Impacts of Non-Road Mobile Machinery (NRMM) in Bristol: Policy Options for Reducing Emission

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Experts in air quality management & assessment

The format of this report has been amended by Bristol City Council in order for the report to comply with accessibility requirements.

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Executive Summary

Poor air quality is one of the greatest environmental risks to public health in the UK. Long-term exposure to air pollution can cause chronic conditions such as cardiovascular and respiratory diseases as well as lung cancer, leading to reduced life expectancy. The Environment Bill, currently before Parliament[1], requires the setting of a new, national air quality target for $PM_{2.5}$, as well as long term targets for air quality generally. It is likely that this will require additional effort by national and local government to reduce emissions of key pollutants, including $PM_{2.5}$ and NO_X.

This report provides evidence on emissions from Non-Road Mobile Machinery (NRMM) and sets out recommendations for policy approaches to reduce these emissions effectively. NRMM comprises mobile equipment not directly related to the transportation of passengers or goods, such as excavators, bulldozers and cranes used in construction. It can also include generators being used for a variety of uses, as well as railway machinery. The engines in this type of equipment can emit significant levels of pollutants, depending on their age and the emission standard. This may be particularly relevant to machinery being used on construction sites. Diesel-fuelled NRMM will emit both nitrogen oxides and particulate matter.

National data, and data from London NRMM, have been used to provide an estimate of the emissions resulting from NRMM in Bristol. The limitations of using the currently available data sources were analysed, with the aim of understanding how this could be improved to provide more accurate calculations in the future.

In this report, we apply a 'top down' approach, in order to provide an overall estimate of emissions in Bristol, which is consistent with nationally accepted methodologies and emissions estimates. In order to provide a basis for quantifying specific policy measures, as well as a future-proofed methodology to undertake localised emissions estimates, we also apply a bottom up approach using local data combined with data from London. The two approaches are summarised as follows:

- **Top-down**: emissions are based on scaling published UK emissions data to the Bristol level. In this case, the uncertainty of the UK level data will be further increased by the appropriateness of the scaling factors used.
- **Bottom-up**: emissions are calculated using local information on development sites, combined with a profile of NRMM activity for different construction-related activities and associated emission factors. The quality and certainty of the result is inherently linked to the availability of local data on sites using NRMM and the scale

[1] https://services.parliament.uk/bills/2019-21/environment.html

of activity. A bottom-up approach has the potential to deliver more accurate results than a top-down approach, but it generally requires more resources.

For the bottom up calculations a number of key local data were missing, in particular NRMM calculations could not be included for *small* development sites as a list of minor developments in Bristol was not available; the data from London indicates that the vast majority (approximately 98%) of registered residential development sites may fall into this category, with sites <0.5 Ha classified as small. There is also uncertainty surrounding the developments classification between “dwelling” and “other”, as internal guidelines on classification may not be fully represented in the final development lists. For these reasons, this stage of the process is not designed to provide a robust estimate of *absolute* emissions, but rather to provide a methodology for quantifying measures. In particular, quantifying proportional reductions in emissions when applying emissions standards to NRMM across Bristol) and providing Bristol with a robust method to quantify absolute emissions if the underlying data sets are improved.

Although the evidence presented in this report indicates that NRMM emissions do not make up a large proportion of total emissions in Bristol, the calculations have a number of uncertainties, and are not wholly based on Bristol-specific data. It is, therefore, recommended that the data underpinning the analysis are improved, in order to assist Bristol City Council in deciding whether to prioritise this sector, or not. It should also be recognised that close to large scale construction sites, NRMM will be a more significant contributor to air pollutant impacts than the Bristol-wide calculations suggest.

Bristol City Council could undertake the following actions to reduce, or support the reduction of, emissions from NRMM in the future.

- Option 1: Baseline activity data improvement campaign
- Option 2: Adoption of Supplementary Planning Guidance for the Control of dust and emissions from construction and demolition in Bristol
- Option 3: Adoption of a Code of Construction Practice, including minimum emission standards for equipment used in construction
- Option 4: Set up a register for construction NRMM in Bristol
- Option 5: Set up minimum emissions standards for equipment used by Council contractors
- Option 6: Investigate incentives for the uptake and use of low carbon NRMM (hybrid and full electric) for construction projects in Bristol, and
- Option 7: Lobbying government for more direct powers.

The policy options are presented as three packages, which could be considered as a stepwise approach, scaling up as the extent, severity and priority of the issue increases.

The baseline results from the bottom up approach are considered to represent a large underestimate in total emissions (largely due to the lack of data on construction sites in Bristol). Nevertheless, it has still been possible to consider the impact on emissions under policy scenarios that prohibit the use of NRMM that is older than either Stage IIIB and Stage IV, on a percentage reduction basis. In these scenarios, all activity associated with older stage engines has been shifted to either Stage IIIB or Stage IV. The results indicate that significant emissions savings can be achieved by adopting minimum engine standards for construction sites. Therefore, even though it is not a large contributor to overall city emissions, there is scope for large reductions in emissions both city-wide and locally.

Throughout the course of the study, stakeholders have been consulted, both locally and nationally to both investigate ways of refining data available, and to discuss policy options in relation to the feasibility of implementation. Uncertainties in the data have been outlined and ways of improving underlying local data sets have been included. In order to reduce uncertainty in emissions estimates, and be able to apply the bottom up approach, the priority data requirement is the number, size and type of development sites in Bristol, followed by the type, engine technology and power of NRMM used on sites in Bristol.

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1. Introduction

1.1 Poor air quality is one of the greatest environmental risks to public health in the UK. Long-term exposure to air pollution can cause chronic conditions such as cardiovascular and respiratory diseases as well as lung cancer, leading to reduced life expectancy. Short-term exposure (over hours or days) to elevated levels of air pollution can also cause a range of health effects related to lung function, exacerbation of asthma, increases in respiratory and cardiovascular hospital admissions, and mortality. There are a number of other emerging links for air pollution and health, including dementia, a variety of mental health conditions, and adverse pregnancy outcomes.

1.2 In June 2019, the Mayor of Bristol presented plans in the Clean Air Day speech to tackle air pollution in Bristol[2]. This committed to gathering evidence on the emissions of pollution from Non-road mobile machinery (NRMM) to determine whether there is a need to tighten emissions standards within Bristol.

1.3 This report provides evidence on the scale of pollutant emissions from NRMM and provides recommendations for policy approaches to reduce these emissions effectively. Emissions from NRMM are potentially significant sources of emissions within cities. including Bristol. This report aims to gain a better understanding of the impact of these emissions sources within Bristol.

1.4 Air pollution can be quantified in terms of emissions (the amount of pollutants released into the atmosphere from a source) or the concentration of pollutants in a location (air quality). This report focusses on emissions. Emissions are related to concentrations, but not in a linear way, due to the effects of meteorology and atmospheric chemistry. Whilst it is exposure to elevated concentrations which cause the health effects, measures to reduce emissions will minimise these effects.

1.5 NRMM comprises mobile equipment not directly related to the transportation of passengers or goods, such as excavators, bulldozers and cranes used in construction. It can also include generators being used for a variety of uses, and railway machinery. These engines can emit high levels of pollutants, depending on their age and the emission standard. This may be particularly relevant to machinery being used on construction sites. Diesel-fuelled NRMM will emit both nitrogen oxides and particulate matter.

[2] https://news.bristol.gov.uk/news/embargoed-until-speech-delivered-mayor-of-bristol-commits-to-protect-most-vulnerable-from-pollution

1.6 PM both as PM_{10} and $PM_{2.5}$ [3] has many different sources, both natural and anthropogenic. These can be primary, with the particles emitted directly into the atmosphere, or secondary with particles formed from precursor gases through atmospheric reactions. Sources of primary particles include road and non-road vehicles, industrial sources and power stations, domestic heating and shipping. Natural sources of particles include sea salt. The formation of secondary particles in the atmosphere happens over hours to days, thus secondary $PM_{2.5}$ is found downwind (by tens or hundreds of kilometres) of the sources of emission. Reducing exposure to PM is particularly challenging, given the variety of sources.

1.7 Nitrogen dioxide concentrations are determined by emissions of nitrogen oxides[4], mainly from combustion processes. Road transport and electricity supply industry are the main sources in the UK as a whole. Within Bristol, road transport is the main contributor.

1.8 In addition to providing emissions estimates from NRMM, this report sets out recommendations as to how, in the future, Bristol City Council could improve on the data used in this report. The report concludes with policy recommendations based on the available data and experience from other local authorities. The Environment Bill, currently before Parliament[5], requires the setting of a new, national air quality target for $PM_{2.5}$, as well as long term targets for air quality generally. It is likely that this will require additional effort by national and local government to reduce emissions of key pollutants, including $PM_{2.5}$ and NO_X.

1.9 The project has been undertaken by Air Quality Consultants Ltd, and Aether on behalf of Bristol City Council.

[3] PM_{10}, or course particles are particles that are less than 10 microns (µm) in diameter. $PM_{2.5}$, or fine particles, are particles that are less than 2.5 µm in diameter

[4] The term nitrogen oxides (NOx) covers both nitrogen dioxide (NO_2) and nitric oxide (NO). Once emitted there are chemical reactions that transform some of the nitric oxide to nitrogen dioxide. The proportion of NO_2 within NOx is thus variable, tending to increase with distance from the emission source.

[5] https://services.parliament.uk/bills/2019-21/environment.html

2. Policy and Local Context

Clean Air Strategy

2.1 The Clean Air Strategy (Defra, 2019a) sets out a wide range of actions by which the UK Government will seek to reduce pollutant emissions and improve air quality. Actions are targeted at four main sources of emissions: Transport, Domestic, Farming and Industry. In the Strategy it is stated that 15% of diesel in the UK is used by non-road mobile machinery and in 2016 this accounted for 21% of emissions of nitrogen oxides and 7% of fine particulate matter. No local-level analysis of emissions from NRMM has been carried out within Bristol. Although Bristol is currently developing Clean Air Zone plans to reduce NOx emissions from road vehicles, the contribution of emissions from NRMM are currently not well understood.

2.2 The Clean Air Strategy includes the following commitments from Government in relation to NRMM:

- *To explore the use of environmental permitting for significant NRMM sources where appropriate to ensure consistent approaches are applied across England to regulate emissions;*
- *Introduce new legislation to enable the Transport Secretary to compel manufacturers to recall NRMM for any failures in their emissions control system, to ensure the more stringent standards deliver a reduction in emissions in the real world;*
- *Where certain types of NRMM pose a risk to air quality only in specific locations, we will work with industry and local bodies to identify local solutions; and*
- *Keep under review the need to make tampering with an NRMM emissions control system a legal offence, recognising that such systems will increasingly be required to meet the emission standards.*

2.3 Other priority areas include innovation funding to help provide solutions where market-ready solutions are not currently available, for example for low and zero-emission options for NRMM.

2.4 In May 2018, HM Treasury and Defra jointly published a call for evidence into red diesel use, and whether red diesel availability for NRMM discourages the purchase of cleaner alternatives[6]. In several sectors including construction machinery, lower emission machinery is becoming available, but it may not suit all applications, and other sectors do not yet have viable alternatives to machinery with diesel engines.

[6] Red diesel use makes up over 15% of total diesel use, it is believed the majority of red diesel is used by NRMM

The Non-Road Mobile Machinery (Emission of Gaseous and Particulate Pollutants) Regulations 1999

2.5 In the UK, the legislation governing emissions produced by engines fitted in NRMM is the Non-Road Mobile Machinery (Emission of Gaseous and Particulate Pollutants) Regulations 1999[7], as amended. This sets emission standards for carbon monoxide, hydrocarbons, oxides of nitrogen and, for diesel engines, particulate matter. Engines installed in NRMM are split into categories for spark ignition (SI) and compression ignition (CI), and then further classified according to the engine power rating. These categories are then given limits for emissions, more commonly known as the engine's 'stage'.

2.6 The emissions standards for NRMM are complex as they come into force in stages, with each stage phased, depending on the application and the engine size. The emissions standards are summarised in Appendix 0. Stage IIIa was phased in between 2010 and 2012 for constant speed engines, between 2005 and 2009 for propulsion engines for inland waterway vessels, between 2005 and 2009 for railcars and locomotives, and between 2005 and 2008 for other engines. Stage IIIb was then introduced between 2011 and 2013 for land-based application engines between 37 and 560 kW, in 2011 for locomotive and railcar engines above 130 kW. Stage IV was phased in between 2013 and 2014, only for land-based application engines between 56 and 560 kW. Stage V was introduced on 1 January 2018 for engine type-approval and on 1 January 2019 for placing on the market of engines; except for land-based engines between 56 and 130 kW which benefit from a one-year delay and rail engines, both for railcars and locomotives, which benefit from a two-year delay.

Local Policies

2.7 Bristol City Council is in the process of updating the Local Plan, with the latest draft version for consultation published in March 2019[8]. The latest Local Plan includes Draft Policy HW2, 'Air Quality', which states:

"Development with the potential to generate significant numbers of additional journeys will be expected to provide an appropriate level of sustainable transport improvements consistent with Draft Policy T1 'Development and transport principles' and Retained Policy DM23 'Transport development management', which may include a financial contribution to measures set out in the council's Air Quality Action Plan.

[7] Regulations can be found at https://www.legislation.gov.uk/uksi/1999/1053/contents/made

[8] see https://www.bristol.gov.uk/planning-and-building-regulations/local-plan-review for details

Development that has the potential for significant local emissions to the detriment of air quality will not be permitted unless it is essential for reasons of economic or wider social need. The development will be expected to provide an appropriate scheme of mitigation and will not be permitted in proximity to homes, schools, or other existing sensitive uses.

Development will not be permitted if mitigation cannot be provided to an appropriate standard with an acceptable design.

Development in designated Air Quality Management Areas should take account of existing air pollution and include measures to mitigate its impact on future occupiers consistent with other policies of the development plan such as those on climate change and urban design."

2.8 Until the new Local Plan is adopted, the current Core Strategy (Bristol City Council, 2011), adopted in June 2011, and the Site Allocations and Development Management Policies document (Bristol City Council, 2014) continue to apply. The Core Strategy includes one policy that is directly relevant to air quality; Policy BCS23 states that: *"Development should be sited and designed in a way as to avoid adversely impacting upon: Environmental amenity or biodiversity of the surrounding area by reason of … air … pollution …"*

2.9 The Site Allocations and Development Management Policies document was adopted in July 2014. The document includes one policy that is directly related to air quality; Policy DM33: 'Pollution Control, Air Quality and Water Quality' states that:

"Development which has the potential, either individually or cumulatively, for an unacceptable impact on environmental amenity…by reason of pollution as set out in the Core Strategy but is considered to be desirable for reasons of economic or wider social need will be expected to provide an appropriate scheme of mitigation. In assessing a scheme of mitigation, account will be taken of:

i. The location, design and layout of the proposed development; and

ii. Measures to bring levels of emissions to an acceptable level; and

iii. Measures to control run-off and other diffuse pollution; and

iv. Hours of operation; and

v. Measures that reduce existing levels of pollution.

Development will not be permitted if mitigation cannot be provided to an appropriate standard with an acceptable design, particularly in proximity to sensitive existing uses or sites…;

…development that has the potential for significant emissions to the detriment of air quality, particularly in designated Air Quality Management Areas, should include an appropriate scheme of mitigation which may take the form of on-site measures or, where appropriate, a financial contribution to off-site measures. …"

2.10 The Local Plan process provides opportunity to ensure that emissions from NRMM are controlled, for example under Policy DM33, *ii measures to bring levels of emissions to an acceptable level*.

Air Quality Action Plans

2.11 Defra has produced an Air Quality Plan to tackle roadside nitrogen dioxide concentrations in the UK (Defra, 2017); a supplement to the 2017 Plan (Defra, 2018a) was published in October 2018 and sets out the steps Government is taking in relation to a further 33 local authorities where shorter-term exceedances of the limit value were identified. Alongside a package of national measures, the 2017 Plan and the 2018 Supplement require those identified English Local Authorities (or the GLA in the case of London Authorities) to produce local action plans and/or feasibility studies. These plans and feasibility studies must have regard to measures to achieve the statutory limit values within the shortest possible time, which may include the implementation of a Clean Air Zone (CAZ). Bristol was one of these 33 local authorities and feasibility work for the CAZ is progressing. An Outline Business Case was submitted to Government in November 2019, and BCC are continuing to work to submit the Full Business Case. The CAZ is designed to reduce concentrations of nitrogen dioxide to acceptable levels in the shortest possible time. See the Clean Air for Bristol website for further details.

Local Air Quality Action Plan

2.12 Bristol City Council has declared an AQMA that covers the city centre and parts of the main radial roads. The AQMA was originally declared in 2001 for exceedances of the annual mean nitrogen dioxide and 24-hour mean PM_{10} objectives, and was subsequently updated in 2003, 2008 (to also include the 1-hour mean nitrogen dioxide objective) and 2011. The Council has developed an Air Quality Action Plan adopted in 2004, which is contained within the Local Transport Plan and currently being revised to include work for the Clean Air Zone. The Air Quality Strategy outlined in the plan focuses on information, promotion awareness and alternatives, network management, signing, partnership working, freight, major transport schemes and monitoring. The Strategy focusses on transport emissions. Commitments to address emissions from non-transport sources were made in a Clean Air Day speech in June 2019 by the Mayor of Bristol, details of which can be seen at https://news.bristol.gov.uk/news/embargoed-until-speech-delivered-mayor-of-bristol-commits-to-protect-most-vulnerable-from-pollution.

Clean Air Plan

2.13 Due to exceedances of Air Quality Limit Values, Bristol City Council has been directed by Government to produce a Clean Air Plan to achieve air quality improvements in the shortest time possible. As part of the plan, Bristol City Council has considered a range of options for the implementation of the Clean Air Zone (CAZ), including both charging and non-charging measures, in order to achieve sufficient improvement in air quality.

Further Information about Pollutants and Health Effects

Particulate Matter

2.14 Particulate Matter (PM) is different from the gaseous pollutants in that it is not a clearly defined chemical compound. PM_{10} and $PM_{2.5}$ are the most commonly used units. They are measured as the mass of particles in a cubic metre below the stated size, 10 micrometres in the case of PM_{10} and 2.5 micrometres for $PM_{2.5}$. Both PM_{10} and $PM_{2.5}$ have many different sources, both natural and anthropogenic. Particulate matter is a mixture of both *primary* and *secondary* components. Sources of *primary* particles include combustion processes, such as diesel engines, but can also include *mechanically derived* particles such as tyre, brake and road wear, windblown dusts (including, for example, dust from the Sahara) and sea salt. Mechanically derived particles tend to be larger in size (PM_{10}) whereas combustion derived particles are smaller ($PM_{2.5}$). *Secondary* particles can comprise a very wide range of components but, in terms of contributions to total measured levels of PM_{10} and $PM_{2.5}$, ammonium nitrate and ammonium sulphate are key components. Fine particles, and in particular *secondary* particles, can travel long distances and are known as *transboundary* pollutants. The formation of secondary particles happens relatively slowly (hours to days), thus secondary PM is found well downwind of the sources of emission of the precursor gases. This means that the particles measured in Bristol often originate elsewhere. The management of exposure to particles is particularly challenging, given the wide variety of sources.

2.15 Within the City of Bristol, previous work has shown that the population-weighted total $PM_{2.5}$ concentration in 2013 was 11.45 $\mu g/m^3$. Of this, the majority (81%) is anthropogenic, with 50% of the anthropogenic fraction being secondary $PM_{2.5}$, and 23% being regional primary. This leaves 27% of the anthropogenic fraction being effectively from local sources, which can be considered to be locally controllable. For comparison with population-weighted figures above, the annual mean $PM_{2.5}$ concentration at the St Pauls urban background monitoring site in 2018 was 12 $\mu g/m^3$.

Nitrogen Dioxide

2.16 Nitrogen dioxide concentrations are predominantly determined by emissions of nitrogen oxides[9], mainly from combustion processes. Road transport and the electricity supply industry are the main sources in the UK as a whole. Within Air Quality Management Areas (i.e. where nitrogen dioxide objectives are not being achieved), road transport is the main contributor.

2.17 Within the City of Bristol, previous work has shown that the population-weighted total nitrogen dioxide concentration in 2013 was 20.06 µg/m^3. All of this can be treated as anthropogenic. Of this, around 74% of emissions are from local sources, which can be considered to be potentially locally controllable. Over half (59%) of this locally-controllable nitrogen dioxide is associated with local road transport. For comparison with population-weighted figures above, the annual average nitrogen dioxide at St Pauls urban background monitoring site in 2018 was 23.8 µg/m^3.

Health Effects

2.18 Particulate matter is the most important air pollutant in terms of human health effects. PM_{10} is thought to be able to penetrate into the upper airways, while $PM_{2.5}$ can penetrate deeper into the lungs. Both contain much smaller particles which, although they have very little mass, are far more numerous and can penetrate all areas of the lungs and even pass directly into the bloodstream or the brain. The impact of air pollution on health varies, depending on the pollutants present, the time of exposure and the existing health of the individual exposed.

2.19 Some of the effects occur over a short period, from minutes to days – these are known as *acute effects* – whereas others result from long-term exposure, known as *chronic effects*. For some effects, air pollution is thought to have a *causal effect*, that is air pollution causes a condition that was not there before; for other effects, air pollution can *exacerbate* an existing condition, such as triggering an asthma attack.

2.20 PM is considered one of the key pollutants affecting public health and both long-term and short-term exposure is associated with adverse health effects. There is strong evidence that exposure to $PM_{2.5}$ results in increased hospital admissions and premature mortality due to cardiovascular and pulmonary diseases. These include ischaemic heart disease, stroke, chronic obstructive pulmonary disease, bronchitis and pneumonia in

9 The term nitrogen oxides (NOx) covers both nitrogen dioxide (NO_2) and nitric oxide (NO). Once emitted there are chemical reactions that transform some of the nitric oxide to nitrogen dioxide. The proportion of NO_2 within NOx is thus variable, tending to increase with distance from the emission source.

children and chronic bronchitis in adults, and lung cancer. Exposure to $PM_{2.5}$ may aggravate existing health conditions such as asthma.

2.21 In terms of non-cardio-pulmonary conditions, associations have been found between exposure to $PM_{2.5}$ and diabetes. Studies have also demonstrated that exposure to $PM_{2.5}$ is associated with pre-term birth and low birth weight and in children it leads to decreased development of lungs and lung function.

2.22 Particulate pollution has health effects even at very low concentrations – indeed no threshold has been identified below which no damage to health is observed. For this reason, $PM_{2.5}$ standards (the exposure-reduction approach) have been set to reduce population exposure in addition to air quality objectives which are aimed at hotspots.

2.23 Nitrogen dioxide is associated with adverse effects on human health. Increases in daily mortality and hospital admissions for cardiovascular diseases and hospital admissions due to asthma have been associated with short-term exposure to nitrogen dioxide. Associations have been found between long-term exposure to nitrogen dioxide and all-cause, cardiovascular, respiratory mortality, lung cancer and pneumonia. However, some debate remains as to the strength of the causal associations[10]. Decrease in lung function in both children and adults and respiratory infections in early childhood due to long-term exposure to nitrogen dioxide have also been reported.

[10] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/734799/COMEAP_NO2_Report.pdf

3. Approach

3.1 Estimates of emissions resulting from the use of Non-Road Mobile Machinery (NRMM) in the construction sector have been calculated for Bristol. Initially a 'top down' approach is applied, in order to provide an overall estimate of emissions in Bristol, which is consistent with nationally accepted methodologies and emissions estimates.

3.2 In order to calculate accurate and precise local emissions from this source, it is necessary to acquire local data on the use of NRMM, such as the types and age of equipment used, in what quantities, and for how long it is being used. Because of the transient nature of construction sites and the wide variety of NRMM, this is a difficult source to quantify and understand at local level. Equipment may come under the ownership of different operators or hire companies where data confidentiality is an issue. In addition, existing local databases e.g. for planning, rarely contain data on specific NRMM use. It is, therefore, necessary to adapt surrogate datasets and methodologies to understand local emissions. Such an approach has been developed for this project. This methodology has been developed to provide an initial bottom-up estimate for Bristol that could be enhanced in the future, should Bristol collect local datasets related to NRMM. This 'bottom up' approach can also be used as a basis for quantifying specific policy measures on a proportional basis. The two approaches are summarised as follows:

- **Top-down**: emissions are based on the scaling of published UK emissions data to the Bristol level. In this case, the uncertainty of the UK level data will be further increased by the appropriateness of the scaling factors used.
- **Bottom-up**: emissions are calculated using local information on development sites, combined with a profile of NRMM activity for different construction-related activities and associated emission factors. The quality and certainty of the result is inherently linked to the availability of local data on sites using NRMM and the scale of activity.

Top down approach

3.3 UK level emission estimates are available through the National Atmospheric Emission Inventory (NAEI)[11] which calculates emissions for the whole of the UK. This is a nationally verified dataset compiled by environmental experts and is updated every year. This includes estimates at the national scale of emissions from NRMM.

3.4 However, the UK inventory database does not publish data on NRMM at a level that allows the disaggregation of construction-specific activity data and emissions. As such,

[11] https://naei.beis.gov.uk/data/data-selector?q=130402

detailed data were requested and provided by the UK inventory team[12]. These data provide a breakdown of emissions at UK level, by pollutant, for NRMM for the 'construction' category.

3.5 To translate these national emissions data to Bristol, regional gross value added (GVA) (balanced) by industry data[13] was selected as the most appropriate proxy. This provides GVA data specific to the construction sector for Bristol. A scaling factor was derived by comparing this value to the sum of all UK regions.

3.6 Overall, this top down methodology is considered robust due to the use of published UK and sub-national level statistics. This provides a reliable emissions total for comparison and verification against the totals obtained by the bottom up approach.

3.7 The primary limitation of the top down approach is that it will not afford more detailed analysis to inform local policy in this area, for example by exploring the local level profile and deployment of machinery types across Bristol.

Data Sources for Top Down Approach

3.8 Within the NAEI, machinery (or engine-specific) fuel consumption and Emission Factors (g/kWh) are mostly taken from the EMEP/EEA Guidebook (2009) for older models. For modern machinery, Emission Factors are based on engine- or machinery-specific emission limits established in the EU NRMM Directives by assuming the maximum permitted for a given unit at the year of manufacture (Defra, 2020).

3.9 Activity data within the NAEI are derived from a survey of population and hours of use of equipment, undertaken by NETCEN in 2004. Various proxy statistics are used as activity drivers for different groups of machinery types to estimate fuel consumption and the turnover in the off-road engine fleet. A simple fleet turnover model, i.e. the rate at which new vehicles enter the fleet and older ones are retired, is used to estimate the proportion of different legislative classes of NRMM in the fleet. The Department for Business, Energy and Industry Strategy (BEIS) energy projections are also used to estimate activity rates of machinery from 2005 onwards, based on ONS construction statistics[14] for a number of different machinery types such as cranes, generators and rollers. After calculation of fuel consumption using a bottom-up method, figures for diesel engine machinery are allocated between gas oil and road diesel based on the results of

[12] Ricardo Energy & Environment by email (5/5/2020)

[13] https://www.ons.gov.uk/economy/grossvalueaddedgva/datasets/regionalgrossvalueaddedbalancedlocalauthoritiesbynuts1region

[14] https://www.ons.gov.uk/businessindustryandtrade/constructionindustry/datasets/outputintheconstructionindustry

a survey undertaken in 2011, with further checks against the Digest of UK Energy Statistics (DUKES) annual demand totals (Defra, 2020).

3.10 This variety of data sources being used for NAEI predictions as outlined above, including a number of sources which are now relatively old, illustrates the potential uncertainties in national data. This is further discussed in section 8.

Bottom-up approach

3.11 A bottom-up approach can provide emissions data specific to Bristol, which could be used to inform local policy in the future.

3.12 The standard approach to estimate emissions is by multiplying activity data by an emission factor associated with the activity under consideration.

Equation 1: Emission factor approach for calculating air pollutant emissions.

Air pollutant emissions = activity data * emission factor

Activity - This is a measure of the activity which is taking place, in this case the energy consumed by different NRMM classifications. Associated datasets are required to derive estimates of energy usage such as NRMM type, fuel, power output, operating hours and engine efficiency.

Emission Factor - This is the emissions per unit of activity, which usually comes from the scientific literature. It is typically derived from measurement studies.

3.13 Activity data is a quantitative measure of a level of activity that results in emissions taking place during a given period of time. An emission factor is a measure of the mass of emissions relative to a unit of activity. Therefore to estimate (for example) $PM_{2.5}$ emissions, data on energy use (kWh) for different NRMM classifications are multiplied by the applicable emission factor ($gPM_{2.5}$/kWh) taking into account the specified engine power (in kW), fuel type and engine technology level.

3.14 An Excel file has been developed to quantify the emissions in Bristol associated with NRMM activity. Calculations are undertaken in a transparent way and data sources are referenced in the calculations and within a ‘QA Sheet’ tab in the workbook.

Data Sources for Bottom Up Approach

3.15 Efforts were made to acquire local data on the NRMM fleet in Bristol, for example by contacting NRMM hire companies (outlined in paragraph 5.2); however no response was received. Because of the lack of primary data relating to NRMM in Bristol, calculations were based on proxy information available from London, matched to a list of major developments in Bristol[15].

3.16 The data from London provides a list of NRMM deployed between June 2015 to February 2020[16] and the London Development Database (LDD)[17] which provides a record of planning permissions from London's planning authorities; records spanning from 1985 to January 2020 were used[18]. These two datasets were linked using R code. The link was based on common fields, postcode and deployment/development dates, to determine the specific NRMM that was deployed on particular development sites in London. The resulting list was used to determine the average NRMM profile (number of different machineries by engine power and technology level) for different classifications of development.

3.17 From this analysis, average operation hours and subsequent average energy usage (as kWh) for each NRMM type, within a site classification were calculated. This provides the core activity data required for the production of bottom-up NRMM emission calculations. These NRMM usage profiles were then applied to the list of major developments in Bristol[19]. These were classed as developments over 10 properties, or 0.5 hectares for residential developments or over 1 hectare for other developments.

3.18 Emission factors have been taken from the 2019 European Monitoring and Evaluation Programme/European Environment Agency (EMEP/EEA) air pollutant emission inventory guidebook, using chapter 1.A.4 for Non road mobile machinery[20]. NRMM emission factors have been sourced at Tier 3 level[21], which profile pollutant emissions based upon the engine technology (EURO standard), power output and fuel type. The only data which was missing from the London machinery data was fuel type, and therefore it was considered there was enough detail to complete calculations at a high level of detail, to provide a robust methodology that can be enhanced with local data for Bristol at a future stage. All fuel has been assumed to be diesel; this is likely to be

[15] Contained within email from Peter Westbury to Steve Crawshaw 26th February 2020

[16] Contained within email from Stephen Inch to Tim Williamson 18 February 2020

[17] https://www.london.gov.uk/what-we-do/planning/london-plan/london-development-database

[18] https://data.london.gov.uk/dataset/planning-permissions-on-the-london-development-database--ldd-

[19] List of major decisions and start dates on site from Jan 2010 forwarded by email from Andrew Edwards to Clare Beattie on 10th February 2020 (original email from Allison House).

[20] https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-4-non-road-1/view

[21] Emission factors are presented from Tier 1 (simplest level) to Tier 3 (most complex). In this case, Tier 3 emission factors account for the engine technology and power output as well as the fuel being burnt.

representative for the majority of NRMM, whilst also providing a more conservative approach.

3.19 In general, a bottom-up approach has the potential to deliver more accurate results than a top-down approach because it draws on data that is specific to the local situation. However, collecting the required datasets for a bottom-up approach is usually more resource demanding.

4. Emissions Estimates

Baseline scenario

Top Down Approach

4.1 Table 1 presents the estimated emissions of NO_x, PM_{10} and $PM_{2.5}$ allocated to construction NRMM using national data scaled to Bristol[22]. It is worth noting that the PM_{10} and $PM_{2.5}$ results are equivalent; this is a product of the published emission factor values, which assume that particulate emissions from combustion engines are entirely in the smaller size fraction.

Table 1: Emissions Estimates for Bristol in 2018 using NAEI Emissions Data for Construction NRMM

Pollutant	Estimated tonnes in Bristol 2018 NAEI (top down)
NOx (as NO_2)	197.2
PM_{10}	22.1
$PM_{2.5}$	22.1

Bottom Up Approach

4.2 Table 2 presents the estimated emissions of NO_x, PM_{10} and $PM_{2.5}$ of construction NRMM using London data sets applied to Bristol using local data on the number of construction sites.

[22] The top down figures can be put into context. NAEI 2017 figures show total emissions of PM_{10} in Bristol are 640 tonnes for PM_{10}, 413 tonnes for $PM_{2.5}$ and 3070 tonnes for NOx. ie NRMM emissions are approximately 3% of total PM_{10}, 5% of $PM_{2.5}$ and 6% of NOx. However, it should also be recognised that close to large scale construction sites, NRMM will be a more significant source locally than the Bristol-wide calculations suggest.

Table 2: Emissions Estimates for Bristol in 2018 using the bottom up approach for Construction NRMM

Pollutant	Estimated tonnes in Bristol 2018 (bottom up)
NOx (as NO_2)	3.93
PM_{10}	0.11
$PM_{2.5}$	0.11

4.3 The results indicate a wide discrepancy between the bottom up and top down approach. This is expected and is a product of the data gaps and weaknesses in the bottom up approach. One of the main barriers is an inability to accurately classify development sites in Bristol into "large" and "small". For this analysis, this classification has been made based on "site area", which is also a field in the London Development Database (and hence can be cross referenced). Table 2 highlights that the majority of developments in Bristol are classified as "small" on this basis. Other potential classifiers that may provide more useful for multi-floor developments, such as total floor area, is not complete within the London data, or within Bristol's planning database. Sites which have a small site area, but should be classified as large in relation to construction activity include city centre student housing developments which are often multi floor developments, but have a relatively small site area.

4.4 In addition, Bristol only records information on construction activity above certain thresholds. For residential developments, sites over 0.5 Ha are recorded, with other site uses included where the site area is over 1 Ha. As such, a large proportion of smaller construction sites will be missing from the analysis. From analysis of the London Development database, we know that a large proportion of the development sites (98%) were for sites below 0.5 Ha. The underestimate is unlikely to be proportional to this due to the increased usage of NRMM on larger sites, however it is still likely to be the main cause of underestimation in the bottom-up approach.

Table 3: Construction Site Classifications in Bristol, 2018

Data Source	Unit
Large scale Major Dwellings	0
Large scale Major Other	6
Small scale Major Dwellings	57

Data Source	Unit
Small scale Major Other	38

4.5 In order to more accurately apply the London NRMM fleet weightings to Bristol, it would be necessary to have much improved and complete data on the number of developments in Bristol, the duration of construction activities, along with matching data on size classification of those sites.

4.6 Under both the bottom up and top down approaches, the results highlight NO_x as being the primary pollutant of concern from construction NRMM activities. Exhaust emissions of particulate matter is relatively low, although it should be noted that construction activities will also give rise to other forms of airborne (e.g. fugitive) dust emissions. The fugitive emissions are likely to be in the larger size fraction, with less health impact than $PM_{2.5}$.

4.7 The top down approach provides a more valid and realistic estimate of the construction NRMM emissions in Bristol. However, the bottom up approach does allow for the further exploration of data and to assess the impact of policy interventions (see Section 7).

4.8 Little value was seen in artificially adjusting the bottom-up approach upwards to account for the missing data on small development sites in Bristol, or to make further adjustments based upon assumptions of currently inaccurate site classifications. The results highlight that improvement is needed in the collation of localised NRMM data in order to develop emissions results in Bristol that are more accurate than those developed on a top-down basis. Such results would allow for a more local analysis of emissions trends and geographies, which would feed into more targeted policy development and tracking mechanisms.

5. Stakeholder Engagement

5.1 The project team have liaised with both government (Defra) and local government (in particular the Greater London Authority and Brighton and Hove City Council). The consultation with GLA was centred around NRMM; In particular, detailed discussions were held relating to the implementation of the NRMM Register and emissions limits across London including resourcing requirements, practicalities of enforcement and the implementation of the web-based database (for completion by developers).

5.2 As the majority of construction plant are hired rather than owned by construction companies, plant hire companies are a key source of information on the type and age of NRMM used in Bristol. However, within the resources of this project, it has not been possible to run a dedicated and intensive engagement programme with these companies. Consultation was undertaken by Bristol City Council which contacted all plant hire companies operating in the Bristol area; however, no responses were received. It is recommended that if controls similar to those operating in London are considered for Bristol, further engagement work is undertaken with the plant hire community.

5.3 In addition, a meeting was held on 24th February 2020 involving officers from Bristol City Council. The aim of the meeting was to both investigate ways of refining data available at national level to the Bristol level, and to discuss policy options in relation to feasibility of implementation in Bristol.

5.4 The following officers were present:

- Steve Crawshaw — Sustainable City and Climate Change Service
- Chris Swinscoe — Regulatory Services
- Peter Westbury — Planning (Major Planning Applications)
- Jonathan Martin — Licensing
- Dylan Davies — Pollution Control Team Leader
- Emma Tournier — Public Protection (Contaminated Land)
- Georgie MacArthur — Public Health Registrar

5.5 In addition, a telephone conversation was held with Jessica MacDonald (Policy and Public Affairs Officer) following the meeting.

5.6 In relation to NRMM, the following points were made:

- There were suggestions for helpful contractors for discussions around NRMM fleet (Wrings Demolition and TR Demolition);

- Setting up an NRMM register in Bristol was discussed – there were some concerns about the legality of using planning conditions for enforcement of registration. Registers could be used for information gathering, and/ or for setting emissions limits;
- The council own a number of smaller development sites across the city which are allocated for housing. The idea that these could be used as exemplars (e.g. setting higher standards for NRMM) was discussed. These standards would need to be written into contracts; and
- Enforcement of planning conditions was discussed in relation to NRMM but also more generally. There are very few staff working in planning enforcement and this is an ongoing issue in all areas.

6. Recommended Policy Options

6.1 Although the evidence presented in this report shows that NRMM emissions do not represent a large proportion of total emissions[23], the calculations have a number of uncertainties, and are not based on Bristol specific data. It is therefore recommended that the data underpinning this analysis be refined. This will allow Bristol City Council to make a more robust decision on whether to prioritise this sector or not. Emissions from NRMM could be controlled locally through the planning system, as set out below.

6.2 Policy options were discussed with officers at Bristol City Council during a meeting on 24th February 2020, and through subsequent telephone discussions. The viability of implementing minimum standards (with regard to emission limits) for NRMM was discussed, as well as the provision of a register for NRMM (which would either go alongside minimum standards, or be implemented in order to refine local data for future work). Both of these actions have resource requirements. Minimum standards for NRMM could be implemented city wide, or within the Clean Air Zone. There may also be ways to incentivise hybrids, and opportunities for the Council to lead by example (although the Council-owned NRMM fleet appears to be small). Controls on NRMM could be prioritised with major infrastructure projects.

Legislation and practice

6.3 There is currently no legislation specifically addressing emissions from NRMM, other than:

- EU and UK legislation covering the quality (content) of fuel, including the maximum allowable sulphur content (higher sulphur content will generate higher particulate emissions), and
- Regulations covering the emission standards for new engines (emission stages, as discussed above.

6.4 NRMM is not covered by the Clean Air Act 1993, section 2 (prohibition of dark smoke from industrial or trade premises), or by any other environmental legislation, such as the Environment Act 1995. While the provisions of Section 79 of the Environmental Protection Act 1995 (statutory nuisance) could be said to apply, enforcement would be on a case by case basis and thus not a useful policy for reducing emissions from NRMM on a general basis.

[23] The top down emissions estimates (2018) compared to NAEI (2017) figures show emissions from NRMM are approximately 3% of total PM_{10}, 5% of $PM_{2.5}$ and 6% of NOx

6.5 This lack of legislative control, and a greater emphasis on road vehicle emissions, has meant that there are few local authorities in the UK acting to reduce NRMM emissions. The key exception is London, where the Greater London Authority has actively promoted the use of the Borough's planning systems to accelerate the uptake of lower emission NRMM. This approach, which relied on the development of supplementary planning guidance (SPG) on The Control of Dust and Emissions During Construction and Demolition[24] is described in Appendix 0.

6.6 However, as the Boroughs are the local planning authorities, implementation of the NRMM Low Emission Zone takes a number of forms, all of which rely fundamentally on the use of planning conditions:

- A short condition referring back to the SPG for the standards and additionally requiring use of the register to log equipment;
- A long form condition which sets out the standards in detail and also requires use of the register; and
- A condition requiring compliance with the Borough's own adopted Code of Construction Practice (or similar), which in turn sets out the requirements of the scheme.

6.7 Codes of Construction Practice (CoCP) are used both by local authorities to cover development in their area, and in major infrastructure schemes, such as HS2[25]. They generally cover a far wider range of issues than just air pollution and can vary greatly in both length and complexity – Central Bedfordshire County's CoCP runs to just three pages[26] whereas the City of Westminster's is 149 pages plus supporting documents[27]. There are advantages and disadvantages to each of the implementation options, with the key ones summarised in Table 4 below.

[24] https://www.london.gov.uk/what-we-do/planning/implementing-london-plan/london-plan-guidance-and-spgs/control-dust-and

[25] https://www.gov.uk/government/publications/draft-code-of-construction-practice-for-hs2-phase-2a

[26] https://centralbedfordshire.app.box.com/s/hvcscumbiav7iimmkd721l0xerk0zn0k

[27] https://www.westminster.gov.uk/planning-building-and-environmental-regulations/code-construction-practice/code-construction-practice-documents

Table 4: Advantages and Disadvantages of different NRMM LEZ implementation options

Option	Advantages	Disadvantages
Standard planning conditions (stand-alone)	Flexible, can be tailored to fit the specific development. Easy to implement Minimises bureaucracy	More open to challenge as not clearly rooted in policy Less consistent messages for the construction industry Potential to be missed out of some approvals, creating inconsistencies
SPG, enforced through planning conditions	Clearly rooted in planning policy Consistent messaging for construction industry Can address wider issues than just air pollution (including nuisance dust and noise)	More complex and time consuming to develop SPGs more suited to addressing strategic issues rather than site operations
CoCP, enforced through planning conditions	Clearly rooted in local policy Consistent messaging for construction industry Can address wider issues than just air pollution (including nuisance dust and noise) More focussed on site operations Easier to use as part of contracted operations, such as road works	Potentially much more complex and time consuming to develop Wide range of issues covered can lead to partial or negotiated compliance, resulting in inconsistencies

6.8 Simply relying on stand-alone planning conditions is not recommended as it does not provide certainty for either Bristol City Council or the construction industry; it is the consistency of approach which has helped transform the construction hire market in London. The approach used in London combines an SPG (and strategic plan) at the GLA level and CoCP at Borough level (for those Boroughs that have them). This would not necessarily be required for Bristol as it is a single tier authority. Therefore, the choice lies between the complex, but more operationally focused CoCP, or the strategic, but more direct SPG; the most appropriate option is a political rather than a technical decision.

Potential Policy Options

6.9 This section proposes a series of potential policy options which could be considered individually or as a package.

6.10 An explicit information and awareness raising has not been included as one of the options. The choice of equipment used in construction, in the absence of other regulation, will be driven by cost and it is unlikely that a construction company would opt for higher cost, lower-emission plant, unless there was a commercial driver to do so. There are potential circumstances where adopting a low-emission approach could offer commercial advantage, e.g. through contractual obligations, but an information campaign on its own would be unlikely to generate such circumstances. However, information and awareness raising will need to be part of the implementation strategy for measures such as an NRMM Low Emission Zone or equipment register.

6.11 Shifting NRMM used in Bristol to higher emission control stages will have cost implications for equipment owners, requiring the purchase of more modern equipment earlier than might otherwise have been the case. As the majority of NRMM used in the construction sector is hired, these costs will fall initially on the plant hire companies who may then pass the increased costs on to developers, but such costs are likely to be very small on a relative basis. Over the medium to long term, the policy (if adopted) is unlikely to impact on the viability of development in Bristol, but in the short term, smaller plant hire companies would be required to make additional capital investments. This would need to be factored into the implementation process.

6.12 There is some anecdotal evidence from London that larger, national plant hire companies have relocated older plant away from London, which provides an additional driver for Bristol to set minimum emission standards for the city, to avoid becoming a “sink” for older equipment.

6.13 Seven potential policy options are proposed as follows, and detailed in the tables below:

- Option 1: Baseline activity data improvement campaign
- Option 2: Adoption of Supplementary Planning Guidance for the Control of dust and emissions from construction and demolition in Bristol;
- Option 3: Adoption of Code of Construction Practice, including minimum emission standards for equipment used in construction;
- Option 4: Set up a register for construction NRMM in Bristol;
- Option 5: Set up minimum emissions standards for equipment used by Council contractors;
- Option 6: investigate incentives for the uptake and use of low carbon NRMM (hybrid and full electric) for construction projects in Bristol; and
- Option 7: Lobby Government for powers to directly control NRMM emissions.

Option 1: Baseline activity data improvement campaign

Description

6.14 The generation of accurate, local activity data for the NRMM sector, particularly the construction sector, is very challenging. Equipment is highly variable (there are around 40 equipment types recorded in the London register), potentially only present on site for short periods of time, and hire companies are reluctant to share information on their fleet.

Implementation

6.15 Improving local data is certainly possible but is likely to require an intensive, dedicated effort, based on site visits and careful engagement with plant hire companies.

Advantages

6.16 This is likely to result in a more detailed and accurate assessment of NRMM emissions in Bristol, which will further facilitate policy development. This could also provide other local authorities considering action on NRMM with both data and a model approach which they could replicate, both of which would enhance Bristol's national reputation.

Disadvantages

6.17 A detailed information gathering campaign will not, in itself, result in reductions in NRMM emissions. It is also likely to be highly resource intensive and would only provide a snapshot of NRMM use, with trends only being revealed through repeated activity.

Resource Implications

6.18 This is likely to require a high level of personnel time and the resource implications are relatively high. Repeat campaigns to establish trends will also require resource input.

Potential co-impacts

6.19 **Positive:** increased ability to quantify GHG emissions and characterise noise. Will allow more precisely targeted and cost-effective policies.

6.20 **Negative:** none

Potential impact on emissions:

6.21 None, directly. This is an enabling measure which will allow the development of better policies and tracking their impacts.

Option 2: Adoption of Supplementary Planning Guidance for the control of dust and emissions from construction and demolition in Bristol

Description

6.22 National planning guidance states that the local plan can be used for "*controlling dust and emissions from construction, operation and demolition*"[28] Supplementary Planning Guidance provides a transparent and consistent framework for dealing with issues such as this.

Implementation

6.23 Through the Local Plan and the use of standard planning conditions requiring compliance with the SPG. Exceptions could be made for smaller sites and equipment.

Advantages

6.24 Provides a clear driver for the reduction of emissions from the majority of NRMM used in the city. Using a single standard provides clarity and certainty for developers and would also be administratively easier to apply. It could set out any exemptions, such as for smaller sites or equipment, thus avoiding additional burden for smaller sites and developers.

Disadvantages

6.25 Published guidance limits the degree to which individual planning approvals can address the issue. Unless they are regularly reviewed and updated, SPGs will not take account of latest development and thus could, potentially, constrain progress on addressing air quality.

Resource implications

6.26 The London and IAQM guidance on the control of dust from demolition and construction[29] provide a good template from which to develop an SPG for Bristol. Once the SPG has been developed and adopted, the resource implications are minimal, although regular review and update will be required.

6.27 However, compliance with conditions within the SPG will require enforcement if it is to have the desired effect. In London, initial compliance with the NRMM LEZ was low – between 25 and 30%. However, the use of an enforcement team tasked with inspecting sites and checking compliance, has raised compliance levels to above 95%. Such inspections also raise the general compliance level through information and awareness

[28] https://www.gov.uk/guidance/air-quality--3, Paragraph: 008 Reference ID: 32-008-20191101

[29] http://iaqm.co.uk/text/guidance/construction-dust-2014.pdf

raising. Currently, eight compliance officers are employed to cover the whole of the GLA area; on a population basis, that equates to 0.5 full time equivalent (FTE) for a city the size of Bristol.

Potential co-impacts

6.28 **Positive:** modern (higher emission control stage) equipment is likely to be more fuel efficient and quieter, thus reducing GHG emissions and noise.

6.29 **Negative:** Potential impact on the short-term viability of smaller plant hire companies.

Potential impact on emissions

6.30 Medium to high, depending on the level of emission control required, although this will also depend on the level of compliance. The London NRMM LEZ is expected to accelerate the uptake of low emission NRMM as it moves to higher control stages (IV and V) in coming years.

Option 3: Adoption of a Code of Construction Practice, including minimum emission standards for equipment used in construction

Description

6.31 A code of construction practice (CoCP) sets out the standards and procedures to which a developer or contractor must adhere to manage the potential environmental impacts. It can cover a wide range of issues including permitted working hours, liaison with neighbours, noise and dust monitoring, cultural heritage, ecology, land and landscape protection, traffic and transport, and waste management, as well as air quality.

Implementation

6.32 Through standard planning conditions.

Advantages

6.33 Provides a clear driver for the reduction of emissions from the majority of NRMM used in the city. Using a single standard provides clarity and certainty for developers and would be administratively easier to apply. It can set out any exemptions, such as for smaller sites or equipment, thus avoiding additional burden for smaller sites and developers.

6.34 A CoCP can bring the control of all the environmental impacts of construction, such as noise, dust control and other nuisance issues, under one umbrella.

Disadvantages

6.35 Published guidance limits the degree to which individual planning approvals can address the issue. Unless they are regularly reviewed and updated, SPGs will not take account of latest development and thus could, potentially, constrain progress on addressing air quality.

6.36 CoCPs tend to be more complex and comprehensive than SPGs (although this is not always the case) so will require greater resource to develop.

Resource implications

6.37 There are examples of CoCPs that could be drawn upon, and the Planning Inspectorate provides a template CoCP which could be adapted[30]. Once the CoCP has been developed and adopted, the resource implications are minimal, although regular review and update will be required.

[30] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010001/EN010001-004258-120806_EN010001_%20Code%20of%20Construction%20Practice%20%28CoCP%29.pdf

6.38 However, compliance with the conditions in the CoCP requires enforcement if it is to have the desired effect. In London, initial compliance with the NRMM LEZ was found to be low, and between 25 and 30%. However, an enforcement team tasked with inspecting sites and checking compliance raised compliance to above 95%. Such inspections also raise the general compliance level, though information and awareness raising. Currently, eight compliance officers are employed to cover the whole of the GLA area; on a population basis, that equates to 0.5 FTE for a city the size of Bristol.

Potential co-impacts

6.39 **Positive:** more modern (higher emission control stage) equipment is likely to be more fuel efficient and quieter, thus reducing GHG emissions and noise. Could also be used to address other environmental issues.

6.40 **Negative:** Potential impact on the short-term viability of smaller plant hire companies.

Potential impact on emissions

6.41 Medium to high, depending on the level of emission control required, although this will also depend on the level of compliance. The London NRMM LEZ is expected to accelerate the uptake of low emission NRMM as it moves to higher control stages (IV and V) in coming years.

Option 4: Set up a register for construction NRMM in Bristol

Description

6.42 An online register for all construction NRMM used in Bristol, which records details such as site location, duration of deployment, type of equipment, engine size and emission control stage, owner, operator, etc. Such a register is used in London as an aid to enforcement of the NRMM LEZ, although it also provides a resource for helping to calculate emissions from NRMM.

Implementation

6.43 In Bristol, the use of the register could be required under a standard planning condition (as it is in London), or through the Considerate Contractor scheme, the uptake of which could also be incentivised through the planning process. The register could be voluntary, but compliance is likely to be low.

Advantages

6.44 Provides information on the NRMM “fleet” in Bristol both for enforcement of planning conditions (if applicable) and for tracking the effectiveness of policy interventions over time. This could be an alternative to the baseline activity data improvement campaign proposed above, although it will take longer to develop useful information.

Disadvantages

6.45 Places an additional administrative burden (and thus cost) on developers and/or construction companies. Also adds additional complexity to the planning process and requires resource to set up and maintain a register.

Resource implications

6.46 Discussion with the GLA suggests that the resource burden for the London NRMM Register is approximately 0.2 FTE. Setting up the register requires more input, but only at the initial stages. Careful design of the register will help minimise the reporting burden for users.

Potential co-impacts

6.47 **Positive:** increased ability to quantify GHG emissions and characterise noise. Will allow more precisely targeted and cost-effective policies.

6.48 **Negative:** Resource implications for the Council could divert resources from other social programmes.

Potential impact on emissions

6.49 None, directly. This is part of the enforcement mechanism for other policies. It is an enabling measure which will allow the development of better policies and tracking their impacts.

Option 5: Set minimum emission standards for equipment used by Council contractors

Description

6.50 Bristol City Council has the opportunity to take a leadership role on the reduction of emissions from NRMM, through works that it procures and contracts.

Implementation

6.51 Through the procurement and contractual conditions which the Council uses, potentially applying to all construction and maintenance work in the city.

Advantages

6.52 Provides a direct means by which to influence the emission standards of NRMM used in Bristol, albeit at a smaller scale. Could be introduced relatively quickly, for example in advance of a more general approach (see option 3, above).

Disadvantages

6.53 Potentially adds cost to Council projects (although likely to be minor) and a further level of complexity to procurement and contracting processes. Likely to have a relatively small impact on NRMM emissions as a stand-alone measure. May restrict the range of contractors available to the Council depending on the level of emission control required and the availability of equipment.

Resource implications

6.54 Small impact on procurement and contracting resources, with a potential increase in costs for project. However, likely to be very small overall.

Potential co-impacts

6.55 **Positive:** Positive: more modern (higher emission control stage) equipment is likely to be more fuel efficient and quieter, thus reducing GHG emissions and noise. Visible leadership by the Council is likely to influence the behaviour of contractors in the City and of other authorities in the area, increasing the level of emission control.

6.56 **Negative:** Potential impact on costs for the Council which could divert resources from other social programmes.

Potential impact on emissions

6.57 Small, given the likely proportion of Council contracts against the total construction activity in Bristol. However, will act as an enabling measure for other, more general policies.

Option 6: Investigate incentives for the uptake and use of low carbon emission NRMM (hybrid and full electric) for construction projects in Bristol

Description

6.58 Hybrid and full electric construction equipment are now appearing, both for mobile units (excavators, dump trucks) and stationary generators. The use of such units offers the opportunity to reduce both air pollutant and GHG emissions.

Implementation

6.59 There is no obvious mechanism through which greater use within Bristol could be incentivised, other than a policy where hybrid/ electric NRMM has to be used where available; this may be possible in the future, however, the availability and the range of equipment is not currently sufficient to allow them to be mandated as a minimum standard.

Advantages

6.60 Addresses both air pollutant and GHG emissions, providing a co-benefit for climate change mitigation policies.

Disadvantages

6.61 No incentive schemes currently exist to provide a mechanism.

Resource implications

6.62 Likely to be minimal over the long term.

Potential co-impacts

6.63 **Positive:** potential significant impact on GHG emissions and likely some impact on noise (depending on plant type and design). Will require development of a skills pool for the service and maintenance of hybrid plant prompting inward investment.

6.64 **Negative:** Potential impact on costs for the Council which could divert resources from other social programmes.

Potential impact on emissions

6.65 Small to medium, depending on the scale of incentivisation and thus uptake. While the availability of hybrid/electric plant on the market is increasing, it does not currently extend to all equipment types.

Option 7: Lobby Government for powers to directly control NRMM emissions

Description

6.66 Legal frameworks exist for the creation of low emission zones for road vehicles in the UK, and for setting up road-based charging scheme based on emission standards. Developing a similar framework for the control of NRMM would allow local authorities to directly control NRMM use in their area. However, there are currently no legislative proposals for such a framework although the Mayor of London has been lobbying for such powers[31]

Implementation

6.67 Contributing to this lobbying effort, either directly or through existing groups (e.g. UK100), would provide a clear signal of intent by BCC as well as increasing the likelihood that such powers are granted.

Advantages

6.68 Direct powers would greatly facilitate the control of NRMM emissions in Bristol, acknowledging that the use of planning conditions is not ideal. A clear lobbying strategy would provide a demonstrable policy direction and could also help in the development of networks and relationships with other cities with the same objectives.

Disadvantages

6.69 None

Resource implications

6.70 This would require staff time, both in terms of the development of BCC's position and liaising with other organisations and individuals. This will vary depending on what phase the campaign in is but is not likely to exceed 0.5 FTE.

Potential co-impacts

6.71 **Positive:** increased profile for the City and a progressive agenda, prompting inward investment. Development of relationships with other, like minded authorities, enabling further exchange of information and more informed policy development.

6.72 **Negative:** Resource implications for the Council could divert resources from other social programmes.

[31] There is currently a Private Members Bill before Parliament which would allow for the control of non-road air pollutant emission sources in London: https://services.parliament.uk/bills/2019-21/emissionsreductionlocalauthoritiesinlondon.html However, this is unlikely to become law.

Potential impact on emissions

6.73 None, directly. This is an enabling measure which will allow the creation of more effective mechanisms for controlling NRMM emissions.

Policy Recommendations

6.74 The policy options are presented as three packages, which could be considered as a stepwise approach, scaling up as the extent, severity and priority of the issue increases.

Package 1: This includes Options 1 and 7, the improvement of baseline activity data and lobbying Government for more direct powers to control NRMM emissions. These are largely "no regrets[32]" measures, and Option 1 is necessary both to calculate more accurately the local contribution of NRMM to air quality in Bristol and to test the likely impact of further policies.

Package 2: this includes Options 5 and 6, which is the inclusion of minimum emission standards in Council contracts and developing ways to incentivise the uptake and use of hybrid and full electric plant. The co-benefits from both measures, i.e. the potential to reduce noise and CO_2 emissions, make these options attractive in addition to the impact on air pollution emissions.

Package 3: This includes Options 2 or 3[33], and 4, the development of an SPG setting out controls on NRMM emissions within the planning system and/or the development of a Code of Construction Practice, alongside planning conditions to implement those standards. The NRMM register (option 4) is required to facilitate enforcement of the system. This will require increased resource and, with the Code of Construction Practice including a wider scope.

6.75 All three packages have resource requirements, although package 3 will have the greatest resource requirement over the longer term. Gathering better activity data and lobbying may both require high levels of resource, but these will be for shorter periods.

6.76 Dependent on the level of ambition the Council wishes to adopt, it is recommended that consideration be given to all three packages, with packages 1 and 2 being adopted first

[32] i.e. measures which are generally positive and whose benefits are not contingent on the nature or size of the issue being addressed.

[33] Options 2 and 3 are not mutually exclusive although only one is likely to be required for a single tier authority.

7. Impacts Assessment

7.1 A major advantage of developing a bottom up dataset of NRMM activity (and emissions) at a local level is that it provides detail on the local fleet. It is then possible to further analyse the data to assess the impact of common NRMM policy interventions. In terms of emissions of NOx and PM, the most common interventions prohibit older engine standards from operating in central zones e.g. as NRMM low emission zones (LEZs). For particulate matter, the major reduction of emissions from NRMM engines was seen between Euro Stage IIIA and IIIB; for NOx, the major improvement came between Stages III and IV.

7.2 Despite the baseline results of the bottom up approach being underestimated in terms of total emissions, it has been possible to consider the impact of policy scenarios that prohibit the use of NRMM older than Stage IIIB (policy scenario 1) and Stage IV (policy scenario 2) on a percentage savings basis. In these scenarios, all activity associated with older stage engine standards has been shifted to the earliest stage allowed under the scenario. For example, under scenario 1, any activity data (kWh) allocated to engines within a power classification pre-stage IIIB would be reallocated to the equivalent stage IIIB engine. The results of the scenario analysis are provided in Table 5.

Table 5: Emissions reductions achieved by policy scenarios, applied to 2018 data

Pollutant	% reduction policy scenario 1 (Stage IIIB)	% reduction policy scenario 2 (Stage IV)
NOx (as NO_2)	36	83
PM_{10}	70	70
$PM_{2.5}$	70	70

7.3 Significant emissions savings could be achieved by adopting minimum engine standards for construction sites. Prohibiting engines that are pre-stage IIIB is estimated to reduce PM_{10} and $PM_{2.5}$ emissions by a maximum of 70%. No further emissions reductions are achieved for PM with a move to Stage IV.

7.4 For NO_x, the major impact comes with the prohibition of pre-stage IV engines, which would achieve a maximum 83% reduction. A smaller 36% reduction is achieved by prohibiting pre-stage IIIB engines.

7.5 These estimates are indicative only. In reality, full compliance with higher standards is unlikely, in part due to the need for exempt machinery types. These types of machinery may be fewer in number, have a lower natural turnover. or perform a specific construction activity that is not easily replaced or available by new / modern equipment.

8. Quality Control and Uncertainty

8.1 Two alternative methodologies for estimating emissions from NRMM have been used: top down and bottom up. Each approach will have inherent, and slightly different, uncertainties. There are many components that will contribute to the uncertainty of emissions estimates, and these uncertainties may increase by applying a particular dataset at a different spatial scale.

8.2 Although there are significant uncertainties in the emissions estimates, they represent current best practice. Suggestions are provided below to reduce these uncertainties.

8.3 The uncertainties are in five main areas:

- National activity data;
- Local activity data;
- Scaling national or regional datasets to Bristol;
- Emission factors; and
- Projections.

National Activity Data

8.4 The top down approach uses NAEI emissions scaled to Bristol using a database of construction activity. Uncertainty relating to the emission factors will be common to both the top down and bottom up approaches (see below) but the activity data used for the NAEI will have uncertainties, which are then increased by scaling.

8.5 The table below shows the key uncertainties relating to national activity data, within the context of this project:

Table 6: Key uncertainties relating to national activity data

Description	Description
What type of machinery is operating on which construction sites	Activity data are derived from bottom up estimates of population and hours of use of equipment from a survey undertaken in 2004, which may not reflect current types of machinery used
Fleet make up of machinery (i.e. what proportion of each type of machine of which emission standard)	A fleet turnover model is used to estimate the proportion of different legislative classes of NRMM in the fleet, which will have uncertainties, both potentially increasing and decreasing emissions

Description	Description
Engine load	Emissions testing has shown that engine load will affect emissions, for example for generators in all cases the lowest emissions per unit of work done is between 25% and 50% of maximum load.
How long each of the machines are operational	Various proxy statistics are used as activity drivers for different groups of machinery types to estimate fuel consumption, which will have uncertainties associated with them.
Pattern of use	Recent work by Emissions Analytics[34] suggests that Selective Catalytic Reduction (SCR) systems perform poorly when an engine is left to idle for longer than ten minutes, whereupon the exhaust temperature falls.
What type of construction sites are operational	There is large uncertainty surrounding numbers and sizes of construction sites in Bristol. Data exist for planning approvals, but very little information is available regarding whether work has started or when/ if it is likely to start.
Real world emissions	Although work undertaken by Emissions Analytics has shown a significant variability in real world emissions between machines, absolute improvements are clear from construction equipment certified to the latest regulatory stage, resulting mostly from deployment of better engine management and after-treatment technology.

8.6 It is recognised that the data available to estimate NRMM activity and emissions is scarce in the UK, and that the source categories covers a wide range of machinery across many economic sectors. As a result, the current UK inventory estimates for NRMM are associated with high uncertainty. Work is currently being undertaken to obtain more up-to-date, detailed activity data for NRMM population and usage through consultation with various bodies in the construction and industrial machinery sector (Defra, 2020).

Local Activity Data

8.7 Local activity data face the same issues as for national activity data and are not repeated here.

8.8 The data used in the bottom-up calculations were based on development data from London, which may not be representative of Bristol, especially as London has an NRMM

[34] https://www.emissionsanalytics.com/news/2020/3/10/construction-the-neglected-source-of-urban-emissions

Low Emission Zone in place requiring particular engine standards (see Appendix 0). Bristol currently does not have any NRMM specific development guidelines in place.

8.9 There are also limitations associated with combining two separate datasets in the bottom-up methodology. It was not possible to create perfect matches between the London NRMM list and the LDD development sites due to missing data fields such as development completion date and multiple development sites sharing the same postcode.

8.10 Other aspects of the Bristol specific data also limited the information that was able to feed into the final calculations. NRMM calculations were not possible for small development sites as a list of minor developments in Bristol was not available; the data from London indicates that around 98% of registered development sites may fall into this category. There is also uncertainty surrounding the developments classification between “dwelling” and “other”, as internal guidelines on classification may not be fully represented in the final development lists. For example, it would be more useful to attribute site classifications based upon a quantifiable indicator such as % residential site area.

8.11 One additional area of uncertainty is the location of construction sites in Bristol and the duration of the works. This is clearly important for the mapping of emissions as a prelude to undertaking a more detailed assessment, both in terms of the impact of NRMM on air quality and the development of measures to reduce it.

8.12 Improving local activity data is within the purview of the Council and will reduce these uncertainties. Ideally, this would be done using a single regularly updated dataset of development sites and details of the NRMM deployed at each, including the following fields:

- Development site location (e.g. post code), size (floor area) and category;
- For each NRMM deployed at that site:
  - NRMM type
  - Engine technology level (EU emission stage)
  - Engine power (kw)
  - Fuel type (diesel, gasoline two-stroke, gasoline four-stroke)
  - Total number of hours of use (at that particular site)

8.13 In order to reduce uncertainty in emissions estimates, and be able to use the bottom up approach, the priority data requirement is the number, size and type of development sites in Bristol, followed by the type, engine technology and power of NRMM on sites in Bristol.

Scaling National or Regional Datasets to Bristol

8.14 Using datasets for one geographical area and scaling them to fit another is relatively standard practice in the development of emissions inventories. However, uncertainties in the original dataset are amplified by scaling and an assumption is introduced whereby the average conditions applying to the original area are assumed to apply to the scaled area. For this study, two sets of scaled data were used, national data for the top down approach and data from London databases for the bottom-up approach, both scaled to the Bristol level. The main uncertainties associated with this are described in Table 7.

Table 7: Key uncertainties relating to scaled data

Description	Impact
Scaling NAEI data to the Bristol level	**Low.** It is considered that the Construction Statistics Annual Tables[35], as they are applied at local authority level and are specific to construction (rather than any other metric relating to economic activity more generally), are a good metric for scaling national emissions to Bristol.
Applying London activity data to Bristol	**Medium.** Assuming that London Activity data reflects Bristol includes the assumption that the NRMM fleet are the same (which may assume that the Bristol fleet are cleaner than it actually is), and also assumes that the general construction site types are similar in London and Bristol.

8.15 The net result of these uncertainties is that the bottom up approach is likely to produce a large underestimate compared to the NAEI data but that both are highly uncertain. The actions recommended to reduce uncertainty in local activity data will produce datasets which do not need to be scaled and will thus eliminate this source of uncertainty.

Emission Factors

8.16 All emission factors are an attempt to provide an average emission over time for the activity they are describing and thus will always be uncertain to an extent: an average implies that there are higher and lower figures in the emission profile and thus the emission factor may not represent any one unit. For example, an emission factor for a certain sized digger does not mean that any individual digger in that size range produces precisely that emission profile. Moreover, real world conditions will include variables which are not accounted for in simple emission factors, such as how well maintained the

35 https://www.ons.gov.uk/businessindustryandtrade/constructionindustry/datasets/constructionstatisticsannualtables

digger is, what type of diesel it is using, the profile of use and the load under which the engine is working.

8.17 Greater detail in the activity data allows for the use of more sophisticated emission factors, thereby reducing uncertainty. The actions recommended to reduce uncertainty in local activity data will greatly assist in providing the required level of detail, with a priority on data relating to the types of machinery used and the fleet being used in Bristol.

Projections

8.18 Predicting emissions in a future year will always be subject to greater uncertainty. There are uncertainties as the assumptions on which those predictions are based, and it is necessary to rely on a series of projections which relate to both activity and emissions factors.

9. Summary and Recommendations for Future Action

9.1 Data on NRMM has been used to provide an estimate of the emissions resulting from construction activities in Bristol. The limitations of using various, currently-available data sources are analysed with the aim to understand how data could be collected in the future in Bristol to provide more accurate calculations.

9.2 In this report, we apply a 'top down' approach, in order to provide an overall estimate of emissions in Bristol, which is consistent with nationally accepted methodologies and emissions estimates. In order to provide a basis for quantifying specific policy measures, as well as a future-proofed methodology to undertake localised emissions estimates, we also apply a bottom up approach using local data combined with data from London. The two alternative methodologies are summarised as follows.

- **Top-down**: emissions are based on the scaling of published UK emissions data to the Bristol level. In this case, the uncertainty of the UK level data will be further increased by the appropriateness of the scaling factors used.
- **Bottom-up**: emissions are calculated using local information on development sites, combined with a profile of NRMM activity for different construction related activities and associated emission factors. The quality and certainty of result is inherently linked to the availability of local data on NRMM-using sites and activity. . A bottom-up approach has the potential to deliver more accurate results than a top-down approach, but it generally requires more resources.

9.3 The evidence presented in this report shows that NRMM emissions do not represent a large proportion of total emissions[36], the calculations have a number of uncertainties attached to them, and are not based on Bristol specific data. Little value was seen in artificially adjusting the bottom-up approach upwards to account for the missing data on small development sites in Bristol, or to make further adjustments based upon assumptions of currently inaccurate site classifications. The results highlight that improvement is needed in the collation of localised NRMM data in order to develop emissions results in Bristol that are more accurate than those developed on a top-down basis. Such results would allow for a more local analysis of emissions trends and geographies, which would feed into more targeted policy development and tracking mechanisms.

[36] The top down emissions estimates (2018) compared to NAEI (2017) figures show emissions from NRMM are approximately 3% of total PM_{10}, 5% of $PM_{2.5}$ and 6% of NOx. However, it should also be recognised that close to large scale construction sites, NRMM will be a more significant source locally than the Bristol-wide calculations suggest.

9.4 It is therefore recommended that the data underpinning these estimates are improved, in order to assist Bristol City Council in a robust decision as to whether to prioritise this sector or not. Emissions from NRMM could be controlled locally through the planning system, as set out below.

9.5 In addition to proposals by central Government, Bristol City Council could undertake the following actions to reduce emissions from NRMM into the future.

- Option 1: Baseline activity data improvement campaign
- Option 2: Adoption of Supplementary Planning Guidance for the Control of dust and emissions from construction and demolition in Bristol;
- Option 3: Adoption of Code of Construction Practice, including minimum emission standards for equipment used in construction;
- Option 4: Set up a register for construction NRMM in Bristol;
- Option 5: Set up minimum emissions standards for equipment used by Council contractors;
- Option 6: investigate incentives for the uptake and use of low carbon NRMM (hybrid and full electric) for construction projects in Bristol; and
- Option 7: Lobby Government for powers to directly control NRMM emissions.

9.6 The policy options are presented as three packages, which could be considered as a stepwise approach, scaling up as the extent, severity and priority of the issue increases.

Package 1: This includes Options 1 and 7, the improvement of baseline activity data and lobbying Government for more direct powers to control NRMM emissions. These are largely “no regrets” measures, and Option 1 is necessary both to calculate more accurately the local contribution of NRMM to air quality in Bristol and to test the likely impact of further policies.

Package 2: this includes Options 5 and 6, which is the inclusion of minimum emission standards in Council contracts and developing ways to incentivise the uptake and use of hybrid and full electric plant. The co-benefits from both measures, i.e. the potential to reduce noise and CO_2 emissions, make these options attractive in addition to the impact on air pollution emissions.

Package 3: This includes Options 2 or 3[37], and 4, the development of an SPG setting out controls on NRMM emissions within the planning system and/or the development of a Code of Construction Practice, alongside planning conditions to implement those standards. The

[37] Options 2 and 3 are not mutually exclusive although only one is likely to be required for a single tier authority.

NRMM register (option 4) is required to facilitate enforcement of the system. This will require increased resource and, with the Code of Construction Practice including a wider scope.

9.7 All three packages have resource requirements, although package 3 will have the greatest requirement over the longer term. Gathering better activity data and lobbying may both require high levels of resource, but these will be for shorter periods.

9.8 Dependent on the level of ambition the Council wishes to adopt, it is recommended that consideration be given to all three packages, with packages 1 and 2 being adopted first.

9.9 It has been possible to consider the impact of policy scenarios that prohibit the use of NRMM older than Stage IIIB and Stage IV on a percentage savings basis. In these scenarios, all activity associated with older stage engine standards has been shifted to the earliest stage allowed under the scenario. For example, under scenario 1, any activity data (kWh) allocated to engines within a power classification pre-stage IIIB would be reallocated to the equivalent stage IIIB engine.

9.10 The results indicate that significant emissions savings can be achieved by adopting minimum engine standards for construction sites. Prohibiting engine standards that are pre-stage IIIB is estimated to reduce PM_{10} and $PM_{2.5}$ exhaust emissions by a maximum of 70%. No further emissions reductions are achieved for PM with a move to minimum Stage IV. For NO_x, the major impact comes with the prohibition of pre-stage IV engines, which would achieve a maximum 83% reduction. A smaller 36% reduction is achieved by prohibiting pre-stage IIIB engines.

9.11 Throughout the report, stakeholders have been consulted, both locally and nationally to both investigate ways of refining data available, and to discuss policy options in relation to feasibility of implementation. Uncertainties in all the data have been outlined and ways of improving underlying local data sets have been included. In order to reduce uncertainty in emissions estimates, and be able to use the bottom up approach, the priority data requirement is the number, size and type of development sites in Bristol, followed by the type, engine technology and power of NRMM on sites in Bristol.

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10. Glossary

AQC	Air Quality Consultants
AQMA	Air Quality Management Area
CAZ	Clean Air Zone
Defra	Department for Environment, Food and Rural Affairs
Exceedance	A period of time when the concentration of a pollutant is greater than the appropriate air quality objective. This applies to specified locations with relevant exposure
EU	European Union
IAQM	Institute of Air Quality Management
kW	Kilowatt
LAQM	Local Air Quality Management
LEZ	Low Emission Zone
$\mu g/m^3$	Microgrammes per cubic metre
NAEI	National Atmospheric Emissions Inventory
NO	Nitric oxide
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides (taken to be NO_2 + NO)
NPPF	National Planning Policy Framework
NRMM	Non-road Mobile Machinery
Objectives	A nationally defined set of health-based concentrations for nine pollutants, seven of which are incorporated in Regulations, setting out the extent to which the standards should be achieved by a defined date. There are also vegetation-based objectives for sulphur dioxide and nitrogen oxides
PM_{10}	Small airborne particles, more specifically particulate matter less than 10 micrometres in aerodynamic diameter
$PM_{2.5}$	Small airborne particles less than 2.5 micrometres in aerodynamic diameter
SCR	Selective Catalytic Reduction
SPG	Supplementary Planning Guidance
Standards	A nationally defined set of concentrations for nine pollutants below which health effects do not occur or are minimal

11. Appendices

A1 NRMM Emissions Standards

Table A1.1: Emission Standards for Non-road Diesel Engines

Cat	Net Power (kW)	g/kWh			
		HC	HC+NOx	NOx	PM
Stage I					
A	130 ≤ P ≤560	1.3	-	9.2	0.54
B	75 ≤ P ≤130	1.3	-	9.2	0.70
C	37 ≤ P ≤75	1.3	-	9.2	0.85
Stage II					
E	130 ≤ P ≤560	1.0	-	6.0	0.2
F	75 ≤ P ≤130	1.0	-	6.0	0.3
G	37 ≤ P ≤75	1.3	-	7.0	0.4
D	19 ≤ P ≤37	1.5	-	8.0	0.8
Stage IIIA					
H	130 ≤ P ≤560	-	4.0	-	0.2
I	75 ≤ P ≤130	-	4.0	-	0.2
J	37 ≤ P ≤75	-	4.7	-	0.2
K	19 ≤ P ≤37	-	7.5	-	0.2
Stage IIIB					
L	130 ≤ P ≤560	0.19	-	2.0	0.025
M	75 ≤ P ≤130	0.19	-	3.3	0.025
N	56 ≤ P ≤75	0.19	-	3.3	0.025
P	37 ≤ P ≤56	-	4.7	-	0.025
Stage IV					
Q	130 ≤ P ≤560	0.19	-	0.4	0.025
R	56 ≤ P ≤130	0.19	-	0.4	0.025
Stage V					
c-6	130 ≤ P ≤560	0.19	-	0.4	0.015
c-5	56 ≤ P ≤130	0.19	-	0.4	0.015
c-4	37 ≤ P ≤56	-	4.7	-	0.015
c-3	19 ≤ P ≤37	-	4.7	-	0.015

Note: Stage V also includes emissions standards for P > 560, 8 ≤ P ≤ 19 and P < 8; it also includes emissions standards for particle numbers.

A2 NRMM Emissions Control in Greater London

In London, strategic planning policy, such as the preparation of the London Plan, is the responsibility of the Mayor and Greater London Authority, whereas its implementation, such as the administration of planning applications, is the responsibility of the London Boroughs. Using the London Plan as the overall policy instrument, the GLA's approach has been:

1. The development of supplementary planning guidance (SPG) on The Control of Dust and Emissions During Construction and Demolition[38].

2. Establishing, in the SPG, minimum emission standards (stages) for construction equipment used in London referred to in the new draft London Plan as a Low Emission Zone (LEZ) for NRMM.

3. Setting up of a register for construction equipment in London, to allow the enforcement of the NRMM LEZ.

4. Setting minimum emission standards for NRMM used in major infrastructure projects, such as the Olympic Park, Crossrail, Thames Tideway and HS2, and in public sector contracts, such as the London Highways Alliance Contract (under development).

Under the NRMM LEZ from September 2015, NRMM of net power between 37kW and 560kW used in London has been required to meet the following standards. These apply to both variable and constant speed engines for both NOx and PM.

- NRMM used on the site of any major development within Greater London will be required to meet Stage IIIA of the Directive as a minimum; and
- NRMM used on any site within the Central Activity Zone or Canary Wharf will be required to meet Stage IIIB of the Directive as a minimum.

From September 2020 the following will apply:

- NRMM used on the site of any major development within Greater London will be required to meet Stage IIIB of the Directive as a minimum; and
- NRMM used on any site within the Central Activity Zone or Canary Wharf will be required to meet Stage IV of the Directive as a minimum.

These requirements may be met by either reorganisation of the NRMM fleet, replacing equipment (with new or second hand equipment which meets the policy), retrofit abatement

[38] https://www.london.gov.uk/what-we-do/planning/implementing-london-plan/london-plan-guidance-and-spgs/control-dust-and

technologies, or re-engining. Some equipment is exempt from these requirements, where, for example, NRMM plant is not widely available in the numbers required to meet the above standards and the options for retrofitting or re-engining are currently cost prohibitive. The list of exemptions is reviewed regularly. Smaller NRMM(19kW to 37kW) are not currently included within the policy, nor is equipment used in activity where planning permission is not required (permitted development, road works, emergency power generators, etc).

The London Boroughs are responsible for the application and enforcement of this policy through the planning process. In general this is done through the use of planning conditions in one of the following three ways:

- A short condition referring back to the SPG for the standards and additionally requiring use of the register to log equipment
- A long form condition which sets out the standards in detail and also requiring use of the register
- A condition requiring compliance with the Borough's own adopted Code of Construction Practice (or similar), which in turn sets out the requirements of the scheme.

Often developers do not know what equipment will be required during construction at planning application stage, therefore as part of the Construction Dust Management Plan developers are often required to provide a written statement of their commitment and ability to meet these standards. This statement is then used for the purposes of monitoring and enforcement.

Uptake of the register, which started in 2015, was initially low, but the deployment of a dedicated enforcement team (currently eight officers to cover the whole of London) has increased compliance from around 28% before enforcement inspections to 98% afterwards. The main aim of the register is to monitor compliance with the NRMM LEZ but it is also a very useful source of activity data to generate and validate emissions estimates for London.

A3 Professional Experience

Stephen Moorcroft, BSc (Hons) MSc DIC CEnv MIEnvSc MIAQM

Mr Moorcroft is a Director of Air Quality Consultants, and has worked for the company since 2004. He has more than 35 years' postgraduate experience in environmental sciences. Prior to joining Air Quality Consultants, he was the Managing Director of Casella Stanger, with responsibility for a business employing over 100 staff and a turnover of £12 million. He also acted as the Business Director for Air Quality services, with direct responsibility for a number of major Government projects. He has considerable project management experience associated with Environmental Assessments in relation to a variety of development projects, including power stations, incinerators, road developments and airports, with particular experience related to air quality assessment, monitoring and analysis. He has contributed to the development of air quality management in the UK, and has been closely involved with the LAQM process since its inception. He has given expert evidence to numerous public inquiries, and is frequently invited to present to conferences and seminars. He is a Member of the Institute of Air Quality Management.

Dr Clare Beattie, BSc (Hons) MSc PhD CSci MIEnvSc MIAQM

Dr Beattie is an Associate Director with AQC, with more than 20 years' relevant experience. She has been involved in air quality management and assessment, and policy formulation in both an academic and consultancy environment. She has prepared air quality review and assessment reports, strategies and action plans for local authorities and has developed guidance documents on air quality management on behalf of central government, local government and NGOs. She has led on the air quality inputs into Clean Air Zone feasibility studies and has provided support to local authorities on the integration of air quality considerations into Local Transport Plans and planning policy processes. Dr Beattie has appraised local authority air quality assessments on behalf of the UK governments, and provided support to the Review and Assessment helpdesk. She has carried out numerous assessments for new residential and commercial developments, including the negotiation of mitigation measures where relevant. She has also acted as an expert witness for both residential and commercial developments. She has carried out BREEAM assessments covering air quality for new developments. Dr Beattie has also managed contracts on behalf of Defra in relation to allocating funding for the implementation of air quality improvement measures. She is a Member of the Institute of Air Quality Management, Institute of Environmental Sciences and is a Chartered Scientist.

Tim Williamson, BSc (Hons) MSc MIEnvSci MIAQM

Mr Williamson has 25 years' experience in environmental policy support, development and analysis, mainly in air quality but also covering climate change and resource efficiency. He has broad experience of the field, having held positions in the public and private sectors, and for an environmental NGO, Environmental Protection UK. Tim has worked at the national level, leading multi-disciplinary evidence teams on air quality and, latterly, resource efficiency in Defra for 11 years. He has also worked both for and with local authorities, covering Local Air Quality Management and carbon reduction programmes. Tim has a strong track record in international work, having been involved in EU policy development and on projects supporting both the European Commission and European Environment Agency, and Governments in several parts of the world. He is a Member of the Institute of Air Quality Management and is a Chartered Scientist.

Richard Claxton (Senior Consultant, Aether)

Richard has considerable experience in national emission inventories, local air quality management and air quality assessments. He has gained first-hand experience of national emissions inventory compilation (UK, Barbados), as well as providing in-country support to the Irish and Icelandic environment agencies. Richard has planned and delivered a number of capacity building workshops for national representatives, including Turkey, Uzbekistan, Bosnia & Herzegovina and South Africa.

Richard is qualified as a reviewer of greenhouse gas inventories under the UNFCCC (waste sector and generalist) as well as for non-Annex I parties' Biennial Update Reports (BURs).

Richard has contributed to, and taken the technical lead on both international and local emissions inventory projects, as well as air quality assessments for proposed developments as part of the planning application process. Richard is also taking a lead role in developing innovative ways of presenting data relating to national emissions.