neutral 0
	Townscapes	The proposal would not cause any negative impact upon townscape features.	Neutral 0
Economy	Journey Time Changes	It is anticipated that bus priority measures will allow for improved travel time for those utilising the bus service.	Slightly Beneficial +1
	Capital Costs	High >£2M	High >£2M
	Land	No loss of land is anticipated from this measure.	Neutral 0
Social and Cultural	Journey Quality	The measure will introduce improvements to journey quality, especially with bus prioritisation in City Centre areas.	Moderately Beneficial +2
	Physical Activity	The proposal may encourage increase in use of Public transport and thus increase in physical activity in walking to and from bus stop/ stations; especially in the City Centre.	Slightly Beneficial +1
	Accidents	No evidence to suggest the measures will result in an increase in accidents.	Neutral 0
	Access	The proposal is not expected to impact on access to services, employment, or healthcare in Cardiff.	Neutral 0
Value for Money	Value for Money	It is anticipated that the Benefit to Cost ratio for this option would be within the range of 0 to 1.	Poor - Expected BCR Between 0 and 1.

Name of Measure :	**M12: Accelerate Park and Ride programme in NW & NE of Cardiff. NW; Implement new Park and Ride facilities at Junction 33 (750 Spaces) and Llantrisant Road (250 Spaces). NE; expansion of P & R on the A48.**		
Timescales	**2019**		
Feasibility	**Yes. Road network is managed by the Council Highways Operations.**		
Objective		Summary of Key Impacts	Assessment
			Qualitative
Environment	Air Quality	The proposed schemes do have the potential to influence a modal shift towards buses and therefore generate positive improvements to air quality levels, especially in known areas of poor air quality, such as the Llandaff AQMA. The scheme will have the ability to provide improvements along the City Centre road links which have predicted exceedences. These anticipated improvements to air quality levels may be further enhanced by combining the proposed scheme with other city centre measures.	Moderate Beneficial +2
	Noise	Sensitive receptor dwellings located in the vicinity of road links impacted via the proposals may expect a slight decrease in noise levels due to fewer private vehicles on the network.	Slightly Beneficial +1
	Landscape	The proposals do have the potential to impact upon Landscape in the area. However the impact will be effectively managed and controlled via the implementation of planning conditions controlled by Cardiff's Planning Department.	Slightly Adverse -1
	Historic Env	The scheme will not have any impact on the historic environment of Cardiff.	Neutral 0
	Biodiversity	The proposals do have the potential to impact upon biodiversity in the area. However the impact will be effectively managed and controlled via the implementation of planning conditions controlled by Cardiff's Planning Department.	Slightly Adverse -1
	Water Environment	It is unlikely that the measure will impact the River Taff, River Ely or Rhymney River or the Severn Estuary and thus there will be no negative impact to the water environment.	Neutral 0
	Townscapes	The proposal would not cause any negative impact upon townscape features.	Neutral 0
Economy	Journey Time Changes	It is not anticipated that journey time improvements will be made as a result of this measure.	Neutral 0
	Capital Costs	High >£2M	High >£2M
	Land	No loss of land is anticipated from this measure.	Neutral 0
Social and Cultural	Journey Quality	The measure will introduce improved facilities.	Slightly Beneficial +1
	Physical Activity	The proposal may encourage increase in use of Public transport and thus increase in physical activity in walking to and from bus stop/ stations; especially in the City Centre.	Slightly Beneficial +1
	Accidents	No evidence to suggest the measures will result in an increase in accidents.	Neutral 0
	Access	The proposal is not expected to impact on access to services, employment, or healthcare in Cardiff.	Neutral 0
Value for Money	Value for Money	It is anticipated that the Benefit to Cost ratio for this option would be within the range of 0 to 1.	Poor - Expected BCR Between 0 and 1.

Name of Measure :	M18: Improve and promote the uptake of low emission vehicles by enhancing Cardiff's EV infrastructure and identify opportunities to promote awareness.		
Timescales	**TBC**		
Feasibility	**Yes. The Council takes ownership of highway management, however financial funding is not confirmed.**		
Objective		Summary of Key Impacts	Assessment
			Qualitative
Environment	Air Quality	Initial feasibility studies undertaken shows that increased uptake in Low Carbon Vehicles (LCVs) does lead to improvements in air quality levels, especially in urban areas. The Council should promote the uptake of Low Emission Vehicles (LEV) by assessing its own vehicle fleet. However, based upon the current fleet compositions and known source apportionment assessments, due to the expected uptake rate of licensed low emission vehicles, the impact to air quality levels will be insignificant in the short term.	Slightly Beneficial +1
	Noise	The introduction and promotion of EV infrastructure and anticipated increase in licensed low emission vehicles will lead to reductions in noise, especially in the outlined case study areas discussed in the feasibility study.	Slightly Beneficial +1
	Landscape	The introduction and promotion of EV infrastructure would have no impact on landscape as schemes would utilise existing road infrastructure	Neutral 0
	Historic Env	The proposal will not have any impact on the historic environment of Cardiff	Neutral 0
	Biodiversity	The scheme will not negatively impact on biodiversity nor will it impact any protected sites.	Neutral 0
	Water Environment	It is unlikely that the measure will impact the River Taff, River Ely or Rhymney River or the Severn Estuary and thus there will be no negative impact to the water environment.	Neutral 0
	Townscapes	The scheme is not expected to impact upon townscape features.	Neutral 0
Economy	Journey Time Changes	It is not anticipated that journey time improvements will be made as a result of this measure.	Neutral 0
	Capital Costs	Medium>£500k- £2M	Medium>£500k-£2M
	Land	No loss of land is anticipated from this measure.	Neutral 0
Social and Cultural	Journey Quality	The measure will allow persons to have the ability and confidence to utilise their low emission vehicles, therefore diminishing the "range anxiety" theory.	Slightly Beneficial +1
	Physical Activity	No evidence to suggest that a rapid uptake in EVs would lead to an increase in active travel of walking or cycling.	Neutral 0
	Accidents	Due to lack of noise whilst travelling at low speeds, hybrid/ EV can give rise to increase in accidents with pedestrians and cyclist. (New Laws in 2019 will require new models to be fitted with noise emitters whilst travelling at low speeds)	Slightly Adverse -1
	Access	The proposal is not expected to impact on access to services, employment, or healthcare in Cardiff.	Neutral 0
Value for Money	Value for Money	It is anticipated that the Benefit to Cost ratio for this option would be within the range of 0 to 1	Poor - Expected BCR between 0 and 1

Name of Measure :		M23: Review car parking and car permit charges.	
Timescales		**2019**	
Feasibility		**Yes. the Council currently enforces on-street and off-street parking management**	
Objective		Summary of Key Impacts	Assessment
			Qualitative
Environment	Air Quality	The Council has the power to influence its Car Parking policy by amending hierarchy and other parameters considered. By deciding that low emission vehicles (LEV)are prioritised in the hierarchy of parking management it is anticipated that the uptake of low emission vehicles and use of sustainable modes of transport will increase and lead to improvements in air quality levels. The income stream generated by amended parking charges will be ring fenced in the transport sector which is anticipated to be used improving other sustainable forms of transport and transport schemes. However due to low percentage of LEV currently licensed in Cardiff improvements to air quality in the short term will be insignificant.	Slightly Beneficial +1
	Noise	By endorsing the use of LEVs, including electric vehicles there will be a positive impact to noise levels, especially in urban residential areas towards the City Centre.	Slightly Beneficial +1
	Landscape	The introduction of amended parking charges and parking arrangements would have no impact on landscape as schemes would utilise existing road infrastructure	Neutral 0
	Historic Env	The proposal will not have any impact on the historic environment of Cardiff	Neutral 0
	Biodiversity	The scheme will not negatively impact on biodiversity nor will it impact any protected sites.	Neutral 0
	Water Environment	It is unlikely that the measure will impact the River Taff, River Ely or Rhymney River or the Severn Estuary and thus there will be no negative impact to the water environment.	Neutral 0
	Townscapes	The scheme is not expected to impact upon townscape features.	Neutral 0
Economy	Journey Time Changes	It is not anticipated that journey time improvements will be made as a result of this measure.	Neutral 0
	Capital Costs	Low <£500k	Low <£500k
	Land	No loss of land is anticipated from this measure.	Neutral 0
Social and Cultural	Journey Quality	It is anticipated that traffic congestion will be reduced and through income streams generated further enhancements to transport schemes will be made, therefore positively impacting journey time and quality.	Slightly Beneficial +1
	Physical Activity	By increasing the uptake of LEVs and use of sustainable travel alternatives, this may lead to an increase in persons walking/ cycling due to an improved healthier environment.	Slightly Beneficial +1
	Accidents	No evidence to suggest the measures will result in an increase in accidents.	Neutral 0
	Access	This measure is anticipated to have a slight negative impact upon services access and employment. It will not impact upon healthcare services.	Slightly Adverse -1
Value for Money	Value for Money	It is anticipated that the Benefit to Cost ratio for this option would be within the range of 1 to 2	Fair - Expected BCR 1-2

Name of Measure :	M25: Implementation of a Charging Clean Air Zone		
Timescales	**2019-2020**		
Feasibility	**Yes. Road network is managed by the Council Highways Operations.**		
Objective		Summary of Key Impacts	Assessment
			Qualitative
Environment	Air Quality	The proposed scheme could result in significant reductions in concentrations citywide. This measure combined with other measures has the ability to reduce air quality levels to as low as reasonably practicable.	Substantial Beneficial +3
	Noise	Sensitive receptor dwellings located in the vicinity of road links impacted via the proposals may expect a slight decrease in noise levels due to fewer private vehicles on the network.	Moderately Beneficial +2
	Landscape	The introduction of the proposed Scheme is not expected to impact on landscape as will utilise existing road infrastructure.	Neutral 0
	Historic Env	The scheme is unlikely to have any impact on the historic environment of Cardiff.	Neutral 0
	Biodiversity	The scheme will not negatively impact on biodiversity nor will it impact any protected sites.	Neutral 0
	Water Environment	It is unlikely that the measure will impact the River Taff, River Ely or Rhymney River or the Severn Estuary and thus there will be no negative impact to the water environment.	Neutral 0
	Townscapes	The scheme is not expected to impact upon townscape features.	Neutral 0
Economy	Journey Time Changes	There are envisaged journey time improvements by use of alternative modes of transport resulting in reduced congestion.	Slightly Beneficial +1
	Capital Costs	High >£2M	High >£2M
	Land	No loss of land is anticipated from this measure.	Neutral 0
Social and Cultural	Journey Quality	The measure is anticipated to encourage a modal shift and therefore due to reduced congestion and use of other services a slight positive impact is expected for journey quality.	Moderately Beneficial +2
	Physical Activity	The proposal may encourage increase in use of Public transport and thus increase in physical activity in walking to and from bus stop/ stations; especially in the City Centre.	Slightly Beneficial +1
	Accidents	No evidence to suggest the measures will result in an increase in accidents.	Neutral 0
	Access	The proposal is expected to impact on access to services, employment, or healthcare in Cardiff.	Large Adverse -3
Value for Money	Value for Money	It is anticipated that the Benefit to Cost ratio for this option would be within the range of 1 to 2.	Fair - Expected BCR Between 1 and 2.

Table 10 - Summary of WelTAG Well-being Aspects Appraisals

		Key Criteria		Environment					Social and Cultural					Social and Cultural				
Measure	Shortlisted Measure	Timescales	Feasibility	Air Quality	Noise	Landscape	Historic Environment	Biodiversity	Water Environment	Townscape	Journey Time Changes	Capital Costs	Land	Journey Quality	Physical Activity	Accidents	Access	Implementation Timescale
M8	Implement further speed restrictions and enhance already established 20mph Zones.	Y	Y	+1	+2	+1	0	0	0	0	-1	Low <£500k	0	0	+2	+3	+1	2018-2020
M13	Development of Cycling Superhighways infrastructure and Expansion of Next bike Scheme	Y	Y	+1	+1	0	0	0	0	0	+2	Medium £500k-£2m	0	+3	+3	+3	+1	2018-2019
M14	Implement Zero Emission Buses on Cardiff Network	Y	Y	+3	+2	0	0	0	0	0	0	High >£2M	0	+1	+1	0	0	2019-2021
M21	Revision to Taxi Licensing Policy to include emissions standards	Y	Y	+2	+2	0	0	0	0	+1	0	Low <£500k	0	+2	0	0	0	2019
M11	Bus Network Programme- Strategic Bus Network to improve bus networks and efficiency of the services via increased and improved bus lanes	Y	Y	+2	+1	0	0	0	0	0	+1	High >£2M	0	+2	+1	0	0	2019-2020
M12	Accelerate Park and Ride (P & R) programme in NW & NE of Cardiff. NW; Implement new Park and Ride facilities at Junction 33 (750 Spaces) and Llantrisant Road (250 Spaces). NE; expansion of P & R on the A48.	Y	Y	+2	+1	-1	0	-1	0	0	0	High >£2M	0	+1	+1	0	0	2019-2021
M10	City Centre West and Central Interchange and Eastside City Centre Schemes;	Y	Y	+2	+1	0	0	0	0	+2	+1	High >£2M	0	0	+1	+1	0	2019-2020
M18	Improve and promote the uptake of low emission vehicles by enhancing Cardiff's EV infrastructure	N	Y	+1	+1	0	0	0	0	0	0	Medium £500k-£2m	0	+1	0	-1	0	TBC
M23	Review car parking and car permit charges.	Y	Y	+1	+1	0	0	0	0	0	0	Low <£500k	0	+1	+1	0	-1	TBC
M25	Implementation of a Charging Clean Air Zone	Y	Y	+3	+1	0	0	0	0	0	+1	High >£2M	0	+1	+1	0	-3	2019-2020

Key

+3 = Large Beneficial +2 = Moderate Beneficial +1 = Slight Beneficial 0 = Neutral -1 = Slight Adverse -2 = Moderate Adverse -3 = Large Adverse

The following is a list of measures which be fully modelled following Welsh Government guidance using appropriate transport and air quality modelling methodologies.

- **M8: Implement further speed restrictions and enhance already established 20mph Zones;**
- **M13: Development of Cycling Superhighways infrastructure and expansion of Nextbike Scheme;**
- **M14: Increase Zero Emission Buses on Cardiff Network**
- **M21: Improvement of Taxi Licensing Policy, to set minimum vehicle emissions standards;**
- **M10: City Centre West and Central Interchange and Eastside City Centre Schemes;**
- **M11: Bus Programme- Strategic Bus Network to improve bus networks and efficiency of the services via increased and improved bus lanes;**
- **M12: Accelerate Park and Ride programme to increase Park and Ride along the A48 and new facility off Junction 33 of the M4;**
- **M18 Improve and promote the uptake of low emission vehicles by enhancing Cardiff's EV infrastructure**
- **M23: Review car parking and car permit charges and allow for reduced rates for EV/OLEV, and increased rates for <Euro 6;**

It must be noted that the above shortlist of measures have initially been identified as measures that will likely have the greatest impact on the road links identified by the PCM modelling as being non-compliant, namely the A48 and A4232 near Cardiff Bay. However, the measures were also assessed in terms of their likely impact on improving air quality within the Councils existing Air Quality Management Areas (AQMAs). The results of the local modelling detailed in Section 3.3 have demonstrated that compliance issues are not forecasted to occur on the A48 or the A4232. Noncompliance issues are now predicted to only occur on Castle Street which is immediately adjacent to the boundary of the City Centre AQMA, and measures put forward to address air quality in this AQMA will likely have an impact on this road link.

As a requirement of the legal direction, the final measures will be benchmarked against a charging Clean Air Zone in terms of establishing whether the package of measures can achieve compliance in a timeframe equal or sooner than that of a CAZ. This will enable the Council to develop its preferred measured that will be fully refined with a full business case and will be detailed in the Final Plan to be submitted no later than 30th July 2019.

3.9 Clean Air Zones

As a requirement of the legal direction, in terms of demonstrating compliance in the shortest possible time, it is expected that the introduction of a CAZ must be extensively analysed as an option and used as a compliance benchmark for the short list of measures detailed above.

A CAZ defines an area where targeted action is taken to improve air quality and resources are prioritised and coordinated in order to shape the urban environment in a way that delivers improved health benefits and supports economic growth. In CAZs access may be restricted, or charges may be imposed, for vehicles that do not meet certain emission standards. Likewise, there are often exemptions for newer vehicles that meet higher emission standards, emergency services vehicles, electric vehicles, scooters and mopeds.

The reason a CAZ must be considered as the benchmark is detailed within the UK National Plan to Tackle Roadside NO2[32], and it has been further stated in the draft Welsh Government

[32] Defra UK plan for tackling roadside nitrogen dioxide concentrations Detailed plan July 2017

Clean Air Zone Framework[33] that CAZ's will likely bring compliance in the shortest time possible in addition to local measures.

The initial PCM modelling undertaken by Defra assessed the impact of a CAZ in accelerating compliance in Cardiff on the road links identified by the PCM model as being non-compliant. The methodology used by Defra to model Clean Air Zones in the UK 2017 Plan is detailed in Appendix F of the Technical Report[34] of the 2017 UK Plan. The results of the initial modelling indicated that a CAZ would bring compliance with 12 months of it being introduced. However as discussed earlier the local modelling results have projected different results in terms of the road links showing non-compliance compared to the PCM modelling and therefore the impact of a CAZ in achieving compliance needs further assessment and review.

Whilst the option of a CAZ will be the benchmark against which other measures are assessed does not imply that the CAZ will become the preferred option. A fundamental point is that the Council needs to ensure that any proposals are proportionate to the scale of the problem and tailored to local circumstances, whilst ensuring compliance in the shortest time possible. A key aspect of this will be ensuring that there are no detrimental impacts on the economy of Cardiff and this will be assessed in detail as part of the full business case for the preferred option(s).

In developing any proposals for a Clean Air Zone, Cardiff Council will need to consider the requirements of the finalised framework on Clean Air Zones from Welsh Government.

[33] https://beta.gov.wales/sites/default/files/consultations/2018-04/180424-clean-air-zone-framework-en.pdf
[34] Technical Report - UK Plan for tackling roadside nitrogen dioxide concentrations July 2017

Chapter 4 Commercial Case

4.1 Introduction

JAQU's Inception package guidance requires the Commercial case of the SOC to provide an assessment of relevant current procurement arrangements for the likely services required and likely attractiveness of the project to potential services providers.

4.2 Market Assessment

Based on the PESTLE tool, the following gives an overview of the potential for the current market to meet the requirements of any preferred option. Prior to commencement of procurement and to be presented within the Full Business Case in the Final Plan, it is proposed that market engagement will be undertaken for the appropriate measures to determine the extent to which the preferred option is an attractive proposition.

Political

The UK and Welsh Governments role is to regulate and ensure local authorities meet the requirement to be compliant with the EU Air Quality Directive in the shortest possible time and is the primary driver behind this business case. Locally there is ambition to deliver significant improvements in air quality.

Economic

As a result of the requirement for delivering NO_2 compliance, the Welsh Government has announced a £20M a Clean Air Fund[35] for improving air quality across the country. It is anticipated that the implementation of the preferred option will mitigate against detrimental economic impacts by the provision of grant support or otherwise from the Welsh Government's Clean Air Fund and other funding mechanisms.

Social

The cultural trend is currently toward increasing uptake of sustainable practice largely in light the respect of reducing carbon emissions to tackle climate change, but over recent years air quality has become more prominent environmental risk. The market is recognising this shift toward a consciousness in emissions by individuals and organisations and as a result growth in provision for renewable energy, increasing availability for alternative vehicle refuelling infrastructure (e.g. EV charge points) and changing local and national policy indicates that the market for sustainability and air quality initiatives is increasingly becoming a social preference.

Technological

Installation of ANPR cameras has already been undertaken in Cardiff to address moving traffic offences (e.g. bus lane/ junction enforcement), If a Clean Air Zone is determined as the preferred option to deliver compliance in the shortest possible time, it is unlikely that the requirement to install ANPR cameras will present a barrier to the market.

The market is already seeing a growth in low emission and zero emission vehicles and charging infrastructure and so it is anticipated that any proposed preferred option will not be impacted by technological advancements.

Legal

The legal Direction imposed by Welsh Government on Cardiff Council, to achieve compliance with the NO_2 annual average limit value within the shortest possible time has resulted in the

[35] https://gov.wales/newsroom/environmentandcountryside/2018/180424-20m-air-quality-fund-among-new-measures-to-improve-air-quality-in-wales/?lang=en

launch of the Clean Air Fund, (see above "economic") providing the market with assurance that the plans will be funded.

Environment
Environment and Environmental Health concerns have resulted in the legal obligation for the Council to meet NO_2 compliance (see above "political"). Environmental concern is also influencing a growth in the sustainable and low emission economy.

4.3 Procurement Options

The Council is a Public Body and must comply with all pertinent EU and UK Procurement Legislation and therefore, staff must, by law, adhere to the same. A number of policies and procedures have been developed to help us achieve these objectives and to ensure that our procurement activities:

- Comply with European Union (EU) and UK procurement legislation;
- Conform to s Contract Standing Orders and Procurement Rules (CPR) updated July 2018, as well as all relevant internal policies, procedures and objectives.
- Achieve evidenced value for money in terms of quality and the price paid
- Test and demonstrate whether social value has been achieved
- Are open and transparent and safeguard against allegations of corruption, fraud or bias
- Are well documented to provide a clear audit trail
- Manage and address risks as well as opportunities

The most appropriate procurement approach for the Final Plan will be dependent upon several factors, namely:

- The final measures included within the Plan;
- The type of system to be implemented ;
- The extent to which the technical and operational solution is specified (e.g. whether fully specified or open to market proposals as a performance-based solution);
- The method by which it is proposed to operate ("in-house" or third-party service provider);
- On-going maintenance and development;
- Whether it is to be designed, implemented and operated by a single service provider or by multiple providers; and
- Timescales for delivery.

There are four key procurement routes available:

- Local authority tendering through an Approved List (shortlist) of invited suppliers;
- Through any applicable existing Council Frameworks;
- Through Welsh Government's National Procurement Services (NPS) for the public sector; and
- Open tender through the Official Journal of the European Union (OJEU

Given the likely scale of the preferred option, it is not thought likely that the procurement value of any element of this work will fall under that required for the Approved List

procurement approach, so this leaves the existing frameworks, NPS, or OJEU processes as options for procurement.

4.3.1 Existing Council Frameworks

There are several currently active frameworks established by Cardiff Council for highways design, installation and maintenance services. These frameworks offer the advantage of being readily available to provide "fast track" procurement of the various services required for the Final Plan. The suitability of using existing frameworks to procure appropriate services to implement the outcome of the Final Plan will explored in more detail within the Final Plan.

4.3.2 National Procurement Services

The NPS has a number of frameworks which offers customers a quick, simple and competitive route to construction consultancy services. The Framework offers access to pre-approved firms that have been rigorously assessed on the quality of the services they provide. Of particular relevance to this Plan, is the CONSTRUCTION CONSULTANCY FRAMEWORKS NPS-PS-0004-14 Construction Consultancy, and the sub framework NPS-PS-0027-15.

4.3.3 OJEU Route

The OJEU tender process can take several forms - open, restricted, competitive dialogue, competitive procedure with negotiation or innovation partnership. Given the nature of the work proposed for the Final Plan, it is expected that only open or restricted procedures would apply.

The final procurement route for the preferred option(s) will be detailed further in the Final Plan.

Chapter 5 Financial Case

5.1 Funding

Within its latest Interim supplemental plan to the UK plan for tackling roadside nitrogen dioxide concentrations 2017 [36] the Welsh Government has stated that it has allocated over £20 million for an Air Quality Fund through to 2021 to help accelerate compliance with NO_2 limits and improve air quality in Wales. The report further states that this fund will primarily be used to provide on-going support, guidance and finance to enable Cardiff Council (and Caerphilly CBC) to take action to achieve compliance in the shortest possible time. The funding will support work to conduct feasibility studies, implement early measures which help accelerate exposure reduction and deliver the options which will achieve compliance in the shortest possible time.

Within the Minister's letter that accompanied the formal direction it was confirmed that finance would be made available for the production of the feasibility study and for the implementation of the chosen scheme.

In addition to the above funding mechanism, the Council will continue to work collaboratively with Welsh Government officers to identify all available and an appropriate funding mechanisms including transportation funds, to maximise the financial contribution from Welsh Government towards the implementation of any measures.

5.2 Cost Assumptions

At this stage, the Financial Case cannot be taken any further, as the Final Preferred option has yet to be determined. This aspect will explored in more detail in the Final Plan once our consultants completed an assessment of the shortlist of measures.

However the following are key funding and cost assumptions that will be applied when developing the Full Business Case for the preferred option:

1. The key assumption for this financial case is that the implementation of the preferred option and subsequent monitoring and evaluation is funded by the Welsh Government's Air Quality Fund and other appropriate funding mechanisms from Welsh Government as detailed in 5.1 above;

2. The Economic Case will outline cost assumptions for implementation of the preferred option.

5.3 Contingency

A full estimation of contingency required will be undertaken as part of the Full Business Case for the preferred option and will be detailed in the Final Plan.

5.4 Assurance of Cost Estimates

A full determination of assurances will be undertaken as part of the Full Business Case for the preferred option and will be detailed in the Final Plan.

[36] Interim Welsh Government supplemental plan to the UK plan for tackling roadside nitrogen dioxide concentrations 2017 July 2018.

5.5 Budget and Risk Management

Costs will be managed by ensuring all procurement follows the procurement strategy outlined in the Commercial Case. The assessment of tenders through this process will be based on both quality and price to ensure value for money.

The budget management responsibility will fall to the overall Project Manager.

5.6 Other Funding Options

The Council will explore all other funding opportunities to obtain additional resources to implement any additional measures that, whilst not achieving compliance in the shortest time possible, will assist in reducing overall NO_2 and other air pollutants across Cardiff.

Chapter 6 Management Case

6.1 Introduction

The purpose of the Management Case within this SOC is to set out how the scheme/s will be delivered successfully. In accordance with the Inception package of JAQUs guidance this Strategic Case considers the following;

- An outline of who is involved in the project including key stakeholders;
- An outline of how the project will be managed and any other key managerial considerations, including: change management, training, evaluation and timetable;
- An indicative project plan ; and
- An indicative organogram of project team and governance structure

6.2 Project Management

The project will be run in accordance with the Council's Project Quality Assurance (PQA) scheme which is Cardiff Council's Project and Programme Management Standard and is based on PRINCE2 (PRojects IN Controlled Environments) and MSP (Managing Successful Programmes) which are the methodologies approved by government for public sector projects. PQA provides guidance on how the Council will manage projects, recognising that projects are:

- Change focussed
- Unique
- Composed of inter-dependent activities
- Carried out by people who don't normally work together
- Temporary, with defined start and end dates
- Established to achieve a specific outcome

A number of key roles have been identified for delivery of the project within the organogram and are set out below along with the responsibilities of each role

6.2.1 Project Board

The Project Board is responsible for the overall direction and management of the project, and has responsibility and authority for the project within the remit (the Project Mandate) set corporately. The Project Board are accountable to the Project Executive.

Membership of the Project Board should include the Project Executive and Service Area representative (Senior User). Other participants may be invited by the Project Executive.

6.2.2 Project Executive (PExec)

The Project Executive (PExec) is accountable for the successful delivery of the project and is most likely to be a senior officer within. The Project Executive's role is to ensure that the project is focussed throughout its life cycle on achieving its objectives - delivering the agreed scope and outputs, as detailed in the project's Business Case. The Project Executive has to ensure that the project delivers value for money.

The role includes acting as the lead officer for the project in stakeholder engagement, such as discussions with elected Members, AM's or MP's. As Chair of the Project Board they give approval to proceed to the next stage and sign off project closure.

The Project Executive will:

- Ensure the project remains focussed on delivering agreed scope and outputs
- Oversee the project and ensure it remains on target – time, cost, quality and scope.
- Take decisions within their delegated authority and ensure these are within the corporate decision making framework.
- Be proactive in providing leadership and direction throughout the project
- Ensure that the project is financially viable, consistent with the Corporate Plan and compliant with Council standards and procedure rules.
- Approve the Initial Project Brief at the end of the Start-up Stage.

6.2.3 Service Area Representative (Senior User)

Senior User is the role that represents the service or customer that will receive the changes delivered by the project.

They represent the interests of the end users who will benefit from the completion of the project. The Senior User is accountable for ensuring that requirements have been clearly and completely defined and what is produced is fit for purpose and acceptable to the end users.

6.2.4 Senior Supplier

The Senior Supplier sits on a Project Board.

They represent the officers / contractors actually doing the work of the project. They are responsible for ensuring all suppliers understand the project requirements and that any advice given to the project team is correctly interpreted. It may not be appropriate for an external contractor to act as Senior Supplier, and consideration could be given to involving's procurement team in this position. An example of a Senior Supplier would be ICT for software development projects.

6.2.5 Project Manager

The Project Manager is responsible, on behalf of the Project Executive, for delivering the project on time, to budget and to the required quality standard. They plan and monitor progress, co-ordinate project activities, ensure the project is effectively resourced, and manage relationships with a wide range of stakeholders.

The Project Manager manages the work of specialists, allocating and utilising resources in an efficient manner and maintaining a co-operative, motivated and successful team.

The Project Manager is also responsible for maintaining project governance and documentation, including producing regular highlight reports and maintaining records in the Project & Programme Management Database (where used).

6.2.6 Project Assurance

Project & Programme Assurance covers all interests of a project/programme, including senior managers, the business, users and suppliers.

The main function of Assurance is to ensure that corporate governance standards are adhered to; that the project has been set up and is being managed correctly, and identified benefits are realised.

Project Assurance has to be independent of the Project Manager, so reports directly to the Audit Manager, Project Board / Project Executive and are their eyes and ears in the day to day management of the project.

6.2.7 Project Support

The Project Support Officer assists the Project Manager in all activities relating to day to day management, establishing and maintaining the necessary systems to ensure effective administration. Not all projects will have a dedicated Project Support Officer and this function is often carried out by the Project Manager.

6.2.8 Audit Committee

The Audit Committee has responsibility for overseeing all aspects of Risk Management, Governance and Internal Control. The Committee will provide guidance and oversight to the management of risk but also challenge the effectiveness of the project management arrangements within. The Committee will look to seek assurance for that project management is being properly undertaken.

6.2.9 Senior Management

The key roles of Management are to:

- Implement processes for project management
- Receive reports from Internal Audit for consideration and implementation, where this is deemed appropriate.
- Promote the accountability and responsibility of all staff within as set in Cardiff Council's PQA Handbook;
- Identify the project management (PQA) training needs of all Directorate employees and co-ordinate training and awareness-building events;
- Ensure that project management (PQA) is incorporated into performance management, business planning and Wales Programme for Improvement processes.

6.2.10 Investment Review Board

The Investment Review Board is the governance body where decisions about delivery of change initiatives are made. No new initiatives should be started or funded without the Investment Review Board's approval.

- Agree the programme & project management framework (PQA);
- Approve the Organisational Development Strategy and Delivery Plan;
- Receive Strategic / Project Business Cases and prioritisation reports and determine the scope and content of change;
- Ensure that resources are allocated appropriately;
- Ensure conflicts between programme and project delivery and BAU that cannot be addressed at programme level are addressed effectively;
- Promote collaborative working across ; and

- Undertake periodic reviews of the effectiveness of delivery of 's vision, and take appropriate action where required

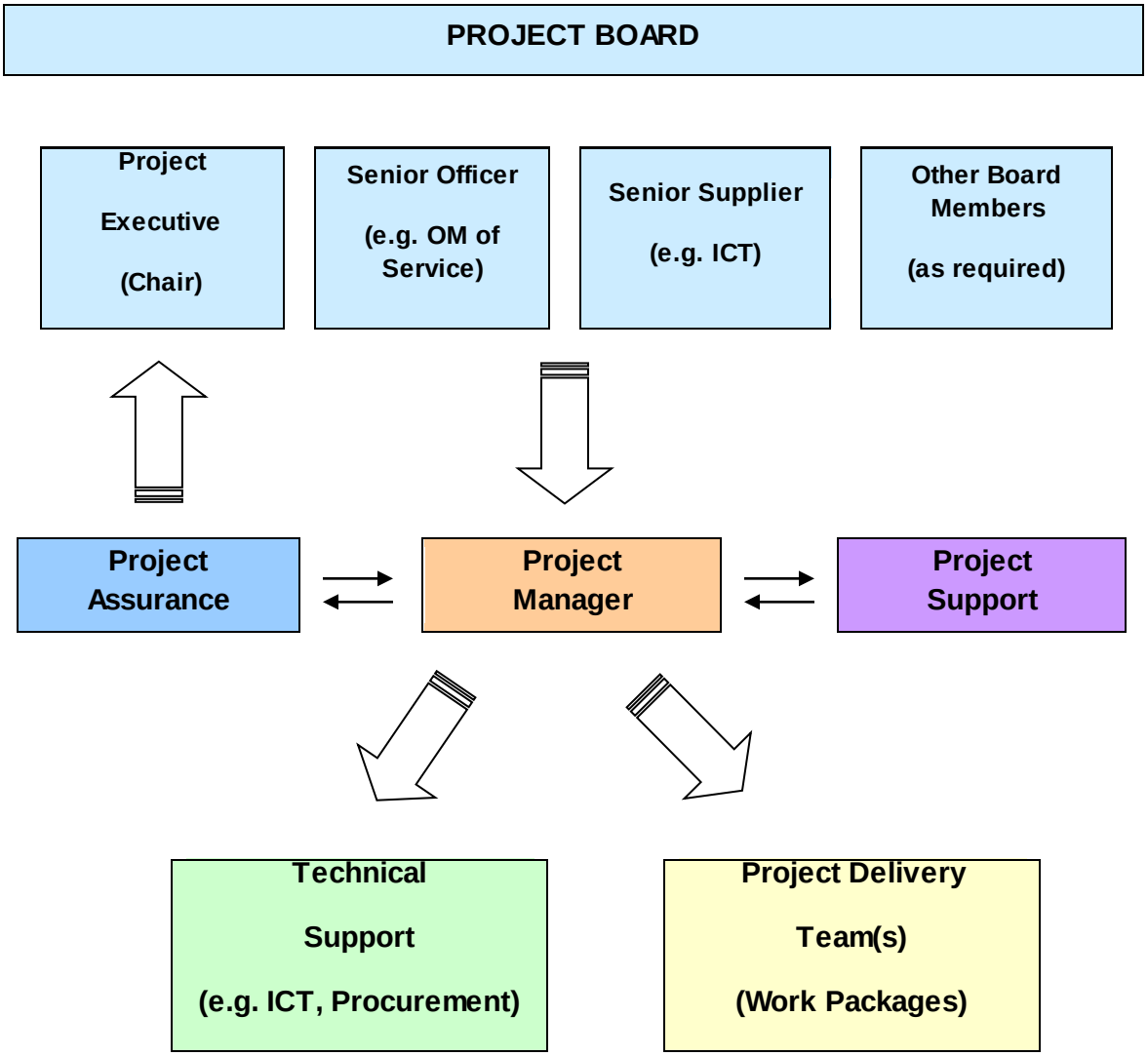
6.2.11 Organisational Development Management Board

The Organisational Development Board (OD) is the strategic group which monitors delivery of programmes and projects, resolving key issues that may compromise delivery and benefit realisation. The key roles of the OD Board are to:

Plans the delivery of change, aligned to vision, objectives, goals and key measures

- Actively and regularly involves SMT throughout the definition and delivery of change, ensuring continued senior management commitment and engagement;
- Ensure all change is delivered within 's agreed governance framework, including PQA;
- Initiate new programmes;
- Monitor delivery of the Strategic 'Organisational Development' Delivery Plan;
- Review and resolve key strategic issues;
- Ensure risks and dependencies are effectively managed;
- Ensure limited resources are managed effectively and efficiently;
- Monitor and approve changes to forecasted benefits;
- Sponsor and support reviews of the effectiveness of change delivery, and take appropriate action where required;
- Determine and drive 's future service delivery models and strategic commissioning arrangements; and
- Develop and deliver a consistent approach to stakeholder engagement and communications

The basic structure of a project team is as follows:-


PROJECT BOARD
Project Executive (Chair)
Senior Officer (e.g. OM of Service)
Senior Supplier (e.g. ICT)
Other Board Members (as required)
Project Assurance
Project Manager
Project Support
Technical Support (e.g. ICT, Procurement)
Project Delivery Team(s) (Work Packages)

6.3 Financial Management

6.3.1 Financial Reporting

The Project Manager will be responsible for undertaking regular financial reporting to inform the Programme Board of the projects progress and performance. A Project Initiation Document will be developed to provide a firm foundation for the initiation of the project. It will set out the direction and scope of the project, and form the 'contract' between the Project Team, Project Manager, Transport Delivery Board and the Programme Board.

Following initiation, the Project Manager will produce monthly highlight reports which will be submitted to the Project Delivery Board.

Scrutiny and oversight of the projects financial management will be provided by the Programme Team.

6.3.2 Variation Monitoring

As with all large scale projects it is expected that elements of the agreed plan, budget, or scope will need to be varied at some point during the project cycle. . It is important that means of controlling any variations are signed offer before being implemented so that they can be dealt with simply and at the correct level.

A variation to the project will be identified through the monthly progress reports where activities are not being carried out according to the plan or for the agreed cost, or an issue has arisen to affect the scope. All variation will be recorded on a variation request log that will be used to specify why the change has come about, what actions are proposed to counter it, and at what level decision-making sits.

A set of tolerances will be determined, so that each level of management in the project has the defined authority to agree certain variations before having to refer to a higher level. The agreed tolerances will be recorded in the Project Initiation Document, as will the period within which variations are cumulative.

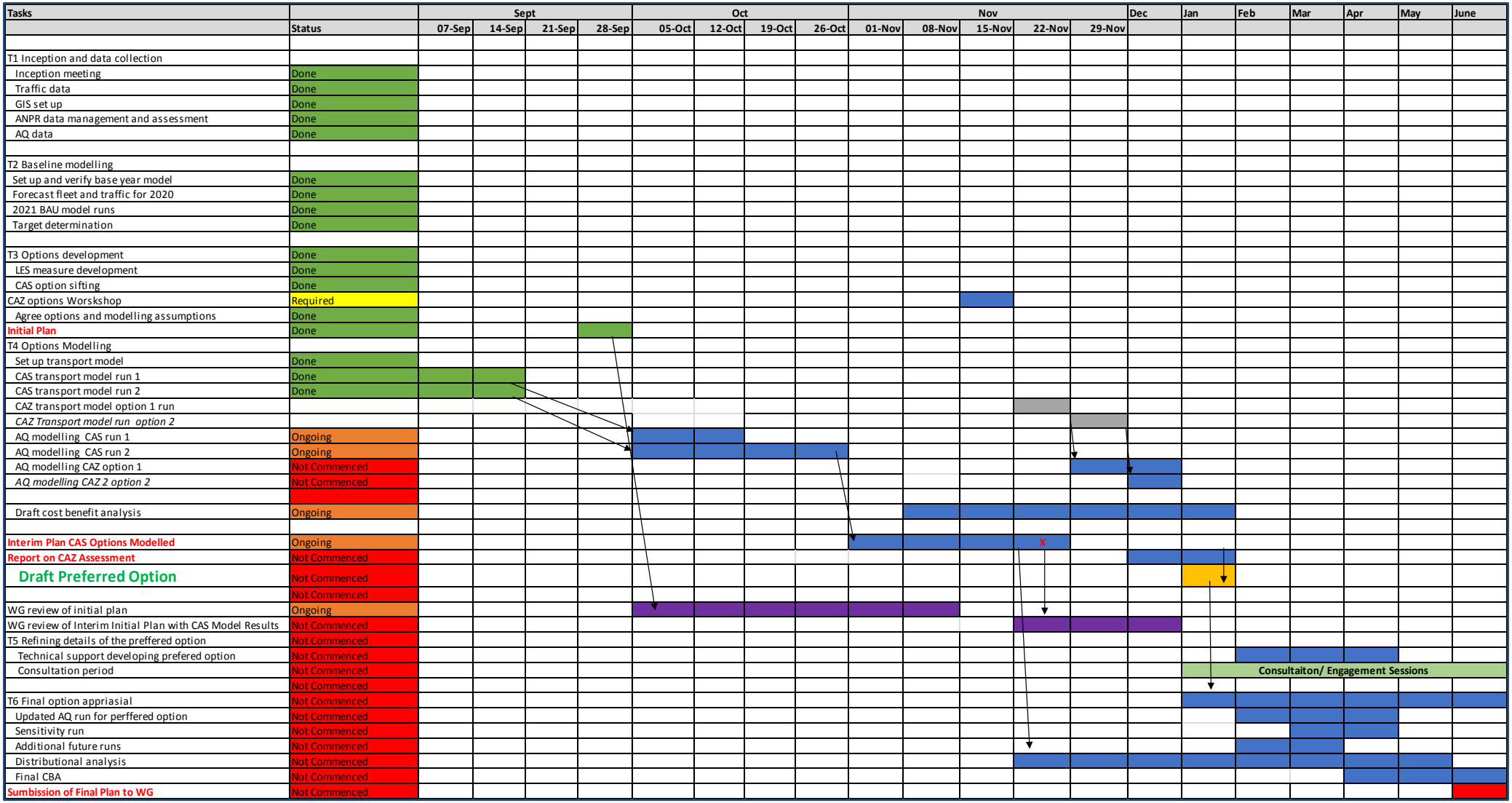
Variations that do not affect the plan or the budget by more than is reported in one month will likely sit within the tolerance of the project manager. Although additional decision-making will not be required, all such variations will be recorded on the monthly progress report and an entry will be made on the variation request log.

Variations of a higher tolerance will be clearly brought to the attention of the Project Delivery Board (PDB) in the finances section of the progress report. This will allow a discussion to take place and a way to proceed be agreed. Larger variations, which exceed the tolerance of the PDB, will need to be taken to a higher level of decision-making beyond the PDB.

6.4 Project Plan

An indicative project plan for completing the Final Plan to develop a Preferred Option is provided in Figure 16. This will be refined, and further detail added, as the project progresses.

Figure 16 - Updated Project Plan



Chapter 7 Summary and Next Steps

7.1 Results of Baseline Modelling

The report has identified through localised modelling that the locations of projected future noncompliance of the NO_2 limit value differ significantly from the national projected compliance issues undertaken by DEFRA using the PCM model. The national PCM model showed exceedances on the A48 to the east of the city and the A4232 to the south west. The local model results indicate **only one** road link, **namely the A4161 Castle Street, (ID 30665)** to show non-compliance issues beyond 2021. The main reason for this exceedance relates to very high traffic flows, some 32,000 vehicles a day, and accompanying slow speeds of around 11mph on this specific road link. The main reasons for the differences between the local model results and the PCM results is primarily down to the fact that the local model has a far greater level of detail which is based on local data, and not national assumptions, and thus can be seen to be a better representation of local circumstances. The key aspects of the local model that influence the results are as follows:

- Traffic flows are based on a local traffic model;
- Traffic speeds are based on a local model and local traffic master;
- Local fleet data from the ANPR, not just national averages; and
- Local topology in terms of gradient, canyons, etc. which the PCM does not allow for.

A shortlist of measures have initially been identified as measures that will likely have the greatest impact on the road links identified by the PCM modelling as being non-compliant, namely the A48 and A4232 near Cardiff Bay. However, the measures were also assessed in terms of their likely impact on improving air quality within the Councils existing Air Quality Management Areas (AQMAs). The results of the local modelling detailed in Section 3.3 have demonstrated that compliance issues are not forecasted to occur on the A48 or the A4232. Noncompliance issues are now predicted to only occur on Castle Street which is immediately adjacent to the boundary of the City Centre AQMA, and measures put forward to address air quality in this AQMA will likely have an impact on this road link. The current shortlist of measures are summarised below in Table 11.

Table 11 Summary of Shortlist of Options

Measure reference:	Scheme Description
M8	Implement further speed restrictions and enhance already established 20mph Zones.
M13	Development of Cycling Superhighways infrastructure and Expansion of Next bike Scheme
M14	Implement Zero Emission Buses on Cardiff Network
M21	Revision to Taxi Licensing Policy to include emissions standards
M11	Bus Network Programme- Strategic Bus Network to improve bus networks and efficiency of the services via increased and improved bus lanes
M12	Accelerate Park and Ride (P & R) programme in NW & NE of Cardiff. NW; Implement new Park and Ride facilities at Junction 33 (750 Spaces) and Llantrisant Road (250 Spaces). NE; expansion of P & R on the A48.
M10	City Centre West and Central Interchange and Eastside City Centre Schemes
M18	Improve and promote the uptake of low emission vehicles by enhancing Cardiff's EV infrastructure
M23	Review car parking and car permit charges.

7.2 Next Steps

The shortlist of measures will be fully modelled following Welsh Government guidance using appropriate transport and air quality modelling methodologies. As required by the Direction, the measures will be benchmarked against a charging Clean Air Zone in terms of establishing whether the package of measures can achieve compliance in a timeframe equal or sooner than that of a Clean Air Zone.

Cardiff Council will submit an Interim Report, with a completed assessment of the shortlist of measures. This will enable the Council to develop its preferred option(s) which will be taken forward to develop a full business case in accordance with the HM Treasury Green Book 5 Cases and be presented in the Final Plan to be submitted to Welsh Government no later than 30th June 2019.

Appendix A – Air Quality Model Verification

Verification of the model involves comparison of the modelled results with any local monitoring data at relevant locations; this helps to identify how the model is performing and if any adjustments should be applied. The verification process involves checking and refining the model input data to try and reduce uncertainties and produce model outputs that are in better agreement with the monitoring results. This can be followed by adjustment of the modelled results if required. The LAQM.TG(16) guidance recommends making the adjustment to the road contribution of the pollutant only and not the background concentration these are combined with.

The approach outlined in LAQM.TG(16) section 7.508 – 7.534 has been used in this case. All roadside diffusion tube NO_2 measurement sites in Cardiff have been used for model verification. A single road NOx adjustment factor was derived and used to calculate:

- Citywide modelling results at receptor points adjacent to relevant PCM road links.
- Citywide 1m resolution NO_2 annual mean concentration rasters providing a continuous representation of the spatial variation in modelled concentrations.

It is appropriate to verify the performance of the RapidAir model in terms of primary pollutant emissions of nitrogen oxides (NOx = NO + NO_2). To verify the model, the predicted annual mean Road NOx concentrations were compared with concentrations measured at the various monitoring sites during 2015. The model output of Road NOx (the total NOx originating from road traffic) was compared with measured Road NOx, where the measured Road NOx contribution is calculated as the difference between the total NOx and the background NOx value. Total measured NOx for each diffusion tube was calculated from the measured NO_2 concentration using the latest version of the Defra NOx/NO_2 calculator (v6.1).

The initial comparison of the modelled vs. measured Road NOx identified that the model was under-predicting the Road NOx contribution at most locations. Refinements were subsequently made to the model inputs to improve model performance where possible.

The gradient of the best fit line for the modelled Road NOx contribution vs. measured Road NOx contribution was then determined using linear regression and used as a domain wide Road NOx adjustment factor. This factor was then applied to the modelled Road NOx concentration at each discretely modelled receptor point to provide adjusted modelled Road NOx concentrations. A linear regression plot comparing modelled and monitored Road NOx concentrations before and after adjustment is presented in Figure A.1.

The total annual mean NO_2 concentrations were then determined using the NOx/NO_2 calculator to combine background and adjusted road contribution concentrations.

Some clear outliers (n = 7) were apparent during the model verification process, whereby we were unable to refine the model inputs sufficiently to achieve acceptable model performance at these locations. These sites were excluded from the model verification. The reasons why acceptable model performance could not be achieved at these sites include:

- Sites located next to a large car park, bus stop, petrol station, or taxi rank that has not been explicitly modelled due to unknown activity data.
- No traffic model road link included where the NO_2 sampler is located, or not all road links included e.g. at a junction.

The RapidAir canyon allocator identified Westgate Street as a canyon, however including a canyon in this location leads to very scattered data in the model verification and the sites located in this canyon do not follow the general trends shown by the remainder of the monitoring locations. Consequently, the canyon in Westgate was manually removed which resulted in the relationship between measured and modelled concentrations at sites in this street following similar trends to the other verification sites, and reduced the error in the model predictions.

To present a conservative approach to adjusting future year predictions of road NOx concentrations, a primary NOx adjustment factor (PAdj) of 1.807 based on model verification using all of the 2015 NO_2 measurements was applied to all modelled Road NOx data prior to calculating an NO_2 annual mean.

A plot comparing modelled and monitored NO_2 concentrations before and after adjustment during 2015 is presented in FigureA.2.

Figure A.1: Comparison of modelled Road NO_x Vs. Measured Road NO_x before and after adjustment

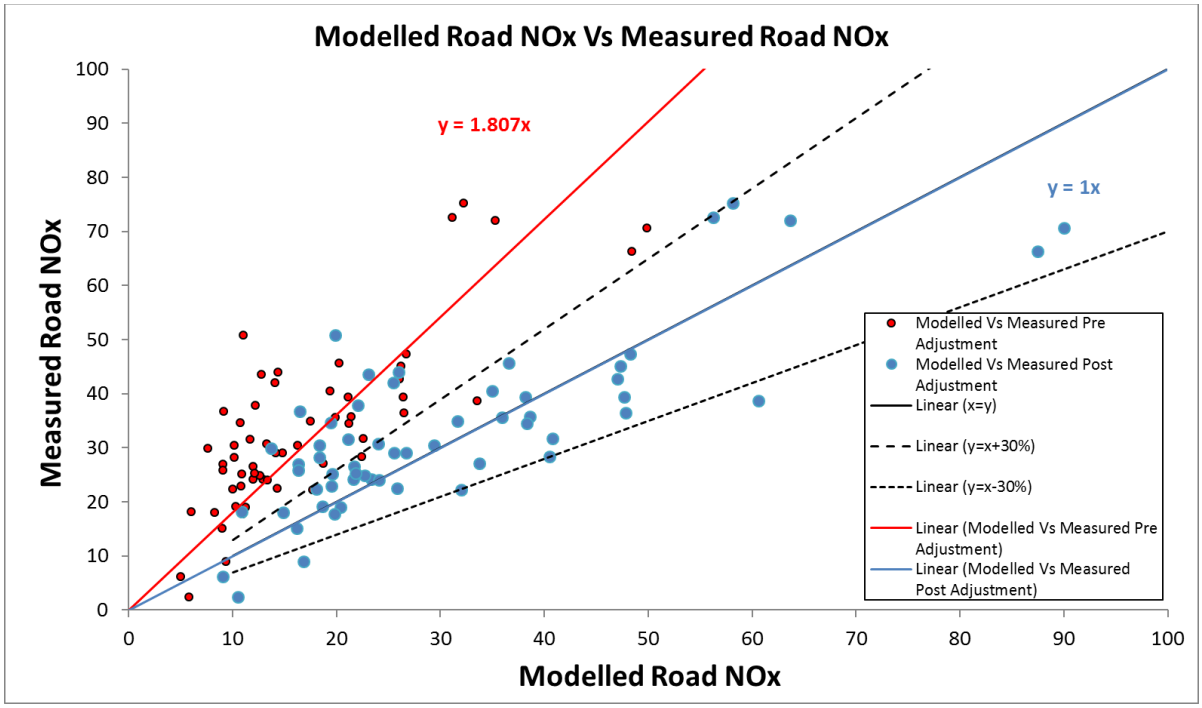
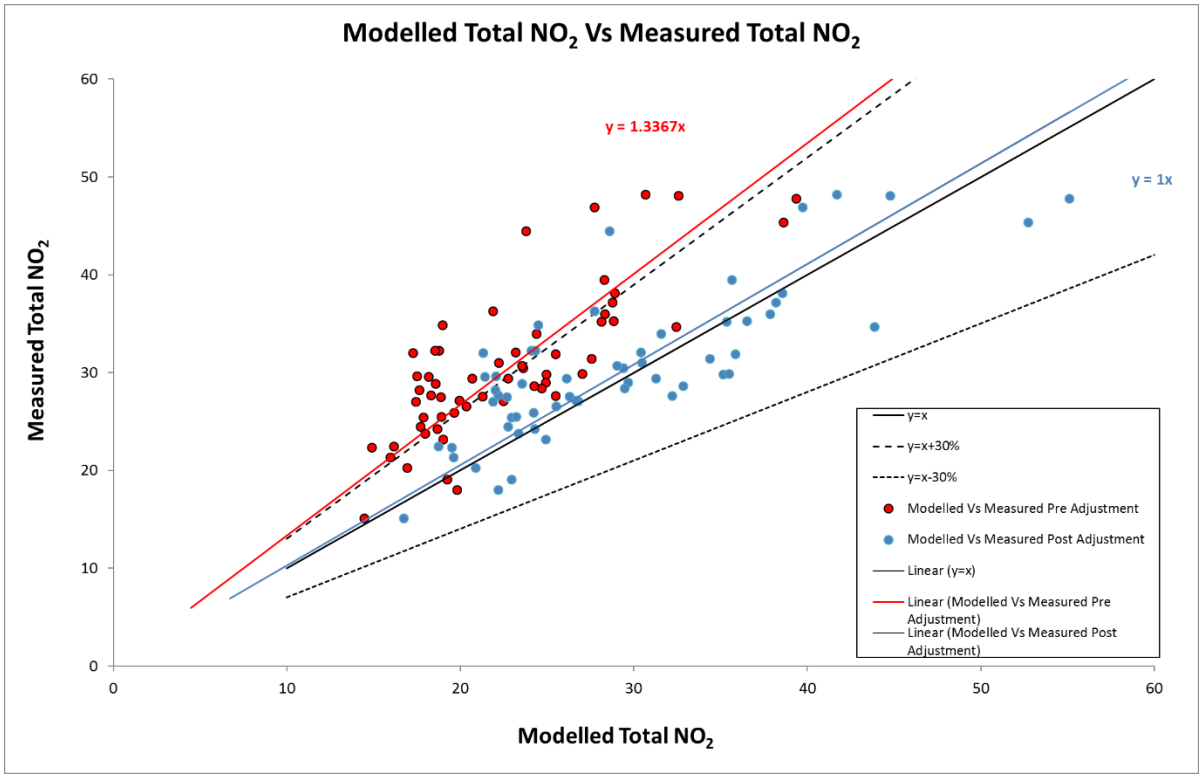


Figure A.2: Modelled vs. measured NO_2 annual mean 2015 before and after adjustment



Model Performance

To evaluate the model performance and uncertainty, the Root Mean Square Error (RMSE) for the observed vs. predicted NO_2 annual mean concentrations was calculated, as detailed in Technical Guidance LAQM.TG(16). This guidance indicates that an RMSE of up to 4 µg/m^3 is ideal, and an RMSE of up to 10 µg/m^3 is acceptable. The calculated RMSE is presented in Table A.1. In this case the RMSE was calculated at 5.1 µg.m^{-3}which is close to the ideal range suggested by the guidance.

Table A.1: Comparison of measured and modelled concentrations at measurement locations in 2015, and the model root mean square error.

NO_2 monitoring site	Measured NO_2 annual mean concentration 2015 (µg.m^{-3})	Modelled NO_2 annual mean concentration 2015 (µg.m^{-3})
DT33	46.9	39.7
DT44	27.1	26.8
DT45	32.1	30.4
DT56	29.6	22.0
DT58	48.3	41.7
DT81	35.3	36.5
DT82	23.8	23.4
DT85	22.4	19.5
DT86	34.9	24.5
DT96	31.1	30.5
DT97	30.5	29.4
DT98	25.4	22.9
DT99	29.8	35.2
DT100	28.9	23.5
DT106	29.4	31.3
DT107	30.7	29.0
DT111	21.3	19.6
DT112	27.1	21.9
DT119	27.7	32.2
DT124	22.5	18.7
DT126	36.0	37.9
DT128	29.6	21.4
DT129	31.5	34.4
DT130	35.2	35.3
DT131	39.5	35.6
DT133	31.9	35.8
DT139	29.4	26.1
DT140	36.3	27.7
DT141	32.3	24.1
DT143	38.2	38.6
DT144	37.2	38.2
DT145	29.9	35.5
DT146	26.6	25.5
DT147	27.7	22.2

NO_2 monitoring site	Measured NO_2 annual mean concentration 2015 ($\mu g.m^{-3}$)	Modelled NO_2 annual mean concentration 2015 ($\mu g.m^{-3}$)
DT148	27.5	22.7
DT152	27.6	26.3
DT153	29.0	29.7
DT156	25.9	24.2
DT157	27.2	26.7
DT158	25.5	23.2
DT159	34.0	31.6
DT161	32.3	24.3
DT162	24.5	22.7
DT163	23.2	24.9
DT164	20.3	20.9
DT165	15.1	16.7
DT166	32.1	21.3
DT167	28.3	22.0
DT168	24.3	24.3
DT170	19.1	23.0
DT171	18.1	22.2
DT172	44.5	28.6
DT173	28.4	29.5
DT175	34.7	43.9
DT174	28.7	32.8
DT176	47.8	43.9
DT177	48.1	55.1
DT178	45.4	44.8
	RMSE (all sites)	**5.1 $\mu g/m^3$**

Appendix B – Transport Modelling Technical Approach

MOTT MACDONALD

Technical Note

Project:	Cardiff Clean Air Feasibility Study		
Our reference:	367590	**Your reference:**	-
Prepared by:	George Bate	**Date:**	27/09/2018
Approved by:	Philip Old	**Checked by:**	Paul Chase
Subject:	Transport Modelling Technical Approach		

This technical note outlines the transport modelling work undertaken by Mott MacDonald to develop the evidence base for the Cardiff Clean Air Feasibility Study. Transport modelling has been undertaken in the South East Wales Transport Model (SEWTM) using methods that are appropriate for a high-level feasibility study, with outputs being provided to Cardiff Council's air quality consultants (Ricardo). The overarching purpose of the transport modelling work for this study is to assist in forecasting air quality conditions with and without specific interventions on the transport network. At the current point in time the "with intervention" transport modelling scenario has not been incorporated into Ricardo's work. As such the methodology for modelling the interventions is not presented in the current version of this technical note.

1 Introduction

SEWTM

SEWTM is a disaggregate multi-modal transport model of South East Wales. The model comprises separate highway and public transport assignment models linked together with a variable demand model. The model was developed for Welsh Government with a 2015 base year, validated to WebTAG Unit M3.1 guidance. It has been designed to:

- Understand the current travel patterns in South East Wales and the performance of the transport system;
- Monitor changes in travel patterns over time;
- Predict future travel patterns and conditions on the transport network;
- Assess the impacts of possible interventions in the transport system in a consistent manner;
- Assess the impacts of land use changes such as new housing developments and employment locations in a consistent manner; and
- Provide inputs required for transport appraisals and business cases.

The model represents an average weekday and for most purposes outputs are divided into four time periods:

- AM peak between 0700 and 0930; peak hour assignment representing 0745-0845;
- Inter-peak (IP) between 0930 and 1530; average hour assignment;
- PM between 1530 and 1800; peak hour assignment representing 1630-1730; and
- Off-peak (OP) between 1800 and 0700; average hour assignment.

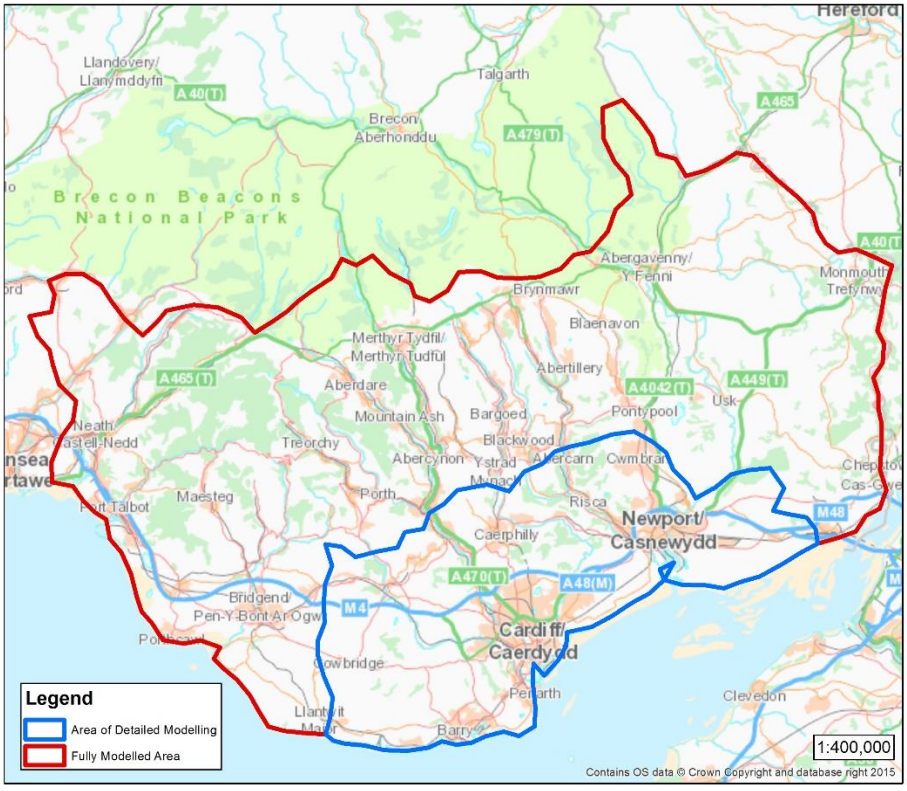
The following assignment user classes are included in the highway model:

- Car commute;
- Car business;
- Car other;
- HGV; and
- LGV.

The highway models utilise an equilibrium assignment which attempts to minimise path costs across all origin-destination (OD) pairs. Convergence is a measure of the proximity to an equilibrium solution; the highway model convergence is compliant with guidance set out in WebTAG Unit M3.1.

SEWTM geographical coverage is shown in Figure B.1. The Cardiff local authority area is within the Area of Detailed Modelling. This is the area of the transport model within which significant impacts of interventions are more certain. Within this area the model will represent all trips (demand), model zones are generally smaller than LSOAs, the transport network is detailed, and junction modelling is included.

Figure B.1: SEWTM modelled area



Source: Mott MacDonald

Method Overview

The transport modelling approach that has been adopted for this study balances the need to forecast the highway network impacts of a range of interventions with the need to maintain a proportionate approach to appraisal, taking account of the high-level nature of the study and the associated time and budget constraints. The full multi-modal Variable Demand Model (VDM) has been used to forecast the 2021 baseline situation given expected changes to population, employment and the highway/public transport networks. The highway assignment user classes have been split by vehicle emissions class using information provided by Ricardo, determined from Automatic Number Plate Recognition (ANPR) surveys. Clean Air Strategy Package transport interventions have been assessed using the 2021 baseline as a starting point and applying highway network and trip matrix adjustments using methods to be set out in a future version of this note.

Technical Note Structure

The remainder of this note is structured as follows:

- Section 2 lists the SEWTM base year (2015) model outputs supplied to Ricardo for use in developing an initial base year air quality model;
- Section 3 sets out the approach and assumptions used in preparing 2021 baseline forecasts; and
- Section 4 explains how the highway trip matrices have been divided into compliant / non-compliant engine standards for subsequent air quality modelling purposes.

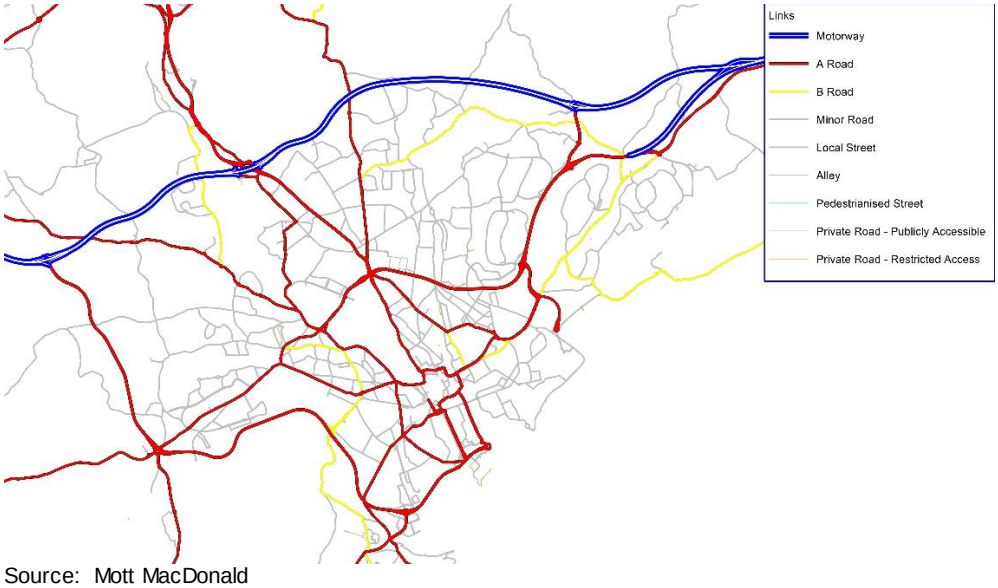
2 Base Model Outputs

SEWTM has been developed with a base year model representing 2015. To enable Cardiff Council's air quality consultants (Ricardo) to build a base year air dispersion model, the following outputs have been provided from the SEWTM base year highway models:

- Link and node structure in GIS shapefile format;
- Correspondence file which defines the relationship between SEWTM highway network links and the Ordnance Survey Integrated Transport Network (ITN) layer – the latter has been used by Ricardo to develop the air dispersion model;
- Highway link flows (vehicles per hour) at a time-period level for every modelled highway network link;
- Bus flows on each link;
- Modelled hour to time period factors, which allow for all-day traffic flows to be estimated;
- Traffic speeds on each modelled link; and
- Link information (number of lanes, single/dual carriageway etc.).

The highway network level of detail contained in SEWTM for the Cardiff area is shown in Figure B.2

Figure B.2: SEWTM highway network in Cardiff area



Source: Mott MacDonald

3 Preparing the 2021 Reference Case Forecast

The forecast year for this project is 2021, whereas the usual SEWTM forecast years are 2026 and 2036. A 2021 reference case VDM forecast has been prepared to provide a baseline scenario. Air quality measures have then been tested using this reference case forecast as a starting point.

Demographic Scenario

To enable a 2021 forecast to be carried out, a 2021 demographic scenario was prepared. Demographic inputs to SEWTM include (but are not limited to):

- Job and population forecasts for the whole of Great Britain;
- Detailed population forecasts for the fully modelled area; and
- Income data for the population in the fully modelled area.

The base year data used for SEWTM is derived from the 2011 Census, and a variety of other data sources. Experian data purchased in 2015 is used to provide growth for detailed demographic inputs at a Local Authority (LA) level. For the purposes of this project a 2021 baseline demographic scenario has been developed by interpolating between the 2015 and 2026 scenarios. This data was then adjusted to take account of explicitly modelled developments (both employment and housing), predominantly in the Cardiff LA. The developments shown in Table B.1 have been explicitly modelled as new point zones, except for Cardiff Central Enterprise Zone, for which the additional population/jobs have been incorporated into existing model zones.

Table B.1: Explicitly modelled strategic developments in SEWTM, 2021

Strategic site	Dwellings	Employment	Adopted Housing Demographic Sample Location
Cardiff Central Enterprise Zone	645	7206	Century Wharf, Cardiff
Plasdwr, North West Cardiff	1146	-	De Clare Drive, Radyr
M4 Junction 33 (Site D/E)	520	-	De Clare Drive, Radyr
North East Cardiff (Site F)	1006	-	Pontprennau
St Edeyrns, Cardiff	703	-	Pontprennau
Ely Bridge, Cardiff	650	-	Pontprennau
Bay Point, Cardiff	225	-	Century Wharf, Cardiff
Glan-Llyn, Newport	1160	1200	Pontprennau

Source: Mott MacDonald, based on information provided by Cardiff Council

The detailed demographic proportions for each new site (for example the proportion of self-employed workers) were taken from existing similar developments, as detailed in Table B.1. Factors were calculated for each model input to apply to existing zones in the relevant LA, such that the model input totals in the final demographic scenario were controlled to those in the baseline interpolated scenario (at LA level).

Highway and Public Transport Networks

Highway and Public Transport (PT) networks have been adapted from existing model scenarios. As agreed with Cardiff Council, the highway networks have had the following schemes coded in addition to the 2015 base models:

- Cardiff Eastern Bay Link Phase 1;
- M4 Junction 32 Improvements (new through-junction link and traffic signals for M4 westbound to A470 northbound movements);
- M4 Junction 33 Improvements (new left-turn filter lane from M4 westbound off-slip to A4232);
- Removal of Severn Bridge tolls; and
- A4336 Five Mile Lane Road Quality Improvements.

The public transport networks represent the proposed KeolisAmey rail scenario for the Core Valley Lines. This includes:

- A total of 4 trains per hour (tph) from Cardiff to each of Treherbert / Aberdare / Merthyr / Rhymney / Coryton;
- New direct services (2tph) from Treherbert / Aberdare / Merthyr into Cardiff Bay, on top of the existing services to Cardiff Central; and
- Some Aberdare services routed via the City Line so that the City Line is better connected to the wider rail network.

Access arrangements for the explicitly modelled development zones have been coded as outlined in Table B.2.

Table B.2: Access Arrangements for Explicitly Modelled Strategic Developments in SEWTM, 2021

Name	Highway Access	Public Transport Access
Cardiff Central Enterprise Zone	No additional access arrangements, existing zones/access used.	
Plasdwr, North West Cardiff	Access split between Llantrisant Road A4119 at the north and Pentrebane Road at the south	Doubled frequency of bus service 122 on the Robin Hill (Creigiau) – Cardiff section of the route, to provide a service into Cardiff every 10 minutes
M4 Junction 33	Access via Llantrisant Road A4119 at the North	
North East Cardiff	Access split between St Mellons Road at the north and Pentwyn Road by high school at the south	New bus service, 20km/h, 4 services per direction per hour, route: University Hospital – Gabalfa – Llanishen – Site F – Pontprennau Asda/St. Edeyrns (and reverse)
St Enerdyns, Cardiff	Access via new arm on existing roundabout at Pontprennau the A4232	
Ely Bridge, Cardiff	New access road, Sanatorium Road, which meets Cowbridge Road West at a signalized junction to the north-west and Broad Street at a signalised junction to the south-east	No additional PT arrangements
Bay Point, Cardiff	Access via roundabout at Morrisons site	No additional PT arrangements
Glan-Llyn, Newport	Access via roundabouts onto A4810	New X74 and X74s bus services / bus service extensions

WebTAG Parameters

The WebTAG databook issued by the Department for Transport (DfT) defines Values of Time (VOT) and Vehicle Operating Costs (VOC) for use in transport modelling and scheme appraisal. Parameter values are generally given by year and updates to the databook are released several times annually. As is usual modelling practice, forecast values have been derived using the base year values available at the time the model was validated, and applying growth in parameter values from the latest version of the databook. For base year values the autumn 2015 version of the databook has been used. For forecast parameter growth the May 2018 databook has been used.

Exogenous Demand and Speed Forecasts

SEWTM does not produce forecasts for HGVs, LGVs, or external-external car trips passing through the model area. The representation of growth in such trips in the forecast highway models is based on the DfT Road Traffic Forecasts (RTF) which provide growth to apply to the 2015 base year trip matrices. The data used in initial SEWTM forecasting was the 2015 (scenario 1) version. Late on during this model application the 2018 version of the data (the first issued since 2015) became publicly available. However, due to time constraints it has not been possible to incorporate the updated forecasts in the modelling.

It is known that the 2018 version of RTF predicts significantly lower growth in HGV and LGV movements (with a modest increase in car travel) compared to the 2015 version. As such it is recommended that any further modelling work on this project incorporates the 2018 version of RTF.RTF 2015 has also been used to derive changes in fixed link speeds in the external model area.

4 Vehicle Type Split

This section details how the highway matrices have been split into compliant and non-compliant (Euro Standard engine) categories derived from ANPR data.

Data Source

Cardiff Council arranged for ANPR cameras to be installed temporarily at 12 locations in Cardiff, covering 21 traffic movements, 19 of which are included in the transport model coverage. Over the course of a week in May 2018, number plates were captured by the cameras and linked to a DfT database containing various emission-related vehicle characteristics. A series of checks has been carried out on the ANPR data to check that it is sensible. Air dispersion modellers at Ricardo processed the data and carried out forecasting and back-casting exercises (for 2015 and 2021) to provide the Euro-emissions class compliant/non-compliant split for each of the 19 movements, split by vehicle type (HGV, LGV, car).

It was considered whether to implement separate splits for different OD pairs, based upon the ANPR survey sites they passed through. However, it was found that there was little variation in the proportion of compliant vehicles between the surveyed movements, particularly for the movements with the highest volumes. Additionally, it was noted that a significant percentage of OD pair paths passing through one survey site also passed through another, meaning that this would be practically difficult to implement. For reasons of simplicity therefore, a volume-weighted average of the proportion of compliant vehicles was taken for each time period and vehicle class, and all OD pairs were split based upon this proportion. The percentage of compliant vehicles for each of the time period-vehicle type combinations is shown for 2021 in Table B.3. The 2015 results are not presented in this report since the air dispersion model was calibrated using un-split transport model data.

Table B.3: Proportion of Compliant Vehicles by Time Period and Vehicle Type (2021)

	Car	HGV	LGV
AM	74.5%	79.3%	45.7%
IP	74.6%	79.1%	45.3%
PM	74.6%	79.0%	45.6%
OP	73.8%	79.0%	45.3%

Following the implementation of the splits in the assigned 2021 reference case networks, the same outputs, as provided for the base year models (see Section 2), were provided to Ricardo for air dispersion modelling.