Manor Road / Richmond

Air Quality Assessment

Hoare Lea

February 2019

Homebase, Manor Road. Richmond, London.

Avanton Richmond Development Ltd.

AIR QUALITY

AIR QUALITY ASSESSMENT

REVISION 04 – 04 FEBRUARY 2019

Audit sheet.

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Contents.

Executive summary.

This report describes the potential air quality impacts associated with the construction and operation of a proposed residential development, located on Manor Road, Richmond. As the site is for residential uses, the annual mean objective for nitrogen dioxide (NO_2) and Particulate Matter 10 micrometres or less applies (PM_{10}).

The Proposed Development site is within an Air Quality Management Area (AQMA) declared for exceedances of the annual mean NO_2 objective and the PM_{10} objective.

A risk assessment of the potential impacts of the construction phase of the development has been undertaken to identify appropriate mitigation measures. Provided these are implemented, for example through a planning condition, the residual impacts are considered to be not significant.

The need to undertake a detailed assessment of road traffic emissions associated with both the construction and the operation of the Proposed Development have been scoped out. There is no residential car parking proposed as part of the development; due to this, the traffic generated by the development is below the criteria set in the Environmental Protection UK (EPUK) and Institute of Air Quality Management (IAQM) planning guidance and as such the impact of additional traffic on local air quality will be insignificant.

Exposure of users of the Proposed Development during the operation of the Proposed Development has been assessed, considering the pollutants NO_2, PM_{10} and $PM_{2.5}$. There is predicted to be no exceedance of any of the air quality objectives for these pollutants and therefore the impacts on the proposed development are not significant.

All heating and cooling of the Proposed Development is to be provided via an electrical solution. As such, there will be no need for assessment of the impact of emissions as there will be none on site from the energy plant.

The development is air quality neutral according to the Greater London Authority's (GLA) benchmarking assessment methodology.

The overall operational air quality impacts of the development are judged to be not significant.

1. Introduction.

1.1 Proposed Development.

Hoare Lea has been commissioned by Avanton Richmond Development Ltd to undertake an assessment of the potential air quality impacts arising from the construction and operation of a proposed residential development, located at Manor Road, Richmond (post code TW9 1YB) and is shown in Figure 1. Hereafter referred to as the 'Proposed Development'

The Proposed Development involves the demolition of existing buildings and structures and comprehensive residential-led redevelopment of four buildings of between four and nine storeys to provide 385 residential units (Class C3), flexible retail/community/office uses (Classes A1, A2, A3, D2, B1), provision of car and cycle parking, landscaping, public and private open spaces and all other necessary enabling works. There is also a bus terminal in the north of the site boundary with buses feeding on to Manor Road.

The site is on Manor Road and currently occupied by a Homebase branch and associated surface car park; it is bounded by railways lines to the south and west of the site; to the east is Manor Road, beyond which there is a Sainsburys and residential premises; to the north of the site are more residential and commercial premises.

The Proposed Development is shown in Figure 1 within the wider context of Richmond.

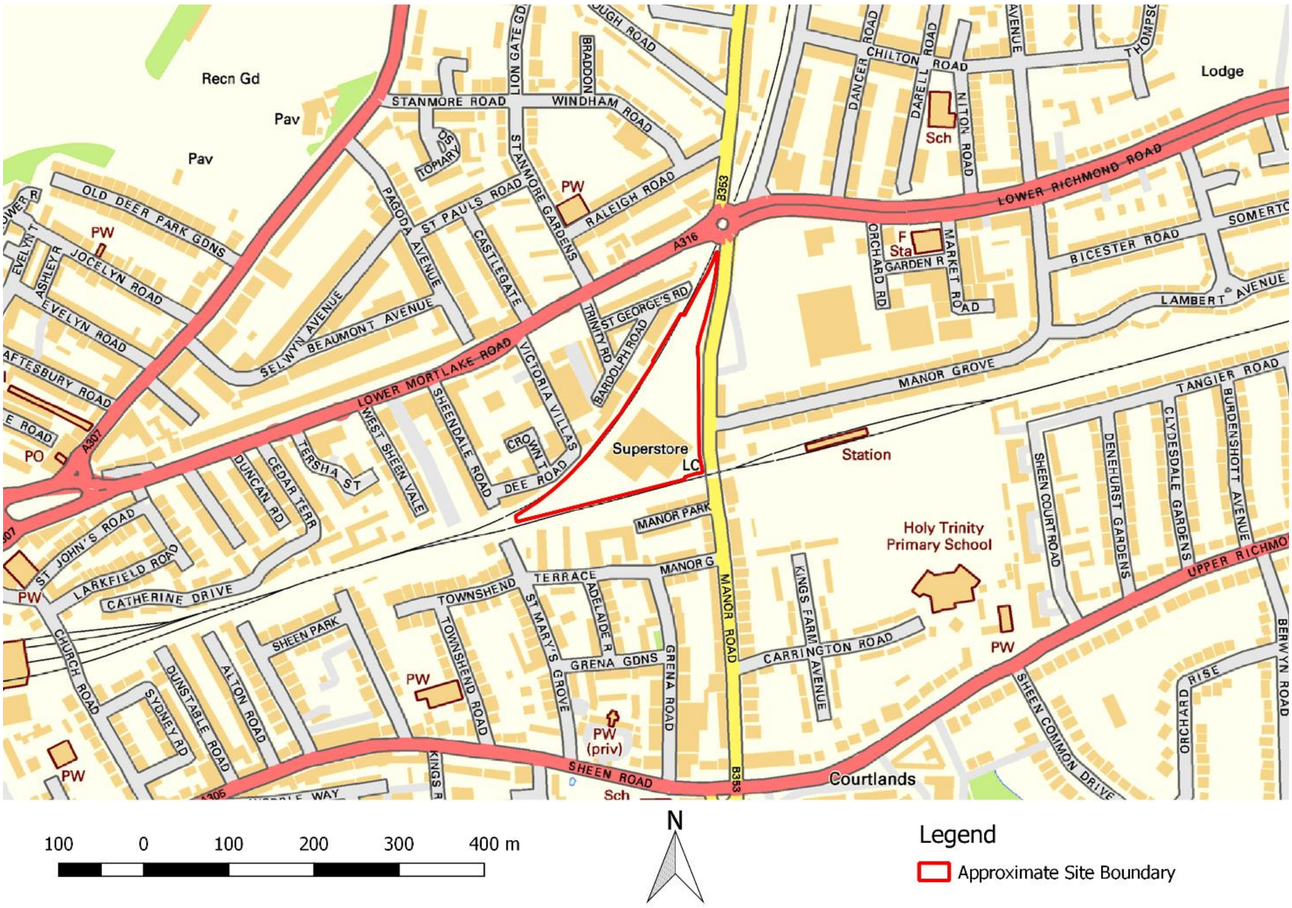

Figure 1 Location of the Proposed Development. Contains OS Data © Crown Copyright and Database rights 2018

The assessment describes the potential air quality impacts associated with the construction and operational phases of the Proposed Development

A glossary of terms provided in section 9.

1.2 Scope of Assessment.

The scope of the assessment was provided to and agreed with Carol Lee Senior Environmental Health Pollution Practitioner (Air Quality) at the London Borough of Richmond upon Thames (LBRT) by email on the 26th July 2018 as follows:

- The assessment of baseline air quality has drawn on the Council's air quality data and Defra's local background data.
- The assessment of the impact of emissions from existing road traffic at proposed receptors has been undertaken using dispersion modelling.
- The transport consultant, Sanderson Associates, has confirmed that the traffic generated by the development results in a change of less than 100 annual average daily traffic (AADT) for light duty vehicles (LDV). For this reason, assessment of impacts on existing receptors has been scoped out in line with the EPUK/IAQM document 'Land-Use Planning & Development Control: Planning for Air Quality' January 2017.
- The assessment was undertaken in line with the EPUK/IAQM document 'Land-Use Planning & Development Control: Planning for Air Quality' January 2017.
- The assessment of energy systems was scoped out as all heating and cooling of the Proposed Development is to be via an electric solution – i.e. no combustion.
- The air quality assessment includes an assessment of construction impacts on air quality and dust using the IAQM methodology, in compliance with London's SPG on 'The Control of Dust and Emissions During Construction and Demolition (2014)'. This includes assessment of demolition.
- An air quality neutral assessment has also been carried out as part of the air quality assessment for the Proposed Development.

The railway line to the west and south of the site is not a relevant line as detailed in Table 4.2 of the LLAQM TG16[2] document, therefore assessment of the impact from the railway line has not been undertaken. There is considered to be no significant impact of this railway line on the Proposed Development.

2. Legislation, Policy and Guidance Documents.

2.1 Air Quality Strategy and Local Air Quality Management.

The Environment Act 1995 (Part IV) requires the Secretary of State to publish an air quality strategy and local authorities to review and assess the quality of air within their boundaries. The latter has become known as Local Air Quality Management (LAQM).

The Air Quality Strategy[1] provides the policy framework for local air quality management and assessment in the UK. It sets out air quality standards and objectives for key air pollutants. These standards and objectives are designed to protect human health and the environment. The Strategy also sets out how the different sectors of industry, transport and local government, can contribute to achieving these air quality objectives.

Air quality in London is devolved to the Mayor of London, who has powers Under Part IV of the Environment Act 1995 to intervene and direct local authorities in Greater London. In support of these devolved powers, the Mayor established a London specific LAQM system (LLAQM)[2] in 2016 for the coordinated discharge of Mayor's and Boroughs' responsibilities.

Local authorities are required to identify whether the objectives have been, or will be, achieved at relevant locations, by the applicable date. If the objectives are not achieved, the authority must declare an AQMA and should prepare an action plan within 12 months. An action plan must identify appropriate measures and policies that can be introduced in order to work towards achieving the objective(s).

The air quality objectives set out the extent to which the Government expects the standards to be achieved by a certain date. They take account of economic efficiency, practicability, technical feasibility and timescale. The objectives for use by local authorities are prescribed within the Air Quality (England) Regulations 2000[3], and the Air Quality (England) (Amendment) Regulations 2002[4].

The objectives for NO_2 and particulate matter (PM_{10} and $PM_{2.5}$) are set out in Table 1. The objectives for NO_2 and PM_{10} were to have been achieved by 2005 and 2004 respectively, and continue to apply in all future years thereafter. The $PM_{2.5}$ objective is to be achieved by 2020. It should be noted that local authorities in England have a flexible role in working towards reducing emissions and concentrations of $PM_{2.5}$.

Table 1: Air Quality Criteria for NO_2, PM_{10} and $PM_{2.5}$

Pollutant	Time Period	Objective
Nitrogen Dioxide (NO_2)	1-hour Mean	200 µg/m^3 Not to be exceeded more than 18 times a year
	Annual Mean	40 µg/m^3
Fine Particles (PM_{10})	24-hour Mean	50 µg/m^3 Not to be exceeded more than 35 times a year
	Annual Mean	40 µg/m^3
Fine Particles ($PM_{2.5}$) *	Annual Mean	25 µg/m^3

* The $PM_{2.5}$ objective, which is to be met by 2020, is not in (Air Quality England) Regulations and there is no requirement for local authorities to assess it, although they are encouraged to do so.

The objectives apply at locations where members of the public are likely to be regularly present and exposed over the averaging period of the objective. Examples of where the annual mean objectives should apply are provided in LAQM.TG16, and include: building facades of residential properties, schools, hospitals. The annual mean objectives are not relevant for the building facades of offices or other places of work where members of the public do not have regular access, kerbsides or gardens.

The 24-hour objective for PM_{10} is considered to apply at the same locations as the annual mean objective, as well as in gardens of residential properties and at hotels.

The 1-hour objective for NO_2 also applies wherever members of the public might regularly spend 1-hour or more, including outdoor eating locations, pavements of busy shopping streets, carparks and bus stations which are not fully enclosed. The 1-hour objective does not apply at kerbside sites where the public do not have regular access.

2.2 EU limit values.

The European Union has also set limit values for NO_2, PM_{10} and $PM_{2.5}$; these are legally binding and have been implemented into English legislation by The Air Quality Standards Regulations 2010[5].

The limit values for NO_2, PM_{10} and $PM_{2.5}$ are the same as the English objectives (Table 1), but applied from 2010 for NO_2, 2005 for PM_{10} and 2015 for $PM_{2.5}$. The limit values apply at all locations (apart from where the public does not have access, where health and safety at work provisions apply and on the road carriageway).

According to the Government's 2017 Air Quality Plan the annual mean NO_2 limit value will be achieved throughout London by 2028[6].

2.3 The London Environment Strategy.

The London Environment strategy (LES), published in May 2018[23], supersedes the previous Mayor's Air Quality Strategy (MAQS)[7] for London, published in December 2010. The LES strategy aims to reduce pollution concentrations in London to achieve compliance within the EU limit values as soon as possible. The LES commits to the continuation of measures identified in the 2002 and 2010 MAQS, and sets out a series of additional measures.

Proposal 4.3.3.a states that the London Strategy provides policies in which all new large-scale developments can not only become 'Air Quality Positive', but also maintain Air Quality Neutral requirements for all other developments. Within the planning guidance for building operations and transport emissions, information about emission benchmarks for 'Air Quality Neutral' developments are set out. Any development that either meets or exceeds the benchmarks is considered Air Quality Neutral as they avoid any increase in PM and NO_x emission[23]s. In order for the benchmarks to remain relevant, the Mayor will continue to review them. To ensure that the requirements are met, execution of the Air Quality Neutral policy will be monitored by utilising both the London Local Air Quality Management (LLAQM) and the London Plan monitoring report.

The current Mayor of London is introducing a programme of measures to improve air quality and is planning on publishing a new air quality strategy, as part of a broader environmental strategy. The main aims with regards to air quality is outlined below:

"London will have the best air quality of any major world city by 2050, going beyond the legal requirements to protect human health and minimise inequalities."

In order to put London on to zero carbon by 2050, it is proposed that by 2019 all new buildings will be zero carbon whilst the early introduction of Ultra Low Emission Zone (ULEZ) in the capital's Congestion Charge Zone in 2020 will be implemented, with its possible extension to cover the area within the north and south circular roads for light duty vehicles and the replacement of the Low Emission Zone by an ULEZ for all light and heavy-duty vehicles in 2021. The long-term plan is to phase out the use of fossil fuels that are used to heat and cool buildings and to provide hot water.

After public consultation, the MAQS has been replaced with the London Environment Strategy. The following proposed policies relate to the planning process with regards to improving air quality:

Policy 4.2.2 – *"Reduce emissions from non-road transport sources, including by phasing out fossil fuels;"*

Policy 4.2.3 – *"Reduce emissions from non-transport sources, including by phasing out fossil fuels;"*

Policy 4.2.4 – *"The Mayor will work with the government, the London boroughs and other partners to accelerate the achievement of legal limits in Greater London and improve air quality;"*

Policy 4.2.5 – *"The Mayor will work with other cities (here and internationally), global city and industry networks to share best practice, lead action and support evidence based steps to improve air quality;"*

Policy 4.3.1 – *"The Mayor will establish new targets for $PM_{2.5}$ and other pollutants where needed. The Mayor will seek to meet these targets as soon as possible, working with government and other partners;"*

Policy 4.3.2 – *"The Mayor will encourage the take up of ultra-low and zero emission technologies to make sure London's entire transport system is zero emission by 2050 to further reduce levels of pollution and achieve WHO air quality guidelines;"*

Policy 4.3.3 – *"Phase out the use of fossil fuels to heat, cool and maintain London's buildings, homes and urban spaces, and reduce the impact of building emissions on air quality;"*

Policy 4.3.4 – *"Work to reduce exposure to indoor air pollutants in the home, schools, workplace and other enclosed spaces."*

Furthermore, the strategy outlines that negative consequences that can occur from developing air quality and climate policies in isolation, particularly with regards to energy and planning policy. Instead, integrated policy design can lead to benefits such as reducing carbon emissions by switching to zero emission vehicles simultaneously.

The Strategy also includes the focus on the 187 Air Quality Focus Areas (AQFA) declared by the GLA. Focus Areas are defined to address concerns raised by boroughs within the LAQM review process and forecasted air pollution trends. These are locations that not only exceed the EU annual mean limit value for NO_2, but are also locations with high human exposure. This is not an exhaustive list of London's hotspot locations, but where the GLA believe the problem to be most acute.

2.4 Local Air Quality Management in Richmond.

LBRT has declared its entire borough in the northwest as an AQMA for exceedances of the annual mean objective for NO_2 and the objective for PM_{10}.

LBRT's Air Quality Action Plan (AQAP) was published in 2017; it covers period from 2017 to 2022 and outlines the action LBRT will take to improve air quality in Richmond during this period. It replaces the previous action plan that ran from 2002 to 2017. Its aim is to reduce concentrations of, and exposure to, pollution thereby positively impacting on the health and quality of life of residents and visitors to the borough. Key priorities for the 2017 to 2022 AQAP are as follows:

- Establish and maintain an effective air quality steering group to ensure that the implementation of AQAP measures are coordinated effectively between relevant council services and external partners.
- To identify the key causes of traffic congestion within our AQ Focus Areas and pollution 'hotspots' and to determine effective measures for improving traffic flow through those areas using detailed air quality and traffic management modelling tools;
- To evaluate the air quality benefits and feasibility of introducing Clean Air Zones (CAZs) in the areas of the borough identified as having the poorest AQ;
- To provide guidance to developers on the impact of development on air quality and ensure that approved schemes include effective mitigation and maximise the opportunity to improve infrastructure for sustainable transport options;
- Encourage the uptake of low emission vehicles through expansion of the electric vehicle charging

infrastructure;

- To formalise anti-idling enforcement in order to minimise emission from vehicles around key locations such as schools, taxi-ranks, AQ focus areas and hot-spots;
- To continue to work with schools, parents and students to improve awareness of air quality and to optimise parents' and children's desire and opportunity to adopt sustainable travel options;
- To review the research pertaining to air quality benefits of 'green infrastructure' and to implement appropriate schemes of planting in relevant locations;
- To continue to review our air quality monitoring network to ensure that it effectively identifies areas of poor air quality and provides accurate data to enable us to evaluate air quality trends and the impact of AQAP measures.

2.5 Planning Policy.

2.5.1 National Planning Policy Framework

The National Planning Policy Framework (NPPF) 2018[8] sets out planning policy for England. It includes advice on when air quality should be a material consideration in development control decisions. Relevant sections are set out below:

Paragraph 170:" Planning policies and decisions should contribute to and enhance the natural and local environment by: preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality"

Paragraph 181: "Planning policies and decisions should sustain and contribute towards compliance with relevant limit values or national objectives for pollutants, taking into account the presence of Air Quality Management Areas and Clean Air Zones, and the cumulative impacts from individual sites in local areas. Opportunities to improve air quality or mitigate impacts should be identified, such as through traffic and travel management, and green infrastructure provision and enhancement. So far as possible these opportunities should be considered at the plan-making stage, to ensure a strategic approach and limit the need for issues to be reconsidered when determining individual applications. Planning decisions should ensure that any new development in Air Quality Management Areas and Clean Air Zones is consistent with the local air quality action plan."

Paragraph 54: "Local planning authorities should consider whether otherwise unacceptable development could be made acceptable through the use of conditions or planning obligations. Planning obligations should only be used where it is not possible to address unacceptable impacts through a planning condition."

The NPPF is supported by Planning Practice Guidance (PPG)[9].

The PPG states that:

Paragraph 001 (Reference ID: 32-001-20140306): "Defra carries out an annual national assessment of air quality using modelling and monitoring to determine compliance with EU Limit Values. It is important that the potential impact of new development on air quality is taken into account in planning where the national assessment indicates that relevant limits have been exceeded or are near the limit."

Paragraph 005 (Reference ID: 32-005-20140306): "Whether or not air quality is relevant to a planning decision will depend on the Proposed Development and its location. Concerns could arise if the development is likely to generate an air quality impact in an area where air quality is known to be poor. They could also arise where the development is likely to adversely impact upon the implementation of air quality strategies and action plans and/or, in particular, lead to a breach of EU legislation (including that applicable to wildlife).”

The PPG also sets out the information that may be required in an air quality assessment, stating that:

Paragraph 007 (Reference ID: 32-007-20140306): “Assessments should be proportional to the nature and scale of development proposed and the level of concern about air quality, and because of this are likely to be locationally specific.”

It also provides guidance on options for mitigating air quality impacts, and makes clear that:

Paragraph 008 (Reference ID: 32-008-20140306): “Mitigation options where necessary will be locationally specific, will depend on the Proposed Development and should be proportionate to the likely impact.”

2.6 London Planning Policy.

The London Plan Consolidated with Alterations since 2011 sets out the spatial development strategy for London. It brings together all relevant strategies, including the MAQS.

Policy 7.14, ‘Improving Air Quality’, addresses the spatial implications of the MAQS and how development and land use can help achieve its objectives. It recognises that Boroughs should have policies in place to reduce pollutant concentrations, having regard to the Mayor’s Air Quality Strategy. This policy seeks development proposals to:

- minimise increased exposure to existing poor air quality and make provision to address local problems of air quality particularly within AQMAs
- promote sustainable design and construction to reduce emission
- be at least ‘air quality neutral’ and not lead to/ further deterioration of existing poor air quality
- ensure that where provision to reduce emissions from a development is made on-site.

A draft London plan, highlighting the spatial development strategy for Greater London which serves as a blueprint for future development and sustainable growth for the city, was published in July 2018 and is currently undergoing examination in public. Once approved, this plan is to supersede the previous London plan released on December 2017.

Policy SI1, ‘Improving Air Quality” aims to ensure that new developments are designed and built, as far as is possible, to improve local air quality and reduce the extent to which the public are exposed to poor air quality.

- development proposals should not:
  - lead to further deterioration of existing poor air quality;
  - create any new areas that exceed air quality limits, or delay the date at which compliance will be achieved in areas that are currently in exceedance of legal limits;
  - reduce air quality benefits that result from the Mayor’s or boroughs’ activities to improve air quality; or
  - create unacceptable risk of high levels of exposure to poor air quality.
- development proposals should use design solutions to prevent or minimise increased exposure to existing air pollution and make provision to address local problems of air quality. Particular care should be taken with developments that are in Air Quality Focus Areas or that are likely to be used by large numbers of people particularly vulnerable to poor air quality, such as children or older people.
- masterplans and development briefs for large-scale development proposals subject to an Environmental Impact Assessment should propose methods of achieving an Air Quality Positive approach through the new development.

- major development proposals must be at least air quality neutral and be submitted with an Air Quality Assessment
- development proposals must demonstrate how they plan to comply with the Non-Road Mobile Machinery Low Emission Zone and reduce emissions from the demolition and construction of buildings following best practice guidance.
- development proposals should ensure that where emissions need to be reduced, this is done on-site. Where it can be demonstrated that on-site provision is impractical or inappropriate, off-site measures to improve local air quality may be acceptable, provided that equivalent air quality benefits can be demonstrated.

Supplementary Planning Guidance (SPG) on 'The Control of Dust and Emissions during Construction and Demolition' requires an assessment of the impacts of construction works on air quality, using the IAQM methodology. An Air Quality and Dust Management Plan (AQDMP), should be submitted with the planning application, together with confirmation that an Air Quality and Dust Management Plan (AQDMP) will be provided to the local authority prior to the commencement of works. Within this report these documents are referred to as the Air Quality Assessment and the Dust Management Plan respectively.

The Sustainable Design and Construction SPG makes reference to the Mayor's 'air quality neutral' policy and provides minimum requirements for emissions from boilers. All major developments in London needs to be assessed against emissions benchmarks for buildings and transport. Developments with emissions of NOX and PM_{10} below these benchmarks are considered to be 'air quality neutral'.

2.7 London Borough of Richmond upon Thames Local Plan.

The Local Plan, adopted on the 3rd July 2018 and covering the period to 2033, is the lead Local Plan document for Richmond. It sets out policies and guidance for the development of the borough over the next 15 years. It looks ahead to 2033 and identifies where the main developments will take place, and how places within the borough will change, or be protected from change, over that period. It also forms part of the development plan for the borough.

It contains the following policies related to air quality:

Policy LP 2 4.2.5 states: "*Tall or taller buildings can have a greater impact on their environment than other building types, posing problems of overshadowing, overlooking, creation of harmful micro-climates, worsening air quality and harmful effects on residents and amenity spaces. The siting and massing of new buildings will be controlled to avoid harmful intrusions into the skyline and on significant local views. In particular buildings that are higher and bulkier than their surroundings can have a visual impact over a wide area, altering the historic skyline and the character and appearance of Conservation Areas as well as open spaces. They can also dominate, obscure or detract from the setting of listed buildings and Buildings of Townscape Merit, Conservation Areas, Scheduled Monuments, Registered Parks and Gardens and the World Heritage Site at Kew.*"

Policy LP 10 B Air Quality states: "*The Council promotes good air quality design and new technologies. Developers should secure at least 'Emissions Neutral' development. To consider the impact of introducing new developments in areas already subject to poor air quality, the following will be required:*

1. an air quality impact assessment, including where necessary, modelled data;

2. mitigation measures to reduce the development's impact upon air quality, including the type of

equipment installed, thermal insulation and ducting abatement technology;

3. measures to protect the occupiers of new developments from existing sources;

4. strict mitigation for developments to be used by sensitive receptors such as schools, hospitals and

care homes in areas of existing poor air quality; this also applies to proposals close to developments *used by sensitive receptors.*"

Policy LP 10 4.10.6 states: "*The Council will seek financial contributions through the use of Planning Obligations towards air quality measures where a proposed development is not air quality neutral or mitigation measures do not reduce the impact upon poor air quality.*"

2.8 Guidance Documents.

2.8.1 Guidance on the Assessment of Dust from Demolition and Construction

The Institute of Air Quality Management (IAQM) produced guidance on the assessment of dust from demolition and construction[10]. This document provides a risk-based methodology for assessing construction impacts, including demolition and earthworks where appropriate.

2.8.2 Guidance on the Assessment of Operational Impact of New Developments

Guidance produced by Environmental Protection UK (EPUK), and IAQM in January 2017 entitled 'Land-Use Planning & Development Control: Planning for Air Quality[11] aims to ensure that air quality is properly accounted for in the development control process. The main foci of the guidance are the assessment of the impact of traffic and energy centre emissions and advice on how to describe air quality impacts and their significance.

2.8.3 Air Quality Neutral Planning Support Update: GLA 80371

Air Quality Consultants Ltd and ENVIRON UK Ltd produced guidance on behalf of the Greater London Authority on how to assess whether a development is air quality neutral. It provides benchmarks for assessing that development is consistent with the Mayor's policy.[12]

3. Methodology of Assessment.

3.1 Consultation.

The approach to the assessment was agreed with the Environmental Health Pollution Practitioner at LBR as described in section 1.2.

3.2 Existing Air Quality in the Study Area.

A baseline air quality review was undertaken to determine the existing air quality in the vicinity of the site.

This desk-top study was undertaken using the following sources:

- Air quality data for Richmond, including a review of the LBRT air quality reports and local monitoring data;
- The UK Pollutant Release and Transfer Register[13];
- Defra's Magic Map Application[14]
- Background pollution maps from Defra's Local Air Quality Management (LAQM) website[15];
- Pollution Inventory from the Environment Agency[16]
- Greater London Authority LAEI Air Quality Focus Areas [17]
- Greater London Authority (GLA) modelling[18]; and
- Aerial photography from Google Maps.

3.3 Construction Phase Impacts.

Fugitive dust emissions during the construction may give rise to increased PM_{10} concentrations and dust deposition, albeit this is a temporary impact. These impacts have been assessed using the IAQM methodology (see Appendix 2) to identify appropriate mitigation measures commensurate with the risk.

Activities on the proposed construction site have been divided into four types to reflect their different potential impacts. These are:

- Demolition
- Earthworks;
- Construction and
- Trackout

The risk of dust emissions was assessed for each activity with respect to:

- Potential loss of amenity due to dust soiling;
- The risk of health effects due to a significant increase in exposure to PM_{10}

A desk based review using online resources of habitats and ecologically designated sites has been undertaken. No relevant ecological receptors within 50m of the Proposed Development has been identified.

First the potential dust emission magnitude was defined based on the scale of the anticipated works and is classified as Small, Medium or Large. Then the sensitivity of the area was defined based on the receptor sensitivity, number of receptors, and the distance from the source.

Receptors were identified within distance bands from the site boundary using aerial imagery and maps of the surrounding area (see Figure 7). The PM_{10} background concentration was also taken into account. The area was then defined as High, Medium or Low sensitivity.

The potential dust emission magnitude and the sensitivity of the area were combined to define the risk of impacts.

3.4 Operational Phase Impacts.

3.4.1 Introduction of Impacts

Concentrations of NO_2, PM_{10} and $PM_{2.5}$ have been predicted at the receptors in 2020, which is the earliest anticipated year of occupation for the Proposed Development. These receptors are located at the façades of the Proposed Development where concentrations are expected to be greatest and there is relevant exposure.

The locations of these receptors are shown in Figure 2

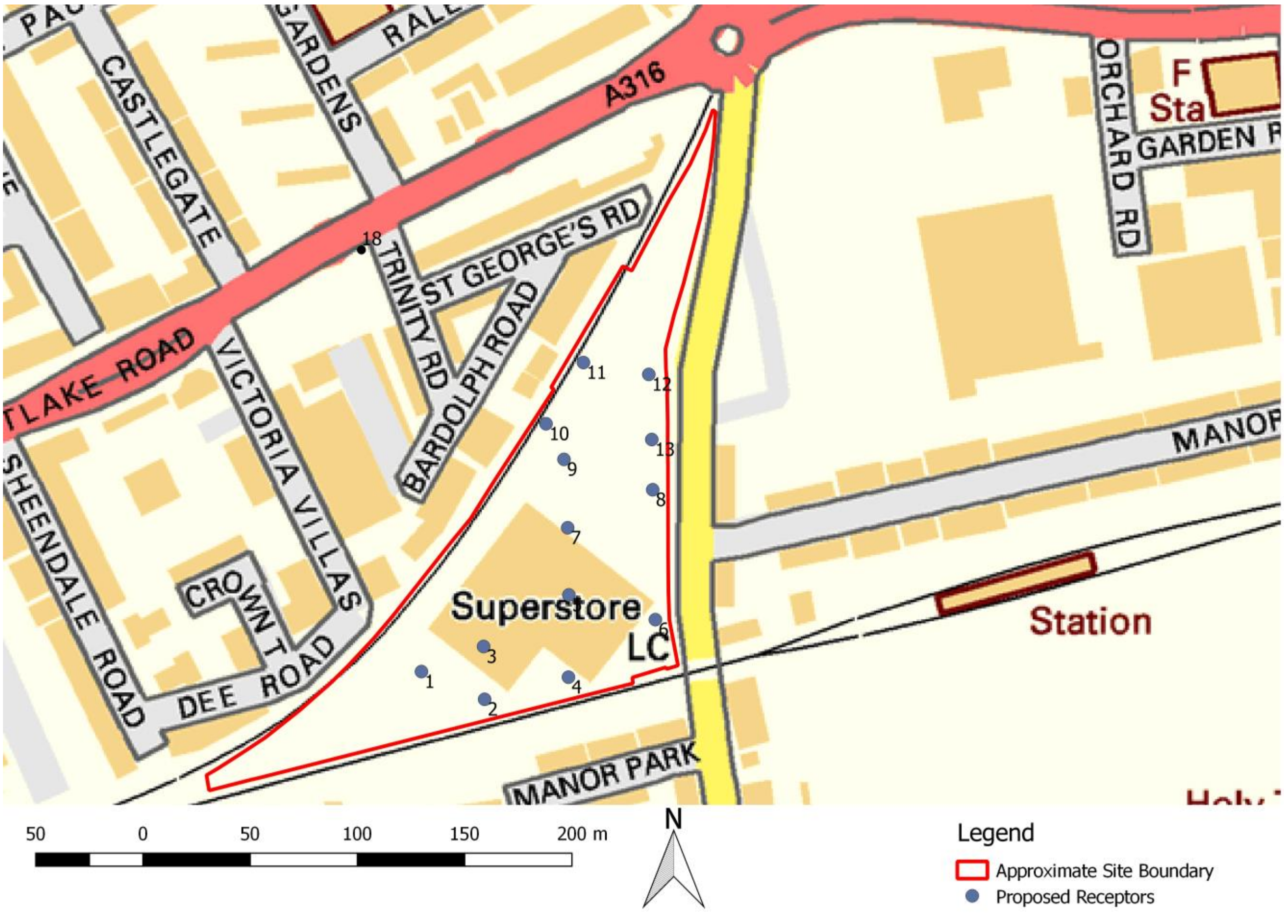

Figure 2 Location of proposed receptors. Contains OS Data © Crown Copyright and Database rights 2018

3.4.2 Air Quality Neutral Assessment

To enable the implementation of the air quality neutral policy of the London Plan, emission benchmarks have been developed for buildings and transport, the latter of which are dependent on the zone in London where the development is located. Developers are required to calculate emissions due to building operations and transport, and to compare these emissions with the benchmarks, which are set out in Appendix 5.

Where the development's emissions exceed the benchmarks, on-site mitigation is required. Where emissions continue to exceed the benchmarks after appropriate on-site mitigation, the excess emissions need to be off-set off-site through agreement with the local planning authority.

Full details of the modelling methodology are provided in Appendix 5.

3.5 Assessment of Significance.

3.5.1 Construction Dust

The IAQM guidance on the assessment of dust from demolition and construction states that the primary aim of the risk assessment is to identify site specific mitigation that, once implemented, should ensure that there will be no significant effect. Therefore, the assessment has been used to determine an appropriate level of mitigation for the construction phase.

The determination of which mitigation measures are recommended include elements of professional judgement and the professional experience of the consultants preparing this report is set out in Appendix 6.

3.5.2 Operational Impacts

For the proposed receptors the predicted concentrations have been assessed against the objectives shown in Table 1. Where an exceedance of an objective is predicted, mitigation measures are recommended to reduce exposure to below the objective value.

The determination of the significance of the effects includes elements of professional judgement and the professional experience of the consultant preparing the report is set out in Appendix 6.

The overall significance of the air quality effects is judged as either significant or not significant taking account of:

- The existing and future air quality in the absence of the development;
- The extent of current and future population exposure to the impacts; and
- The influence and validity of any assumptions adopted when undertaking the prediction of impacts.

4. Baseline Air Quality.

This section sets out the available information on air quality in the vicinity of the Proposed Development.

4.1 LAQM Review and Assessment.

LBRT has declared the whole borough as an AQAM for exceedances of the annual mean objective for NO_2 and the objectives for PM_{10}. The Proposed Development is therefore located within an AQMA.

4.2 Local Air Quality Monitoring.

There are four automatic monitoring stations in operation in the borough. The closest automatic monitor, RHG, is approximately 3.7 km west of the Proposed Development; this is a mobile monitoring station and was located on Chertsey Road for 2017[19]. This is a roadside site and its location is shown in Figure 3.

Table 2 Automatic monitoring for Richmond. Concentration in μg/m^3, 1-hour and 24-hour measurements show number of exceedances of the concentration i.e. 200 μg/m^3 for NO_2 and 50 μg/m^3 for PM_{10}.

Monitoring site and distance (km) from site boundary (approx.)	Objective	2013	2014	2015	2016	2017
NO_2						
RHG, 3.7 km	Annual mean (μg/m^3)	43	42	*	*	37
	Number of days with concentrations >200 μg/m^3	0	0	*	*	0
PM_{10}						
RHG, 3.7 km	Annual mean (μg/m^3)	25	*	*	*	18
	Number of days with concentrations > 50 μg/m^3	8	*	*	*	1

*This mobile unit was located at more than one site therefore data is not available.

It can be seen from Table 2 that the annual mean objective was exceeded in 2013 and 2014, however, it was below the annual mean objective in the most recent year of 2017. This suggests an improvement in terms of air quality conditions. The one-hour objective has not been exceeded in the past five years.

PM_{10} monitoring at the automatic monitoring station shows that the annual objective has not been exceeded in the years with available data, 2013 and 2017, as shown in Table 2. It can also be seen that there has been a decrease in concentrations from 2013 to 2017. The 24-hour objective has not been exceeded.

It should be noted that RHG may not be representative of the air quality conditions experienced at the Proposed Development, given its distance from the development site and the fact it is located on the roadside of a busy main road in Richmond.

LBRT also have 64 diffusion tubes in place across the borough. The diffusion tube monitoring locations within the vicinity of the site are given in Figure 3 and the annual mean concentrations in Table 3 .

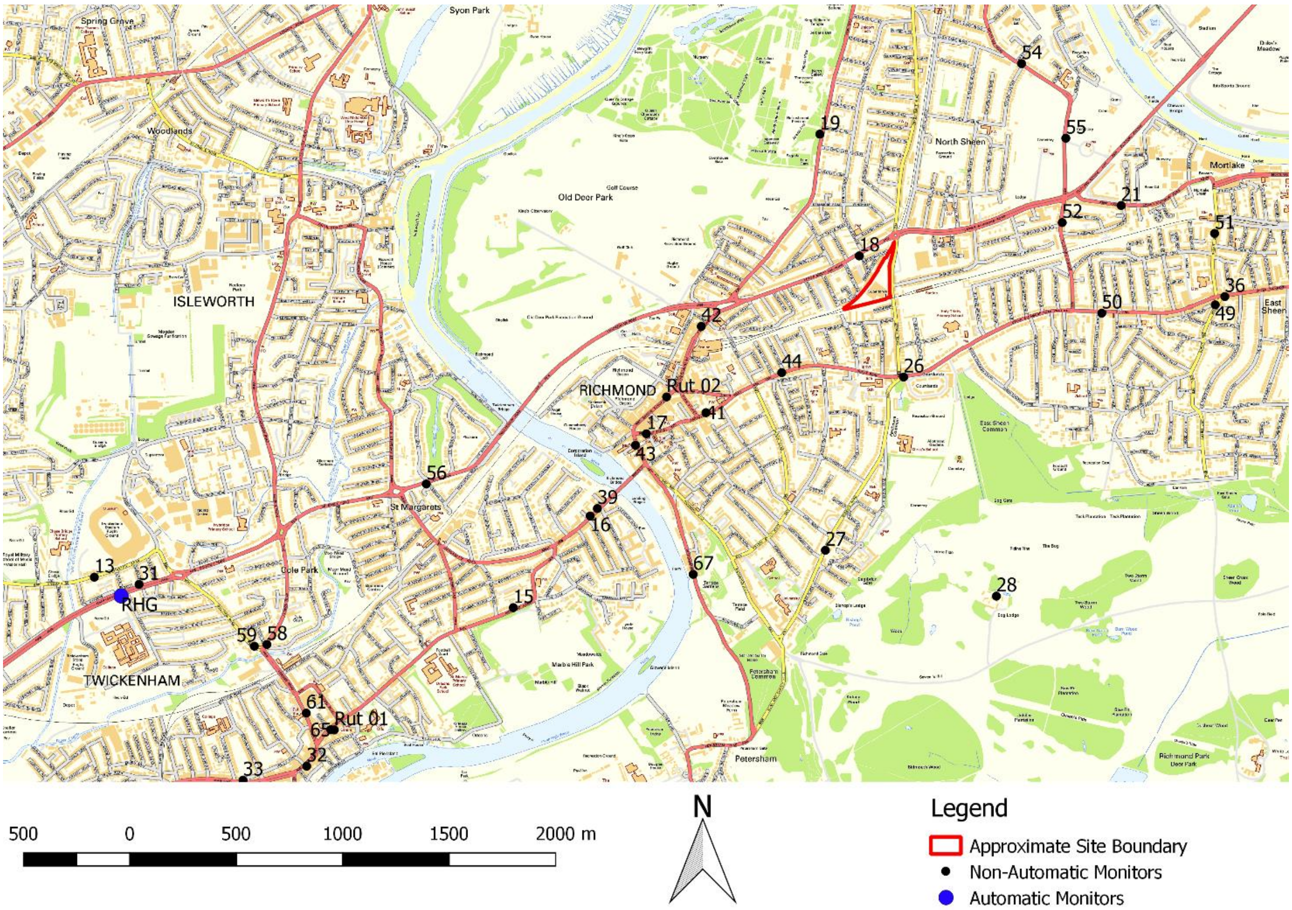

Figure 3 Local authority automatic and non-automatic monitoring locations in vicinity of the Proposed Development. Contains OS Data © Crown Copyright and Database rights 2018

Table 3 Diffusion tube data (annual mean NO_2 concentrations µg/m^3) for the diffusion tubes located within the vicinity of the development site

Site	Site Type	Distance (km) from site (approx.)	2013	2014	2015	2016	2017
18	Roadside	0.1	71	66	67	56	58
21	Roadside	1.1	44	41	37	39	36
26	Roadside	0.4	43	42	40	40	36
27	Roadside	1.1	40	38	37	43	41
19	Roadside	0.7	53	55	48	49	49
42	Roadside	0.7	58	54	47	82	89
67	Roadside	1.4	**	**	**	**	44

**Monitoring commenced in 2017 for this monitoring site

The diffusion tube monitoring data shows that the closest monitoring site, site 18, has exceeded the annual mean objective for NO_2 in 2017 however, has shown a decrease in measured NO_2 concentration over the previous five years. Despite this, the air quality objectives have not been met at this site for the last five years. There are exceedances at monitoring sites located on busy roads, such as sites: 27, 19, and 42. However, as site 27 is 1 km away from the development site, it is unlikely that conditions there are representative of the air quality at the Proposed Development. Whilst site 42 is nearer to the Proposed Development at 0.68 km away, it is located along a busy high street on the junction of Kew Road and the Richmond Station Car Park. Due to this, it is likely that it is heavily trafficked and is subjected to idling traffic on a regular basis. This is unlikely to be the case at the development site, as it is not situated along a high street or opposite Richmond Station. It is therefore likely that the development site will not be subject to the same conditions with regard to air quality.

An annual mean concentration of 60 $\mu g/m^3$ or above is often used to indicate a possible exceedance of the hourly mean NO_2 objective. It is likely that the one-hour objective was exceeded at site 42. It is considered unlikely that the one-hour objective will be exceeded at the Proposed Development based on the monitoring data provided.

4.3 Industrial Pollution.

A desk based review of potential industrial sources using the UK Pollutant Release and Transfer Register[13] did not identify any significant industrial or waste management sources of air pollution that are likely to affect the Proposed Development with regard to air quality.

4.4 Defra Predicted Concentrations.

Defra have produced projections of future concentrations of NO_2 and NOx across the UK up to 2030 for the development of the 2017 Air Quality Plan[20]. The annual average roadside concentrations used to predict the concentrations at the A316 Lower Mortlake Road (road link ID 56694) are shown in Table 4 for 2015 (baseline year), 2018 (current year) and 2020 (earliest year of occupation). This road link is the closest modelled by Defra to the Proposed Development, at approximately 100 m north of the site, but is not considered to be representative of the air quality conditions at the development site.

The background concentrations have been obtained from the national maps published by Defra[15]. These estimated concentrations are produced on a 1km by 1km grid basis for the whole of the UK. The development site falls into grid square x 518500 y 175500 and the predicted concentrations for this grid square for NO_2, PM_{10} and $PM_{2.5}$ are also provided in Table 4.

Table 4 Estimated annual mean roadside and background concentrations in 2015, 2018 and 2020 in $\mu g/m^3$

Year	Roadside	Background		
	NO_2*	NO_2	PM_{10}	$PM_{2.5}$
2015	47	26	17	11
2018	42	23	17	11
2020	38	21	16	10

*Data collected from Road link ID: 56694

It can be seen that the modelled background NO_2 concentrations are below the objective levels for all pollutants at the assumed opening year, 2020. The modelled concentration at the A316 roadside exceeded the objective in each year with the exception of 2020, when it was at the objective concentration. It should be noted that this road link is located on a busy main road in Richmond, whereas the development site is not. Therefore, it is likely that the Proposed Development will not be subject to the same air quality conditions.

4.5 Greater London Authority.

4.5.1 LAEI Air Quality Focus Areas

There are a number of Air Quality Focus Area's (AQFA's) identified in London with four AQFA's in Richmond. These are locations that not only exceed the EU annual mean limit value for NO_2 but are also locations with high human exposure. The Proposed Development is within one of these AQFA's as illustrated in Figure 4.

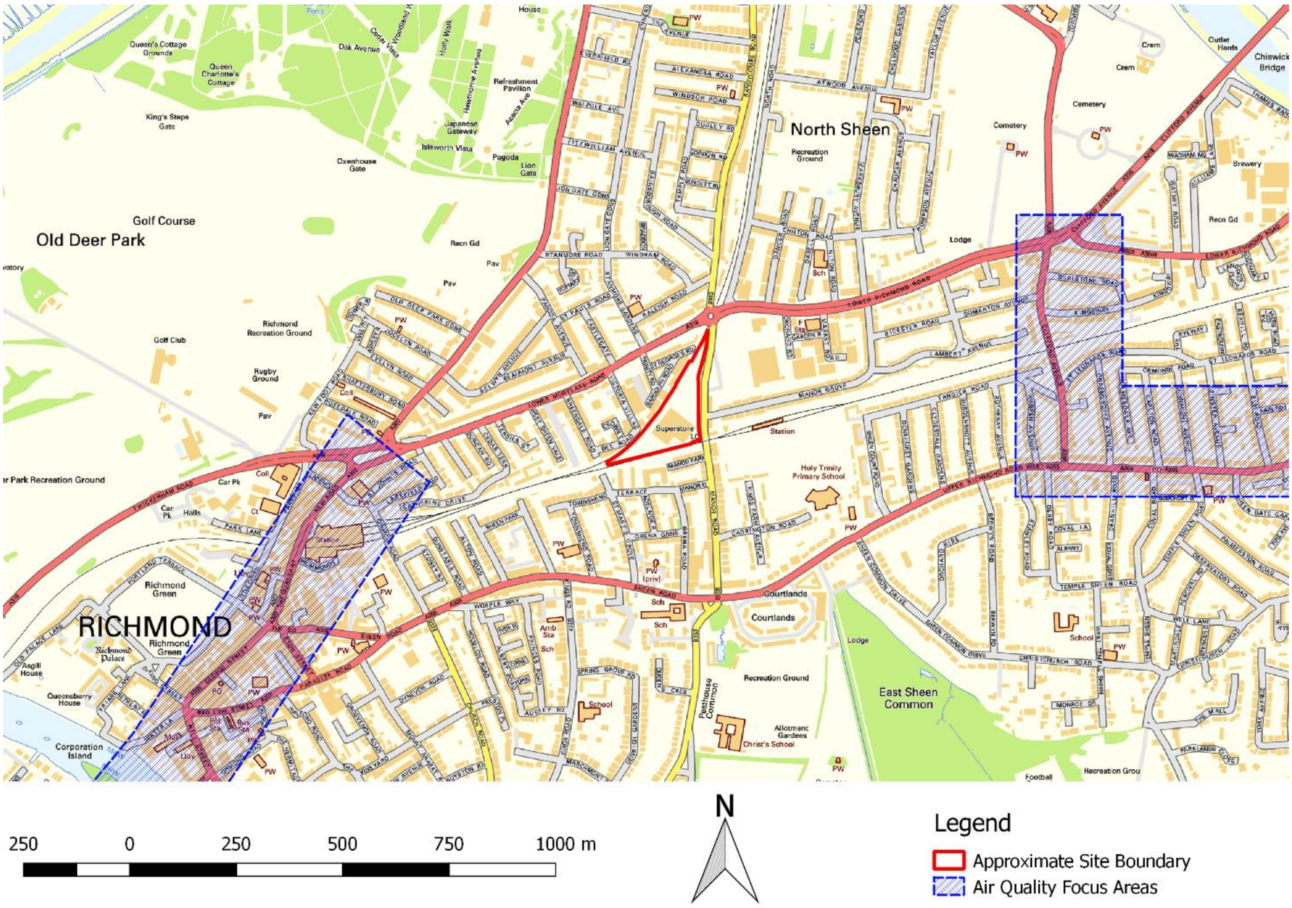

Figure 4 Air Quality Focus Areas and location of Proposed Development in Richmond. OS Data © Crown Copyright and Database rights 2018

The Proposed Development is located close to two declared AQFA's although they are over 400 m from the Proposed Development and there is expected to be sufficient distance for there to be negligible impact from the development on the AQFA.

4.5.2 Pollution Maps

The GLA produce annual mean concentration maps for the whole of London on a 20m by 20m grid for a historic year (2013) and future years (2020, 2025 and 2030). Figure 5 and Figure 6 illustrate the annual mean NO_2 and PM_{10} concentrations in the immediate area of the Proposed Development for 2013.

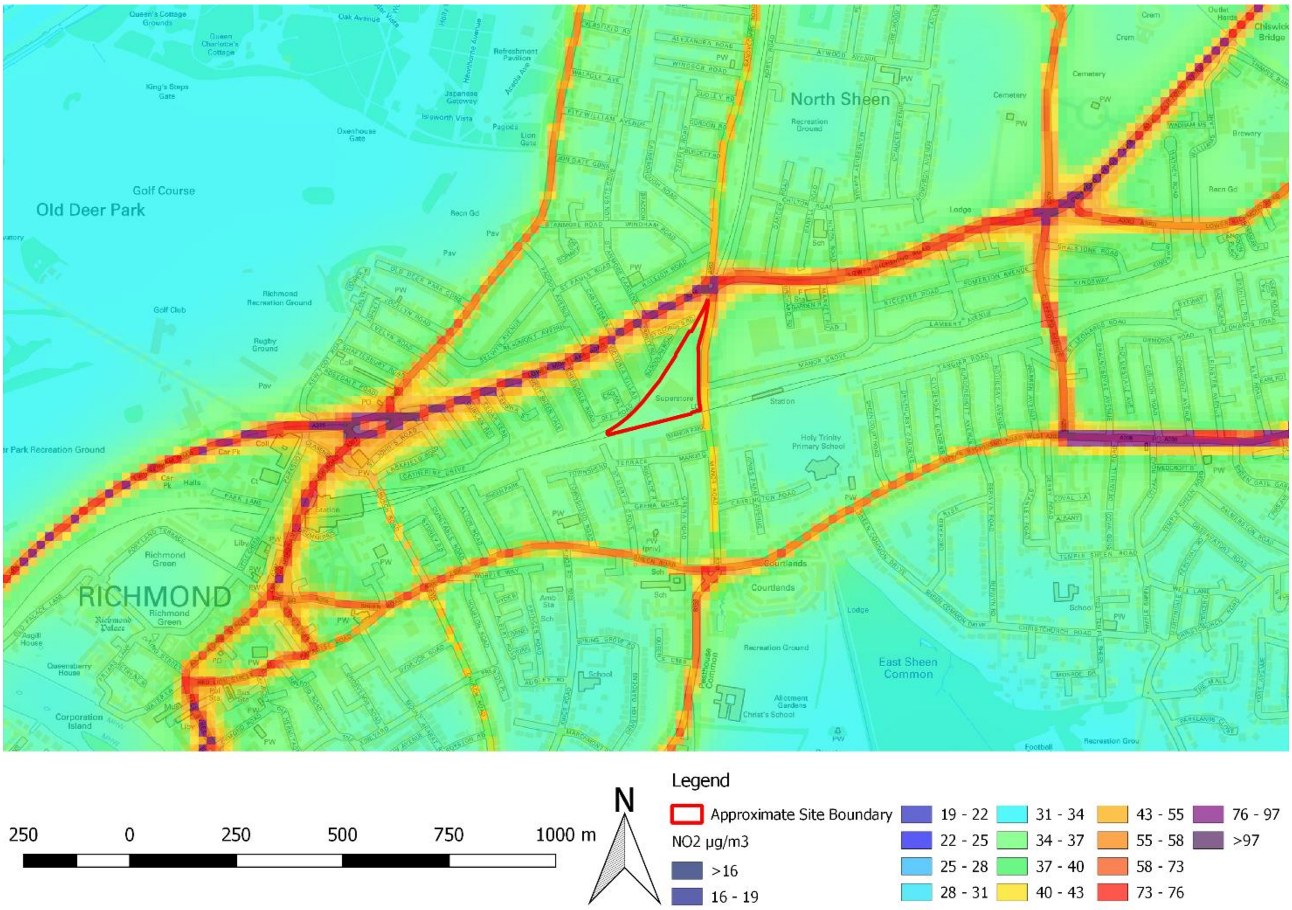

Figure 5 Modelled 2013 annual mean NO_2 concentrations (GLA, 2017), with red outline indicating approximate Proposed Development location OS Data © Crown Copyright and Database rights 2018

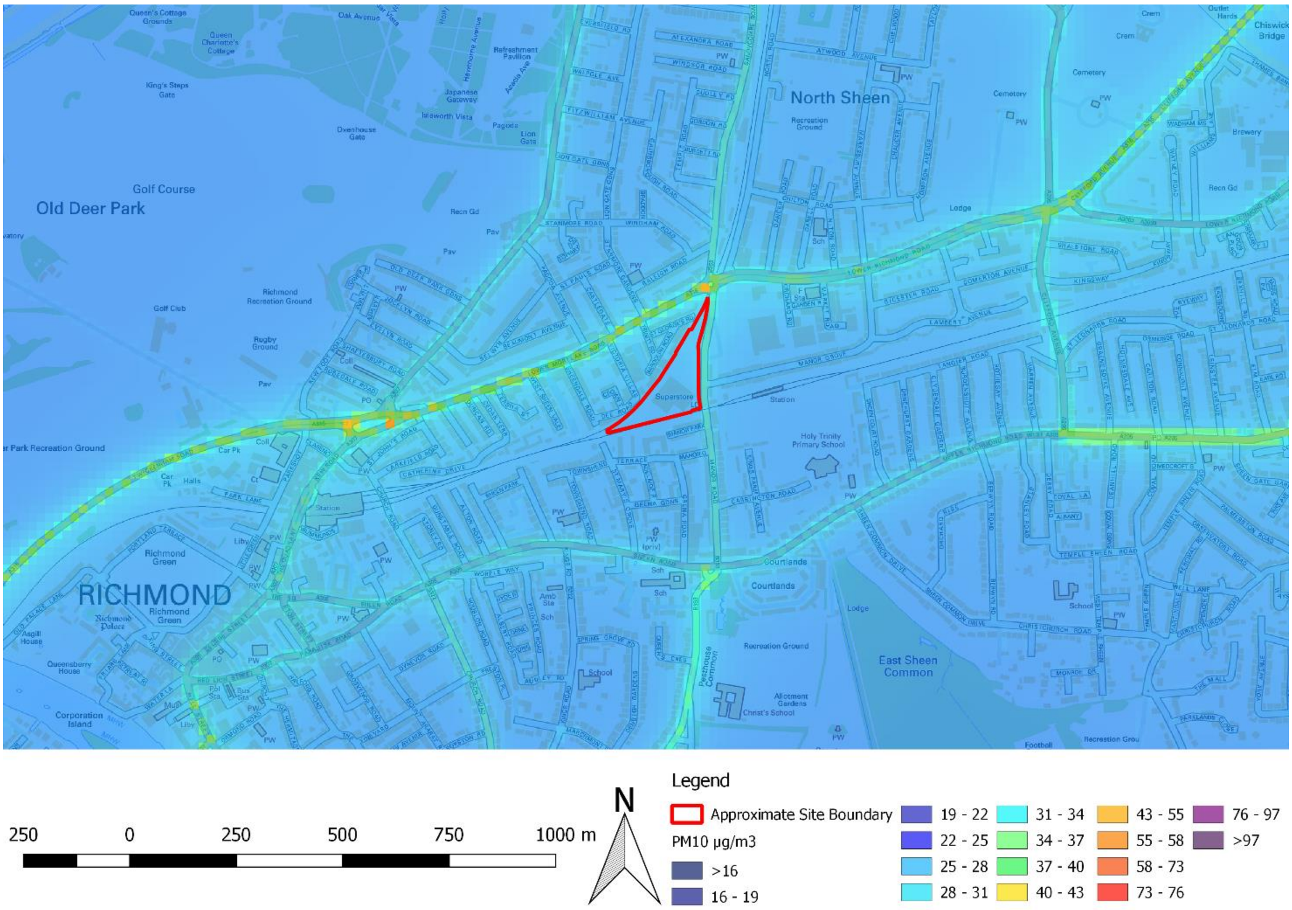

Figure 6 Modelled 2013 annual mean PM_{10} concentrations (GLA, 2017), with red outline indicating approximate Proposed Development location OS Data © Crown Copyright and Database rights 2018

The concentration of key pollutants in 2013 are shown on Table 5 for the coordinates of the Proposed Development. The annual mean NO_2 objective is not predicted to be exceeded in 2013. The objectives for PM_{10} and $PM_{2.5}$ are also not predicted to be exceeded in 2013. It is shown in Table 6 that there is a decrease in concentration for all pollutants, with no predicted exceedances of the annual objectives.

Table 5 Annual mean concentrations of NO_2, PM_{10} and $PM_{2.5}$ (grid reference x 518960, y 175480) (GLA, 2017)

Year	Pollutant Concentration - (µg/m^3)		
	NO_2	PM_{10}	$PM_{2.5}$
2013	36	25	16
2020	29	23	14

4.6 Summary of background data.

In summary, the baseline assessment has shown that the air quality in parts of Richmond is poor, particularly very close to busy roads and those that are near Richmond Station. The annual mean NO_2 objective is not exceeded by any monitoring sites in the most recent year, 2017, with the exception of three sites: 27, 39 and 42. However, these are not considered representative of the air quality conditions experienced at the development site. The most representative diffusion tube site, 26, did not exceed the annual mean NO_2 objective in 2017 and has shown a decrease in monitored concentrations in the previous five years, suggesting an improvement in air quality conditions.

The one-hour objective is not exceeded at the automatic monitoring station located at Chertsey Road, RHG, and is unlikely to have been exceeded at diffusion tube sites at other locations, with the exception of site 42.

The 1-hour NO_2 objective is unlikely to be exceeded at the development site.

PM_{10} concentrations are below the objectives at the automatic monitoring station, RHG, located on Chertsey Road.

Based on the background concentrations, the air quality objectives for PM_{10} and $PM_{2.5}$ are not exceeded at the development site.

5. Impact Assessment.

The potential for air quality impacts during construction and operation of the Proposed Development are discussed in this section.

5.1 Construction phase.

This sub section provides the results for demolition, earthworks, construction and trackout activities associated with the Proposed Development. Based on the impact assessment appropriate mitigation has been identified.

The risk of dust impacts is based on the potential dust emissions magnitude and the sensitivity of the area as described in section 5.1.3. The two factors are then combined to determine the risk of dust impacts with no mitigation applied. In the absence of any site-specific information a higher risk category has been applied to represent the worst-case scenario.

5.1.1 Potential Dust Emission Magnitude

Demolition

The site is currently occupied by a Homebase branch and associated surface car park, which are to be demolished. This is likely to have a total building volume between 20,000 m^3 to 50,000 m^3, with potentially dusty construction material, such as concrete. The potential dust emission magnitude from demolition activities would therefore be considered medium.

Earthworks

As the site has previously been developed it is unlikely that substantial earthworks will be required. The site is large at approximately 15,000 m^2, however, based on the limited earthworks proposed and the fact that the land has previously been developed, the potential dust emissions magnitude from earthworks is considered to be medium.

Construction

The total building volume for the Proposed Development is likely to be between 25,000 m^3 to 100,000 m^3. In accordance with the IAQM criteria, the potential dust emission magnitude from construction based on this detail would be medium.

Trackout

Initial information on the number of outward Heavy-Duty Vehicle (HDV) trips to be generated during the construction phase per day was not available at the time of writing of this report. There may be short distances of unpaved road / tracks proposed as part of the development. However, given the dimension of the site are they are likely to be between 50 m to 100 m in length. The potential dust emissions magnitude from trackout is considered to be medium.

5.1.2 Summary of Potential Dust Emission Magnitude

As outlined in the IAQM guidance, the scale and nature of the works has been assessed to determine the potential dust emissions magnitude for the Proposed Development site. Table 6 shows a summary of the classifications for the Proposed Development for each of the activities.

Table 6 Dust Emission Magnitude for the Proposed Development

Activity	Dust Emission Magnitude
Demolition	Medium
Earthworks	Medium
Construction	Medium
Trackout	Medium

5.1.3 Sensitivity of the Study Area

The area surrounding the site consists primarily of commercial and residential premises. Figure 7 shows the Proposed Development location (red line) and a series of distance bands from the boundary of the site. Note that receptors identified at a greater distance than 350 m have not been included as the IAQM Guidance[10] does not consider that there will be a material impact beyond this distance (see Appendix 2.)

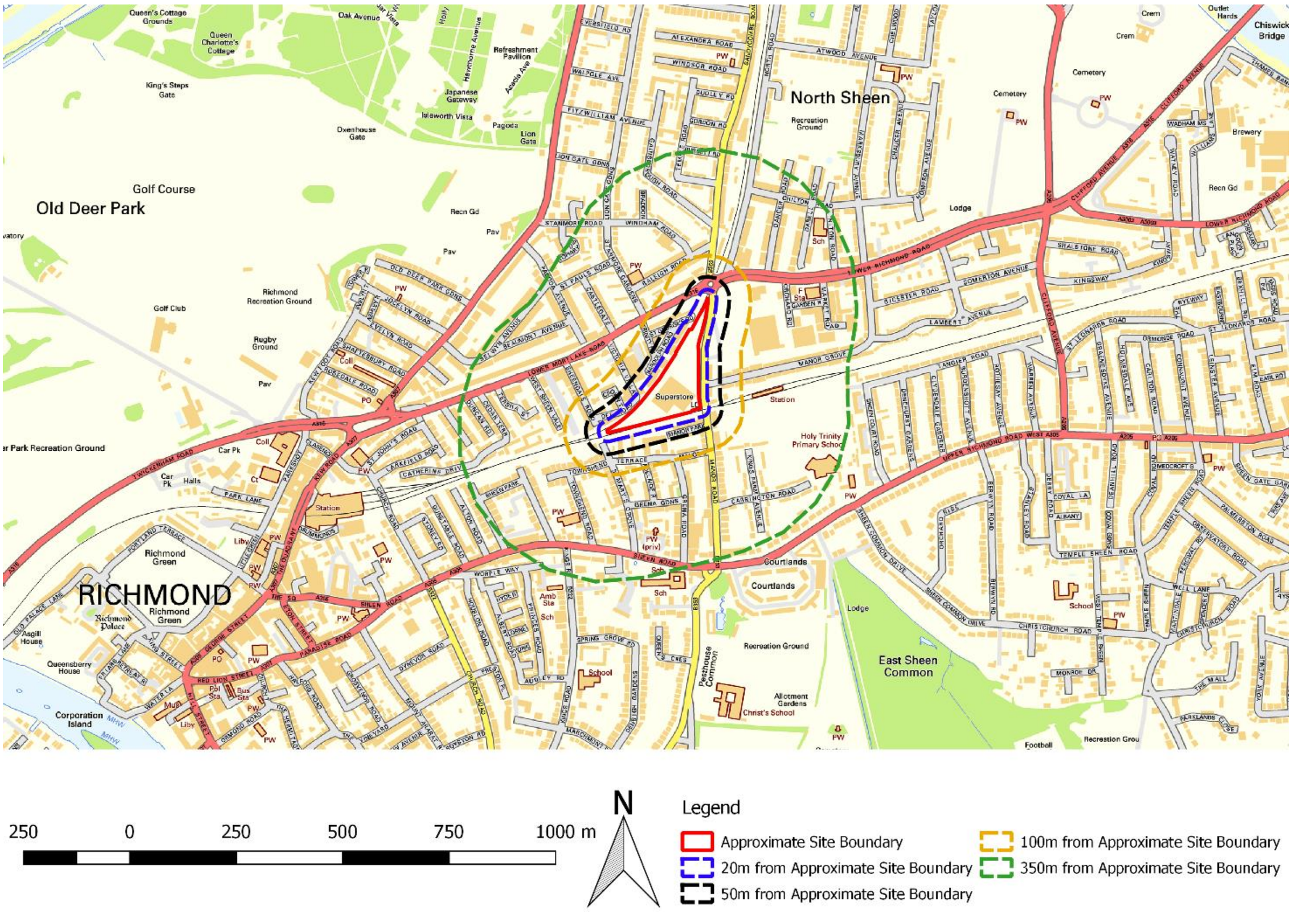

Figure 7 IAQM demolition and construction distance band criteria from site boundary. Contains Ordnance Survey Data © Crown Copyright 2018

5.1.4 Sensitivity of the Study Area to Dust Soiling

For the assessment of construction impacts the surrounding area is considered as a whole and the impacts at all receptors within 350 m are taken in to account. Residential areas are considered to be highly sensitive to dust soiling. There are between one to ten residential receptors within 20 m of the Proposed Development, and therefore the area surrounding the site is considered to be medium sensitivity.

For trackout, the distances are measured from the side of the roads used by construction traffic. Without site specific mitigation, trackout may occur from roads up to 200m from medium development sites, as measured from the site exit, and up to 50m from the edge of the road. The site has been classified as medium sensitivity to dust soiling for trackout.

5.1.5 Sensitivity of the Study Area to the Health Effects of PM_{10}

The LAEI forecast for 2020 modelled background PM_{10} concentrations is 23 µg/m^3. As the local PM_{10} concentration is under 24 µg/m^3 the area is considered to be of low sensitivity to the health effects of PM_{10} for all four activities.

5.1.6 Summary of Sensitivity

The sensitivity of the area is summarised for each activity in Table 7.

Table 7 Sensitivity of the Surrounding Area

Potential Impact	Demolition	Earthworks	Construction	Trackout
Dust Soiling	Medium	Medium	Medium	Medium
Human Health	Low	Low	Low	Low

5.1.7 Risk of Dust Effects

The dust emissions magnitude (section 5.1.1) is combined with the sensitivity of the area (section 5.1.3) to determine the risk of impacts with no mitigation applied. A summary of the unmitigated risk during each activity is provided in Table 8.

It should be noted that the potential for impacts depends significantly on the distance between the dust generating activity and receptor location. Risk was predicted based on the worst-case assumption that all works will be undertaken at the site boundary closest to each receptor area. Therefore, the actual risk is likely to be lower than that predicted during the majority of the construction phase.

Table 8 Summary of Potential Unmitigated Dust Risks

Potential Impact	Demolition	Earthworks	Construction	Trackout
Dust Soiling	Medium Risk	Medium Risk	Medium Risk	Medium Risk
Human Health	Low Risk	Low Risk	Low Risk	Low Risk

5.2 Operational Phase.

5.2.1 Impact on the Proposed Development

Predicted NO_2 concentrations in the proposed first year of occupation (2020) at the future receptors within the Proposed Development are set out in Table 9, with PM_{10} and $PM_{2.5}$ results in Table 18 and Table 19 in Appendix 4. These predicted concentrations include the impact of emissions from road traffic and the existing background concentrations.

NO_2

For NO_2 two sets of concentrations are provided. Scenario A assumes a reduction of NOx concentrations resulting from road traffic over time in line with Defra predictions, while Scenario B assumes that the NOx emissions and the background concentrations from road transport do not change between the base year (2017) and the opening year (2020).

Scenario B is considered conservative as evidence from remote sensing measurements in London show that the most recent diesel cars (i.e. Euro 6) have emissions approximately 50% lower than earlier generations of diesel cars. In addition, evidence from on-board measurements of heavy duty vehicles suggests that lorries and buses with Euro VI engines also have much lower emissions than previous generations of vehicles, and Transport for London has retro-fitted buses with low NO_2 emission control technology. Scenario B results are provided for reference in Table 17 in Appendix 4. In addition, air quality monitoring data from local authority's network suggests that NO_2 concentrations are declining.

Table 9 shows the predicted annual mean NO_2 concentrations in 2020 at the proposed receptors for Scenario A. In Scenario A no receptors at ground, first or second floor levels will be exposed to concentrations above the annual mean objective of 40 µg/m^3.

Table 9 Predicted Concentrations of NO_2 in 2020 at proposed receptors (Scenario A)

Proposed Receptors*	Concentration with development (µg/m^3)	Objective exceeded?	Mitigation Required?	Reason
1.G	22.6	No	No	No exceedance
2.G	22.5	No	No	
3.G	22.6	No	No	
4.G	22.7	No	No	
5.G	22.9	No	No	
6.G	23.9	No	No	
7.G	23.1	No	No	
8.G	24.2	No	No	
9.G	23.4	No	No	
10.G	23.6	No	No	
11.G	24.1	No	No	
12.G	24.6	No	No	
13.G	24.3	No	No	
1.1	22.5	No	No	

Proposed Receptors*	Concentration with development (µg/m^3)	Objective exceeded?	Mitigation Required?	Reason
2.1	22.4	No	No	
3.1	22.6	No	No	
4.1	22.6	No	No	
5.1	22.8	No	No	
6.1	23.3	No	No	
7.1	23.0	No	No	
8.1	23.6	No	No	
9.1	23.2	No	No	
10.1	23.5	No	No	
11.1	23.8	No	No	
12.1	24.0	No	No	
13.1	23.7	No	No	

* – Ground (G) = 1.5m, Level 01 (1) = 4.5m,

Concentrations are predicted to be well below 60 µg/m^3 in both scenarios, which is considered to be the annual mean concentration at which the short-term objective for NO_2 may be exceeded. Therefore, the short-term objective is also likely to be achieved.

PM_{10} and $PM_{2.5}$

Table 18 in Appendix 4 shows that the predicted annual mean PM_{10} concentrations in 2020 at the proposed receptors will be exposed to concentrations below the annual objective (40 µg/m^3). The short-term objective for PM_{10} may be exceeded when the annual mean objective is above approximately 32 µg/m^3. Predicted concentrations are also well below this level and the short-term objective is also likely to be achieved.

Table 19 in Appendix 4 shows that the predicted annual mean $PM_{2.5}$ concentrations in 2020 at the proposed receptors will be exposed to concentrations below the annual mean objective of 25 µg/m^3.

There is no need for mitigation of the air quality impacts and there is considered to be no significant impact at the proposed receptors.

5.3 Air Quality Neutral Assessment.

5.3.1 Building Emissions

There will be no gas fired energy plant included as part of the Proposed Development as energy demand will be met by electrical plant, therefore there will be no building emissions.

5.3.2 Transport Emissions

The input data for the calculation of the transport related emissions (TRE) are shown in Table 10 and the transport emissions benchmark (TEB) input data are shown in Table 10.

Table 10: Calculation of TRE and TEB

Description		Value	Unit
A	Annual Average Daily Traffic	200	No. of vehicles/24 hours
B	Gross Internal Floor Area for Class A1 (Retail)	534	m^2
C	NOx TEB for Class A1 (Retail)	249	$g/m^2/yr$
D	Number of Residential Dwellings	385	No. of dwellings
E	NOx TEB for Class C3 (Residential Institution)	1553	g/dwellings/yr
F = (B x C) + (D x E)	TEB NOx	731	kg/yr
G	Annual Emissions Generated by Development (TRE)	294	kg/yr
H	Gross Internal Floor Area for Class A1 (Retail)	534	m^2
I	PM_{10} TEB for Class A1 Retail	42.9	$g/m^2/yr$
J	Number of Residential Dwellings	385	No. of dwellings
K	PM_{10} TEB for Class C3 (Residential Institution)	267	g/dwellings/yr
L = (H x I) + (J x K)	TEB PM_{10}	126	kg/yr
M	Annual Emissions Generated by Development (TRE)	50	kg/yr

The Proposed Development TRE for NO_x is 294 kg/yr and for PM_{10} is 50 kg/yr. Both these TRE's are below the relevant TEB, 731 kg/yr NO_x and 126 kg/yr PM_{10}; and therefore, the Proposed Development is air quality neutral with regard to transport emissions therefore mitigation is not required.

6. Mitigation.

6.1 Construction Phase.

To mitigate the potential impacts during the construction phase it is recommended that mitigation measures consistent with the GLA's SPG and IAQM guidance are implemented. An Air Quality and Dust Management Plan (AQDMP), should be included as part of a Construction Management Plan and provided to the local authority prior to the commencement of works. This should be implemented via an appropriately worded planning condition.

The following mitigation measures in Table 11 have been selected for the Proposed Development based upon the dust risk categories outlined in 4.1.3 of this report and should be incorporated in the AQDMP:

Table 11 Fugitive dust mitigation measures that are applicable to the Proposed Development

Issue	Mitigation Measure
Communications	Develop and implement a stakeholder communications plan that includes community engagement before work commences on site
	Display the name and contact details of person(s) accountable for air quality and dust issues on the site boundary. This may be the environment manager/engineer or the site manager
	Display the head or regional office contact information
Dust Management Plan	Develop and implement a Dust Management Plan (DMP), which may include measures to control emissions, approved by the Local Authority. The DMP may include monitoring of dust deposition, dust flux, real-time PM_{10} continuous monitoring and/or visual inspections.
Site Management	Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner, and record the measures taken
	Make the complaints log available to the Local Authority when asked
	Record any exceptional incidents that cause dust and/or air emissions, either on- or off- site, and the action taken to resolve the situation in the log book
	Hold regular liaison meetings with other high-risk construction sites within 500m of the site boundary, to ensure plans are coordinated and dust and particulate matter emissions are minimized. It is important to understand the interactions of the off-site transport/deliveries which might be using the same strategic road network routes
Monitoring	Undertake daily on-site and off-site inspection, where receptors (including roads) are nearby, to monitor dust, record inspection results, and make the log available to the Local Authority when asked. This should include regular dust soiling check of surfaces such as street furniture, cars, window sills within 100m of the site boundary, with cleaning to be provided if necessary
	Carry out regular site inspections to monitor compliance with the DMP, record inspection results, and make an inspection log available to the Local Authority when asked

Issue	Mitigation Measure
	Increase the frequency of site inspections by the person accountable for air quality and dust issues on site when activities with a high potential to produce dust are being carried out and during prolonged dry or windy conditions
	Agree dust deposition, dust flux, or real time PM_{10} continuous monitoring locations with the Local authority. Where possible commence baseline monitoring at least three months before work commences on site or, if it is a large site, before work on a phase commences. Further guidance is provided by IAQM on monitoring during demolition, earthworks and construction.
Preparing and maintaining the site	Plan site layout so that machinery and dust causing activities are located away from receptors, as far as is possible
	Erect solid screens or barriers around dusty activities or the site boundary that are at least as high as any stockpiles on site
	Fully enclose site or specific operations where there is a high potential for dust production and the site is active for an extensive period
	Avoid site runoff of water or mud
	Keep site fencing, barriers and scaffolding clean using wet methods
	Remove materials that have a potential to produce dust from site as soon as possible, unless being re-used on site. If they are being re-used cover as described below
	Cover, seed or fence stockpiles to prevent wind whipping
Operating vehicle/machinery and sustainable travel	Ensure all on-road vehicles comply with the requirements of the London Low Emission Zone and London Non- Road Mobile Machinery (NRMM) standards
	Ensure all vehicles switch off engines when stationary – no idling vehicles
	Avoid the use of diesel or petrol-powered generators and use mains electricity or battery powered equipment where practicable
	Impose and signpost a maximum-speed-limit of 15 mph on surfaced and 10 mph on unsurfaced haul roads and work areas (if long haul routes are required these speeds may be increased with suitable additional control measures provided, subject to the approval of the nominated undertaker and with the agreement of the Local Authority, where applicable)
	Produce a construction logistics plan to manage the sustainable delivery of goods and materials
	Implement a Travel Plan that supports and encourages sustainable travel (public transport, cycling, walking and car-sharing)
Operations	Only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays or local extraction, e.g. suitable local exhaust ventilation systems
	Ensure an adequate water supply on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate

Issue	Mitigation Measure
	Use enclosed chutes and conveyors and covered skips
	Minimize drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate
	Ensure equipment is readily available on site to clean any dry spillages, and clean up spillages as soon as reasonably practicable after the event using wet cleaning methods
Waste management	Avoid bonfires and burning of waste materials
Demolition	Soft strip inside buildings before demolition (retaining walls and windows in the rest of the building where possible, to provide a screen against dust)
	Ensure effective water suppression is used during demolition operations. Hand held sprays are more effective than hoses attached to equipment as the water can be directed to where it is needed. In addition, high volume water suppression systems, manually controlled, can produce fine water droplets that effectively bring the dust particles to the ground
	Avoid explosive blasting, using appropriate manual or mechanical alternatives
	Bag and remove any biological debris or damp down such material before demolition
Earthworks	Re-vegetate earthworks and exposed areas/soil stockpiles to stabilise surfaces as soon as practicable
	Use hessian, mulches or trackifiers where it is not possible to re-vegetate or cover with topsoil, as soon as practicable
	Only remove the cover in small areas during work and not all at once
Construction	Avoid scrabbling (roughening of concrete surfaces) if possible
	Ensure sand and other aggregates are stored in bunded areas and are not allowed to dry out, unless this is required for a particular process, in which case ensure that appropriate additional control measures are in place
	Ensure bulk cement and other fine powder materials are delivered in enclosed tankers and stored in silos with suitable emission control systems to prevent escape of material and overfilling during delivery
	For smaller supplies of fine powder material ensure bags are sealed after use and stored appropriately to prevent dust
Trackout	Use water-assisted dust sweeper(s) on the access and local roads, to remove, as necessary, any material tracked out of the site. This may require the sweeper being in continuous use
	Avoid dry sweeping of large areas

Issue	Mitigation Measure
	Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport
	Inspect on-site haul routes for integrity and instigate repairs to the surface as soon as reasonably practicable
	Record all inspections of haul routes and any subsequent action in a site log book
	Install hard surfaced haul routes, which are regularly damped down with fixed or mobile sprinkler systems, or mobile water bowsers and regularly cleaned
	Implement a wheel washing system (with rumble grids to dislodge accumulated dust and mud prior to leaving the site where reasonably practicable)
	Ensure there is an adequate area of hard surfaced road between the wheel wash facility and the site exit, wherever site size and layout permits
	Access gates to be located at least 10m from receptors where possible

6.2 Operational Phase.

The dispersion modelling predicts that there will be no exceedances of the relevant air quality objectives on site and therefore mitigation measures are not required.

6.3 Air Quality Neutral.

The air quality neutral benchmark has been met and further mitigation measures are not required.

7. Residual Impacts.

7.1 Construction Phase.

Assuming the relevant mitigation measures outlined in the mitigation section are implemented through, for example, a planning condition, the residual effect from dust generating activities associated with this phase of the development is considered to be not significant.

8. Summary and Conclusions.

This report describes the potential air quality impacts associated with the construction and operation of a proposed residential development, located on Manor Road, Richmond.

The site is for residential uses, therefore the annual mean objective for nitrogen dioxide (NO_2) and Particulate Matter 10 and 2.5 micrometres or less applies (PM_{10} and $PM_{2.5}$).

The impacts of the construction work on dust and ambient PM_{10} concentrations have been assessed and the risk of dust causing a loss of local amenity and increased exposure to PM_{10} concentrations during construction works has been used to identify appropriate mitigation measures. Provided these are implemented, for example through a planning condition, the residual impacts are considered to be not significant. It is therefore considered that the development is consistent with the latest guidance relating to air quality for construction and demolition.

A residential car park has not been proposed as part of the development, this means there will be limited traffic generation and a reduction compared to the existing use. Therefore, the need to undertake a detailed assessment of road traffic emissions associated with the operation of the Proposed Development has been scoped out as the traffic generated is below the criteria set in the Environmental Protection UK (EPUK) and Institute of Air Quality Management (IAQM) planning guidance.

Exposure of future users of the Proposed Development has been modelled using ADMS-Roads and there are predicted to be no exceedances of any relevant objectives for the pollutants modelled, NO_2, PM_{10}, $PM_{2.5}$.

There will be no gas fired plant onsite and all energy demand will be met by electrical servicing, therefore there will be no emissions from the development energy centre.

The development is air quality neutral according to the Greater London Authority's (GLA) benchmarking assessment methodology.

The overall operational air quality impacts of the development are judged to be not significant.

9. Glossary of terms.

AADT	Annual Average Daily Traffic
AQMA	Air Quality Management Area
CEMP	Construction Environmental Management Plan
Defra	Department for Environment, Food and Rural Affairs
DMP	Dust Management Plan
EPUK	Environmental Protection UK
GIFA	Gross Internal Floor Area
HDV	Heavy Duty Vehicles (> 3.5 tonnes gross vehicle weight)
HGV	Heavy Goods Vehicle
IAQM	Institute of Air Quality Management
LAQM	Local Air Quality Management
LLAQM	London Local Air Quality Management
LLAQM.TG	London Local Air Quality Management – Technical Guidance
LBRT	London Borough of Richmond upon Thames
LDV	Light Duty Vehicles ($\leq$3.5 tonnes gross vehicle weight)
LES	London Environment Strategy
$\mu g/m^3$	Micrograms per cubic metre
NO_2	Nitrogen dioxide
NO_x	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}	Particulate matter with aerodynamic diameter less than 10 micrometres
$PM_{2.5}$	Particulate matter with aerodynamic diameter less than 2.5 micrometres
PPG	Planning Practice Guidance
SPG	Supplementary Planning Guidance
Standards	A nationally defined set of concentrations for nine pollutants below which health effects do not occur or are minimal
Trackout	The transport of dust and dirt from the construction / demolition site onto the public road network, where it may be deposited and then re-suspended by vehicles using the network. This arises when heavy duty vehicles (HDVs) leave the construction / demolition site with dusty materials, which may then spill onto the road, and/or when HDVs transfer dust and dirt onto the road having travelled over muddy ground on site
ULEZ	Ultra Low Emission Zone

10. References.

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Appendix 1 – Proposed Development Plans.

Figure 8 Proposed site plan (indicative only) – Source document: Assael A3004 200A Date: December 2018 Rev: P14

Appendix 2 – IAQM Methodology.

Table 12 IAQM guidance[10] on the sensitivity of the area to dust soiling effects on people and property [ab]

Receptor Sensitivity	Number of Receptors	Distance from the Source (m)[c]			
		<20	<50	<100	<350
High	**>100**	High	High	Medium	Low
	10-100	High	Medium	Low	Low
	1-10	Medium	Low	Low	Low
Medium	**>1**	Medium	Low	Low	Low
Low	**>1**	Low	Low	Low	Low

[a] The sensitivity of the area should be derived for each of the four activities: demolition, construction, earthworks and trackout. See **STEP 2B**, **Box 6** and **Box 9.**

[b] Estimate the total number of receptors within the stated distance. Only the *highest level* of area sensitivity from the table needs to be considered. For example, if there are 7 high sensitivity receptors <20 m of the source and 95 high sensitivity receptors between 20 and 50 m, then the total of number of receptors <50 m is 102. The sensitivity of the area in this case would be high.

[c] For trackout, the distances should be measured from the side of the roads used by construction traffic. Without site-specific mitigation, trackout may occur from roads up to 500 m from large sites, 200 m from medium sites and 50 m from small sites, as measured from the site exit. The impact declines with distance from the site, and it is only necessary to consider trackout impacts up to 50 m from the edge of the road.

Table 13 IAQM guidance[10] on sensitivity of the area to human health impacts [ab]

Receptor Sensitivity	Annual Mean PM_{10} concentration[c]	Number of Receptors[d]	Distance from the Source (m)[e]				
			<20	<50	<100	<200	<350
High	>32 µg/m³ (>18 µg/m³ in Scotland)	>100	High	High	High	Medium	Low
		10-100	High	High	Medium	Low	Low
		1-10	High	Medium	Low	Low	Low
	28-32 µg/m³ (16-18 µg/m³ in Scotland)	>100	High	High	Medium	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	High	Medium	Low	Low	Low
	24-28 µg/m³ (14-16 µg/m³ in Scotland)	>100	High	Medium	Low	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
	<24 µg/m³ (<14 µg/m³ in Scotland)	>100	Medium	Low	Low	Low	Low
		10-100	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Medium	>32 µg/m³ (>18 µg/m³ in Scotland)	>10	High	Medium	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
	28-32 µg/m³ (16-18 µg/m³ in Scotland)	>10	Medium	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
	24-28 µg/m³ (14-16 µg/m³ in Scotland)	>10	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
	<24 µg/m³ (<14 µg/m³ in Scotland)	>10	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Low	-	≥1	Low	Low	Low	Low	Low

[a] The sensitivity of the area should be derived for each of the four activities: demolition, construction, earthworks and trackout. See **STEP 2B**, **Box 7** and **Box 9**.
[b] Estimate the total within the stated distance (e.g. the total within 350 m and not the number between 200 and 350 m), noting that only the **highest level** of area sensitivity from the table needs to be considered. For example, if there are 7 high sensitivity receptors <20 m of the source and 95 high sensitivity receptors between 20 and 50 m, then the total of number of receptors <50 m is 102. If the annual mean PM_{10} concentration is 29 µg/m³, the sensitivity of the area would be high.
[c] Most straightforwardly taken from the national background maps, but should also take account of local sources. The values are based on 32 µg/m³ being the annual mean concentration at which an exceedence of the 24-hour objective is likely in England, Walesand Northern Ireland. In Scotland there is an annual mean objective of 18µg/m³.
[d] In the case of high sensitivity receptors with high occupancy (such as schools or hospitals) approximate the number of people likely to be present. In the case of residential dwellings, just include the number of properties.
[e] For trackout, the distances should be measured from the side of the roads used by construction traffic. Without site-specific mitigation, trackout may occur from roads up to 500 m from large sites, 200 m from medium sites and 50 m from small sites, as measured from the site exit. The impact declines with distance from the site, and it is only necessary to consider trackout impacts up to 50 m from the edge of the road.

Appendix 3 Road Traffic Model Input Data.

A3.1 Road Traffic Modelling.

A3.1.1 Traffic Data

AADT flows, vehicle fleet composition data and average traffic speeds have been derived from the 2013 and 2020 data in the London Atmospheric Emissions Inventory (LAEI). The traffic data are shown in Table 14 and the modelled road network is shown in Figure 9.

A3.1.2 Emissions

Emissions were calculated using the most recent version of the Emissions Factor Toolkit (EFT) v8.0.1. The traffic data were entered into the EFT in order to calculate a combined emission rate for each of the road links in the modelled network.

A3.1.3 Meteorological Data

The model has been run using the full year of meteorological data that corresponds with the most recent set of nitrogen dioxide monitoring data (2017). The meteorological data has been taken from the monitoring station located at Heathrow Airport, which is considered suitable for the area.

A3.1.4 Background Concentrations

Background concentrations have been assumed to be the same as those published by Defra These cover the whole country on a 1 km by 1 km grid and are published for each year from 2015 to 2030. The current maps have been verified against measurements undertaken during 2015.

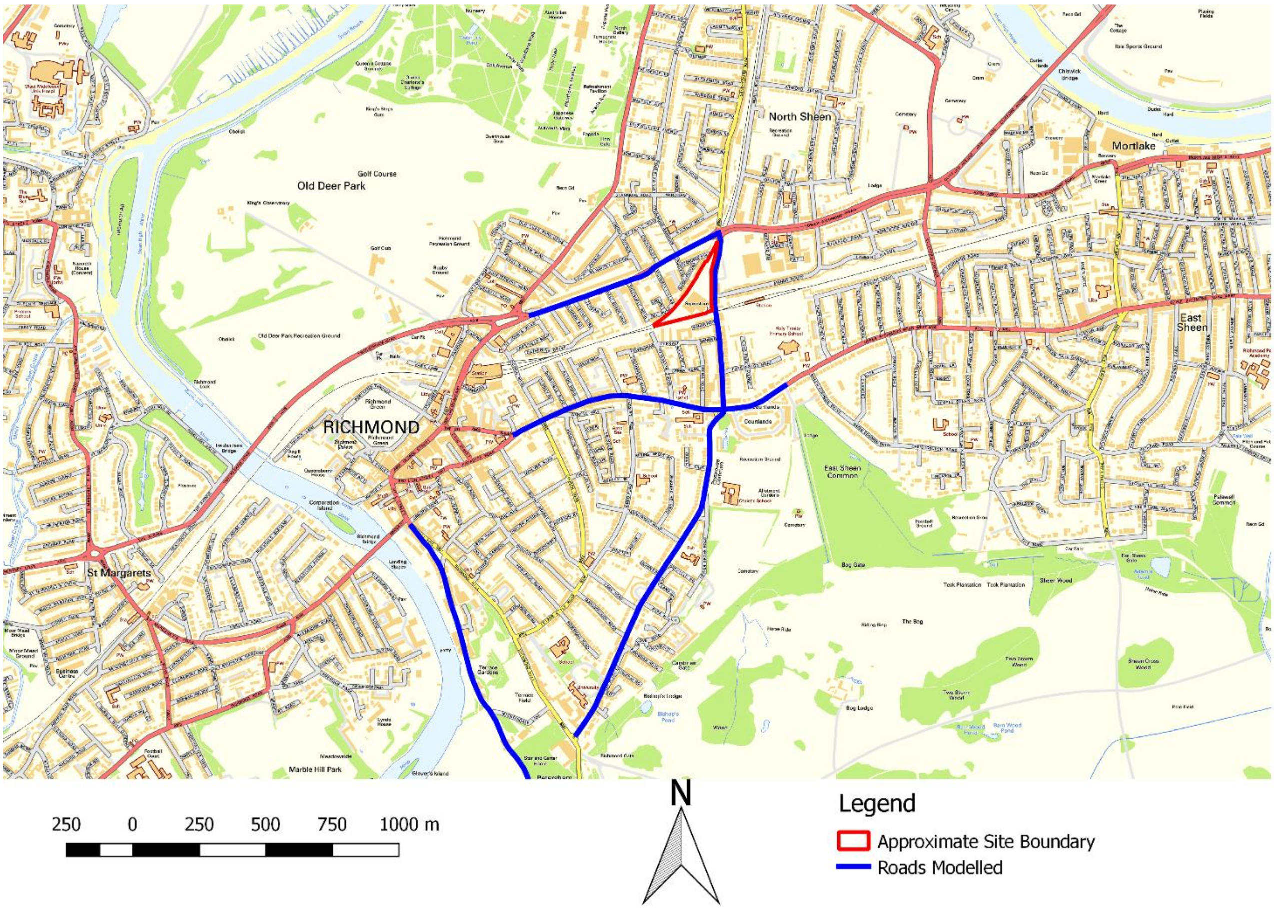

Figure 9 Modelled Roads Contains Ordnance Survey data © Crown copyright and database right 2018

Table 14 Summary of Traffic Data used in the Assessment

Road Name	AADT		HDV %	Speed (km/h)
	2017	2020		
Lower Mortlake Rd	33000	33502	10.1	42
Manor Rd	6642	6823	12.4	28
Sheen Road	11978	12332	7.7	26
Petersham Rd	15205	15839	4.4	38
Queens Road	11669	11962	4.3	21

The average speed along Manor Road takes in to account the level crossing by the North Sheen train station and the build-up of traffic along Manor Road.

A3.2 Verification

The verification process seeks to minimise uncertainties associated with the air quality model by comparing the model output with locally measured concentrations. The verification methodology is described in subsequent sections.

A3.2.1 Background Concentrations

Background concentrations at the monitoring sites in the verification year (2017) have been assumed to be the same as those published by Defra and are shown in Table 15.

Table 15 Annual Mean Background Concentrations at the Monitoring Sites (µg/m^3)

Grid Square	NO_2 2017
518500,175500	24.2
518500,174500	22.1
519500,175500	23.7

A3.2.2 NO_2

Most NO_2 is produced in the atmosphere by reaction of nitric oxide (NO) with ozone. It is therefore most appropriate to verify the model in terms of primary pollutant emissions of nitrogen oxides (NOx = NO + NO_2). The model has been run to predict the 2017 annual mean NOx concentrations at the diffusion tube monitoring sites DT 18, DT 26, DT 27, DT 44 and DT 67.

The model output of road-NOx has been compared with the 'measured' road-NOx, calculated from the measured annual mean NO_2 concentrations and the background concentrations using the NOx from NO_2 calculator v6.1 published by Defra.

The slope of the best-fit line between the 'measured' road-NOx contribution and the model derived road-NOx contribution, forced through zero, has been used to determine a primary adjustment factor). This factor has then been applied to the modelled road-NOx concentration for each receptor to provide adjusted modelled road-NOx concentrations. The NOx to NO_2 calculator has then been used to determine total NO_2 concentrations from the adjusted modelled road-NOx concentrations and the background NO_2 concentrations. A secondary adjustment factor has then been calculated as the slope of the best-fit line between the measured NO_2 concentrations and the primary adjusted total NO_2 concentrations, forced through zero.

The following primary and secondary adjustment factors have been applied to all modelled nitrogen dioxide data:

Primary adjustment factor: 2.1052

Secondary adjustment factor: 0.9791

The results imply that the model has under-predicted the road-NOx contribution. This is a common experience with this and most other models.

Figure 10 to Figure 12 include the adjustment undertaken for NO_2 and also compares secondary adjusted total NO_2 at each of the monitoring sites, to measured NO_2, and shows a 1:1 relationship.

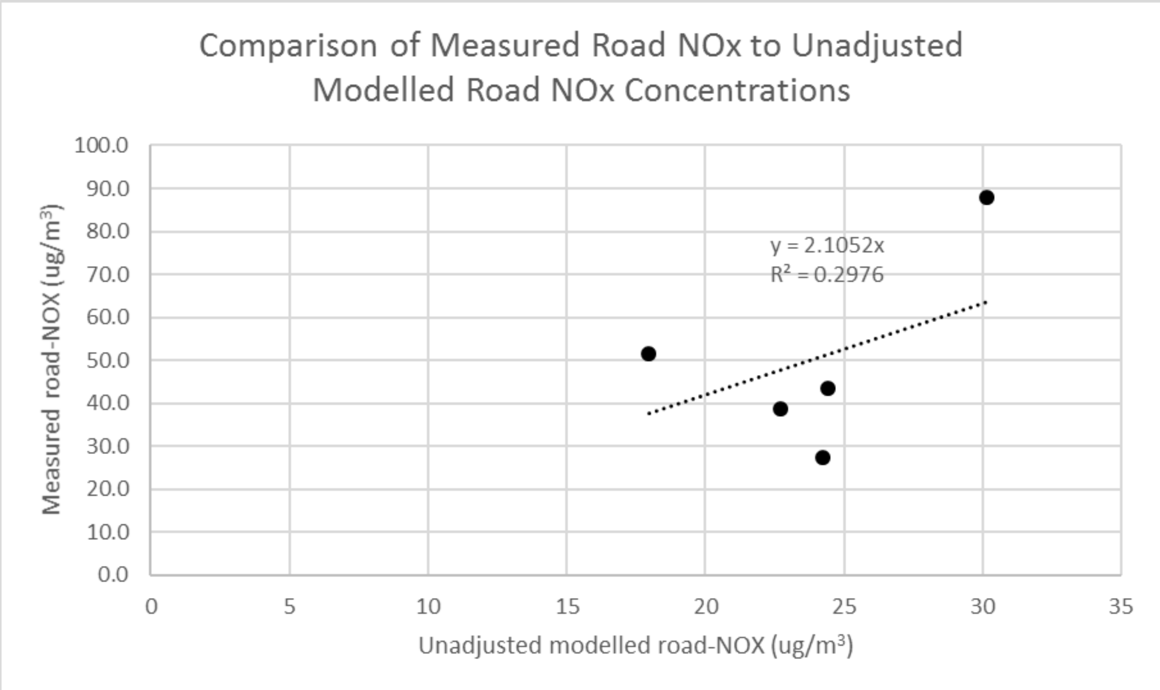

Figure 10 Comparison of Measured Road NOx to Unadjusted Modelled Road NOx Concentrations.

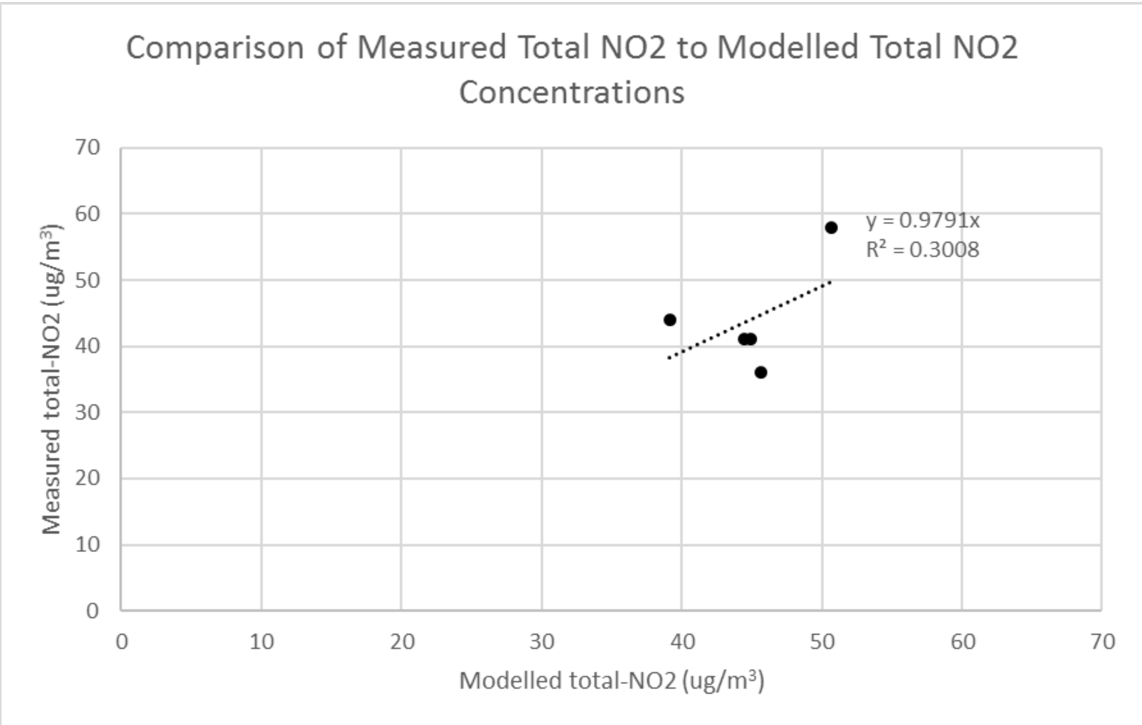

Figure 11 Comparison of Measured Total NO_2 to Primary Adjusted Modelled Total NO_2 Concentrations.

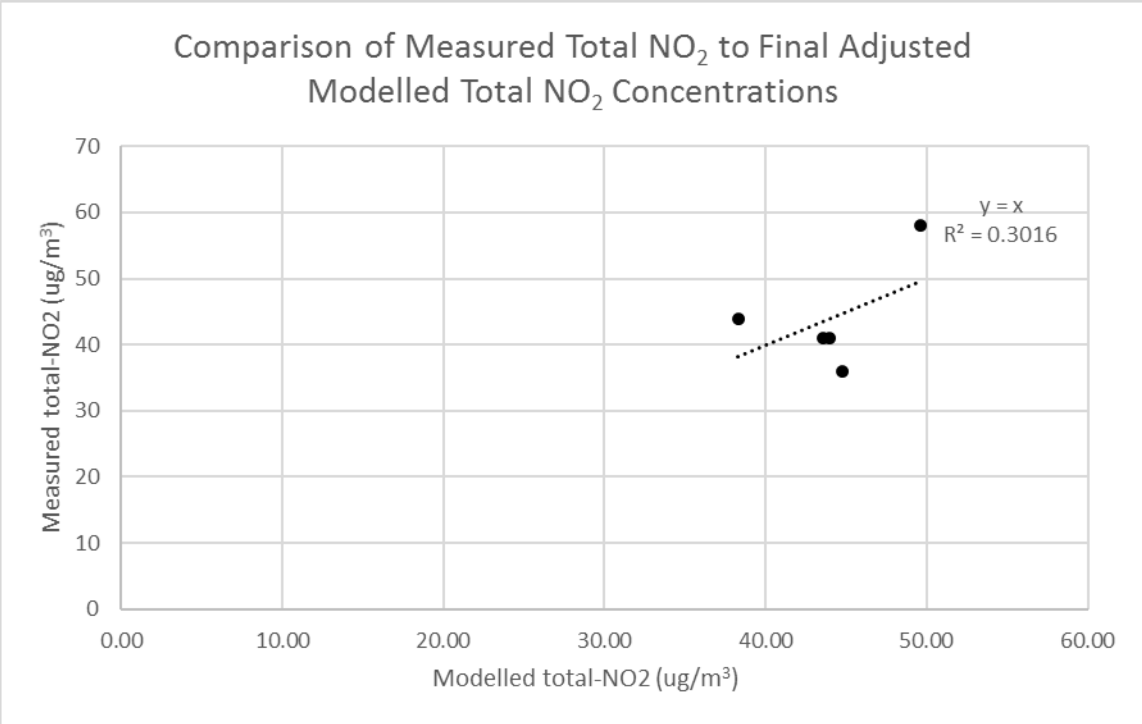

Figure 12 Comparison of Measured Total NO_2 to Final Adjusted Modelled Total NO_2 Concentrations.

A3.2.3 PM_{10} and $PM_{2.5}$.

There are no PM_{10} or $PM_{2.5}$ monitors within the study area; therefore, the model outputs of road-PM have been adjusted by applying the primary adjustment factor calculated for road NO_x.

A3.3 Model Post-processing.

A3.3.1 NO_2

The NOx to NO_2 calculator v6.1 published by Defra has been used to convert the modelled, verified road-NOx output for each receptor to road-NO_2. The background NO_2 concentrations have then been added to the predicted road-NO_2 concentrations and adjusted using the secondary verification factor to give the final predicted concentrations.

A3.3.2 PM_{10} and $PM_{2.5}$

The verified road-PM outputs need no further processing, and have been added to the background concentrations to give the final predicted concentrations.

A3.4 Sensitivity Analysis.

There is some uncertainty with regard to future reductions in road traffic NOx emissions used in the EFT and the background maps. Therefore, a sensitivity analysis has been undertaken which assumes that there are no reductions in emission factors for road traffic from the baseline year.

The model inputs are as described above; however, emission factors from the verification year (2017) have been used with the future year traffic data to predict 'no emissions reduction' NO_2 concentrations.

The future year road traffic component of background NOx and NO_2 concentrations have also been held constant at the verification year (2017) level in order to calculate 'no emissions reduction' background concentrations. This has been done using the source-specific background nitrogen oxides maps provided by Defra. For each grid square, the road traffic component has been held constant at 2017 levels, while 2020 values have been taken for the other components. NO_2 concentrations have then been calculated using the background nitrogen dioxide calculator which Defra publishes to accompany the maps.

For PM, there is no strong evidence that Defra's predictions are unrealistic and so the year-specific mapped concentrations have been used.

The 'no emissions reduction' background concentrations at the application site are shown in Table 16.

Table 16 Estimated Annual Mean 'No Emissions Reduction' Background Concentrations in 2020 (µg/m^3)

Year	NO_2
2020	23.1
Objective	40

Appendix 4 – Additional Modelling Results.

Refer to Figure 2 for model prediction locations.

10.1 Proposed receptors.

Table 17 Predicted Concentrations of NO_2 in 2020 at proposed receptors (Scenario B)

Proposed Receptors*	Concentration with development (µg/m^3)	Objective exceeded?	Mitigation Required?	Reason
1.G	25.1	No	No	No exceedance
2.G	25.0	No	No	
3.G	25.2	No	No	
4.G	25.3	No	No	
5.G	25.5	No	No	
6.G	26.9	No	No	
7.G	25.8	No	No	
8.G	27.3	No	No	
9.G	26.2	No	No	
10.G	26.5	No	No	
11.G	27.1	No	No	
12.G	27.8	No	No	
13.G	27.5	No	No	
1.1	25.0	No	No	
2.1	24.9	No	No	
3.1	25.1	No	No	
4.1	25.1	No	No	
5.1	25.4	No	No	
6.1	26.1	No	No	
7.1	25.6	No	No	
8.1	26.4	No	No	
9.1	26.0	No	No	
10.1	26.3	No	No	
11.1	26.8	No	No	
12.1	27.0	No	No	
13.1	26.6	No	No	

* Proposed modelling receptor number includes G for Ground Floor and a further number which represents the floor of the development

Table 18 Predicted Concentrations of PM_{10} in 2020 at proposed receptors

Proposed Receptors*	Concentration with development (µg/m³)	Objective exceeded?	Mitigation Required?	Reason
1.G	16.6	No	No	No exceedance
2.G	16.6	No	No	
3.G	16.6	No	No	
4.G	16.6	No	No	
5.G	16.7	No	No	
6.G	16.8	No	No	
7.G	16.7	No	No	
8.G	16.9	No	No	
9.G	16.8	No	No	
10.G	16.8	No	No	
11.G	16.9	No	No	
12.G	17.0	No	No	
13.G	16.9	No	No	
1.1	16.6	No	No	
2.1	16.6	No	No	
3.1	16.6	No	No	
4.1	16.6	No	No	
5.1	16.7	No	No	
6.1	16.7	No	No	
7.1	16.7	No	No	
8.1	16.8	No	No	
9.1	16.8	No	No	
10.1	16.8	No	No	
11.1	16.9	No	No	
12.1	16.9	No	No	
13.1	16.8	No	No	

* Proposed modelling receptor number includes G for Ground Floor and a further number which represents the floor of the development

Table 19 Predicted Concentrations of $PM_{2.5}$ in 2020 at proposed receptors

Proposed Receptors*	Concentration with development (µg/m^3)	Objective exceeded?	Mitigation Required?	Reason
1.G	10.5	No	No	No exceedance
2.G	10.5	No	No	
3.G	10.5	No	No	
4.G	10.5	No	No	
5.G	10.5	No	No	
6.G	10.6	No	No	
7.G	10.5	No	No	
8.G	10.6	No	No	
9.G	10.6	No	No	
10.G	10.6	No	No	
11.G	10.7	No	No	
12.G	10.7	No	No	
13.G	10.7	No	No	
1.1	10.5	No	No	
2.1	10.5	No	No	
3.1	10.5	No	No	
4.1	10.5	No	No	
5.1	10.5	No	No	
6.1	10.5	No	No	
7.1	10.5	No	No	
8.1	10.6	No	No	
9.1	10.6	No	No	
10.1	10.6	No	No	
11.1	10.6	No	No	
12.1	10.6	No	No	
13.1	10.6	No	No	

* Proposed modelling receptor number includes G for Ground Floor and a further number which represents the floor of the development

Appendix 5 – Air Quality Neutral.

The methodology report that supports the GLA's SPG on Sustainable Design and Construction provides guidance on the application of the air quality neutral policy.

The developments emissions are compared with the relevant emissions benchmarks to determine whether the development is air quality neutral.

10.2 Transport Emissions.

The TEB for the development is calculated by multiplying the gross internal floor area of each land use class by the relevant TEB from Table 20, and summing the results.

The transport related emissions (TRE) for each land use category are calculated using the:

- Gross internal floor area (m^2) of the development (A1-A5, B1), and/or the number of dwellings (C3, C4);
- Development trip rate (trips/annum);
- Average distance travelled (km) for each land-use class;
- Average road traffic emissions of NOx and PM_{10},

Table 20 Transport Emissions Benchmarks (TEB)

Land Use	NOx			PM_{10}		
	TEB (g/m2/Yr)					
	CAZ	Inner	Outer	CAZ	Inner	Outer
A1	169	219	249	29.3	39.3	42.9
B1	1.27	11.4	68.5	0.22	2.05	11.8
TEB (g/Dwelling/Yr)						
C3	234	558	1553	40.7	100	267

Appendix 6 – Professional Experience.

Chris Rush (Hoare Lea), BSc (Hons), MSc, PG Dip Acoustics, CEnv, MIOA, MIEMA, MIEnvSc, AMIAQM

Chris is an Associate Air Quality Consultant with Hoare Lea. He is a Chartered Environmentalist, a Member of the Institute of Acoustics, a Full Member of the Institute of Environmental Management and Assessment, a Member of the Institution of Environmental Sciences and an Associate Member of the Institute of Air Quality Management.

He has a diverse portfolio of experience and has worked on a range of projects from initial site feasibility, through planning and development to construction and operation. Chris's expertise covers planning, noise and air quality, specifically in relation to residential developments, industrial fixed installations such as waste management centres and transportation environmental impact on developments including air traffic. Chris is involved in the testing and assessment of the impact of indoor air quality and how building design contributes to this.

Andy Day (Hoare Lea), BSc (Hons), MSc, AMIEnvSc, AMIAQM

Andy is an Air Quality Consultant with Hoare Lea. He is an Associate Member of the Institute of Environmental Sciences and an Associate Member of the Institute of Air Quality Management. He is a chemistry graduate with a Master's specialising in the catalysed removal of harmful volatile organic compounds (VOCs) often generated from the combustion of fuel in car engines.

Andy provided input to the research for a scientific paper involving the use of catalysts prepared by a low NOx method for the complete removal of propane and naphthalene in lab based experiments. He has contributed to research as part of his degree into the causes and effects of poor outdoor air quality as well as exposure to poor indoor air quality.

Krystel Goodwin (Hoare Lea), IChemE

Krystel is a Placement Air Quality Consultant with Hoare Lea. She is a Student Member of the Institute of Chemical Engineering. She is currently progressing with an MEng in Chemical Engineering at the University of Birmingham and has interests in air quality and sustainable design.

Krystel has worked on various design projects at university, including feasibility and sustainability assessments for process plants and the built environment. Her most recent project involved the formulation of a thermochemical material and subsequent design of an energy storage system for building applications, along with assessing the impact on associated emissions.

Mohamed Jama (Hoare Lea), BEng (Hons)

Mohamed is a Graduate Air Quality Consultant with Hoare Lea. He is a Chemical Engineering Graduate from the University of Nottingham.

Mohamed's final year project involved designing a plant for the Andrussow production of Hydrogen Cyanide whereby he provided input on devising ventilation systems for waste gas removal. He has gained experience from his involvement in design projects throughout university. His interests lie in sustainability and Air Pollution Control.

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