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Redbridge Phase 1 High Level Transport Study

Air Quality Report

September 2015

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1. Introduction

Atkins Limited. has been commissioned to provide an air quality assessment for two opportunity sites identified in the London Borough of Redbridge's new draft Local Plan for development (from here on referred to as 'the Development Sites').

An air quality assessment is required to address concerns regarding changes in air quality as a result of additional traffic movements generated by the Development Sites. The two sites under consideration are the Oakfields Site (Site 1), which is within the proposed Barkingside Investment Area north of Barkingside Town Centre and the Goodmayes Site (Site 2), adjacent to the A12, which includes land in and around King George and Goodmayes Hospitals including the Ford Sports Ground.

Current masterplans show that the two Development Sites could yield between 1,474 and 2,849 new homes in total with supporting community infrastructure such as new schools. The Development Sites are expected to result in changes in traffic emissions and concentrations of air pollutants at air quality sensitive receptors around the Development Sites. In addition, it is important to ensure that new air quality sensitive receptors, such as the new homes and schools, introduced within the Development Sites, will not be exposed to air pollutant concentrations in excess of relevant Government criteria. The purpose of this report is to assess the potential impacts of the Development Sites on local air quality, and to consider the suitability of both Development Sites for the introduction of new air quality sensitive receptors.

The Development Sites are located within the boundaries of the Redbridge borough-wide air quality management area (AQMA) designated for exceedances of the annual mean nitrogen dioxide (NO_2) and the 24-hour mean particulate matter (PM_{10}) Government criteria. On this basis the pollutants NO_2 and PM_{10} are the focus of this assessment.

To address potential air quality impacts for the Development Sites, this air quality assessment includes:

- A review of relevant local air pollutants and air quality management in the regulatory and policy context;
- A summary of baseline conditions examining information on existing pollutant sources and measured ambient concentrations in the vicinity of the Development Sites, comparing these with relevant air quality criteria; and identification of constraints – sensitive receptors (human health and designated ecological sites), AQMAs and pollution sources, including roads and industry;
- Quantitative consideration of potential air quality impacts on local air quality during the operational phase;
- Consideration of options for mitigation to prevent or reasonably minimise any potentially significant effects, where required; and
- Conclusions and recommendations.

2. Legislation, Policy and Guidance

2.1. Key Air Pollutants

In most urban areas in the UK, including within the boundaries of the London Borough of Redbridge, the main local source of local air pollutants is road traffic. Emissions from vehicle exhausts contain a complex mixture of pollutants including oxides of nitrogen (a mixture of nitrogen dioxide and nitric oxide – dominated by the latter), particulate matter (PM), carbon monoxide, and hydrocarbons (including benzene and 1,3-butadiene). The quantities of each pollutant emitted depend upon the vehicle type, quantity and type of fuel used, engine size, speed of the vehicle and abatement equipment fitted. In recent years, the local air pollutants causing most concern been nitrogen dioxide and particulates.

The pollutants most relevant to traffic emissions, nitrogen dioxide and particulate matter, are introduced briefly below.

2.1.1. Nitrogen Dioxide

Nitrogen dioxide (NO_2) is a secondary pollutant produced by the oxidation of nitric oxide (NO). Nitric oxide and nitrogen dioxide are collectively termed oxides of nitrogen (NO_x). Just over a third of the UK NO_x emissions are from road transport. The majority of NO_x emitted from vehicles is in the form of NO, which oxidises rapidly in the presence of ozone (O_3) to form NO_2. In high concentrations, NO_2 can affect the respiratory system and can also enhance the response to allergens in sensitive individuals, whereas NO does not have any observable effect on human health at the range of concentrations found in ambient air.

2.1.2. Particulate Matter

Particulate matter in vehicle exhaust gases consists of carbon nuclei onto which a wide range of compounds are absorbed. These particles have an effective aerodynamic diameter of less than 10 micrometers (µm). Particles in this size range are referred to as PM_{10}. Diesel engines produce the majority of particulate emissions from the vehicle fleet. About a quarter of primary PM_{10} emissions in the UK are derived from road transport. Particulate matter appears to be associated with a range of symptoms of ill health including effects on the respiratory and cardiovascular systems, on asthma and on mortality. Reviews by the World Health Organisation (WHO) and the Committee on the Medical Effects of Air Pollutants (COMEAP) have suggested exposure to finer fraction of particles ($PM_{2.5}$, which typically makes up around two thirds of PM_{10} emissions[1] and concentrations) has a stronger association with observed ill health effects than PM_{10}.

2.2. Air Quality Legislation

There are two types of air quality regulations that apply in England:

- Regulations implementing mandatory European Union Directive limit values: The Air Quality Standards Regulations 2010 (Statutory Instrument (SI) 2010 No. 1001)[2]; and

- Regulations implementing national air quality objectives: Air Quality (England) Regulations 2000 (SI 2000 No. 928) and Air Quality (England) (Amendment Regulations 2002 (SI 2002 No. 3043)[3,4],

2.2.1. EU Limit Values

The first European Community (EC) air pollution limit values were introduced in the 1980s. The directives contained mandatory limit values that must be attained and more stringent, but non-obligatory, guide values. In April 2008, the European Commission adopted a directive on ambient air quality and cleaner air for Europe (2008/50/EC). This directive merged the previous Air Quality Framework Directive and the first three daughter directives and introduced new objectives for $PM_{2.5}$. This Directive has been transposed into the Air Quality Standards Regulations 2010 (SI 2010 No. 1001).

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[1] Fine ($PM_{2.5}$) and Coarse ($PM_{2.5}$-PM_{10}) Particulate Matter on a Heavily Trafficked London Highway: Sources and Processes, Aurelie Charron and Roy M. Harrison, The University of Birmingham: http://uk-air.defra.gov.uk/reports/cat05/0506061415_Fine_PM25_and_Coarse4.pdf
[2] The Air Quality Standards Regulations 2010: http://www.legislation.gov.uk/uksi/2010/1001/contents/made
[3] The Air Quality (England) Regulations 2000: http://www.legislation.gov.uk/uksi/2000/928/contents/made
[4] The Air Quality (England) (Amendment) Regulations 2002: http://www.legislation.gov.uk/uksi/2002/3043/contents/made

2.2.2. National Air Quality Strategy

The 2007 Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland[5] (UK AQS) sets out the national air quality standards and objectives for a number of local air pollutants. The standards are set by expert organisations with regard to scientific and medical evidence on the effects of the particular pollutant on health, and define the level of pollution below which health effects are expected to be minimal or low risk even for the most sensitive members of the population. The objectives are targets for air pollution levels to be achieved by a specified timescale, which take account of the costs and benefits of achieving the standard, either without exception or, for certain short term averaging period standards, with a permitted number of exceedances. Local authorities have a responsibility (under the Environment Act 1995) to review and assess local pollution levels against these objectives. These criteria are defined in Regulations SI 2000 No. 928 and SI 2002 No. 3043.

However, for some pollutants, such as particulate matter, it is recognised that there is no threshold concentration that can currently be determined, below which there are no effects on the whole population's health. An exposure reduction objective for the finer $PM_{2.5}$ fraction has therefore been introduced in the latest version of the strategy. This type of objective is designed to reduce average concentrations throughout an entire urban background area, thus ensuring that the majority of people will benefit, rather than just those who live in a particular hotspot area.

It should be noted that the UK air quality objectives only apply in locations likely to have 'relevant exposure' – i.e. where members of the public are exposed for periods equal to or exceeding the averaging periods set for the standards. For this assessment, locations of relevant exposure include building façades of residential premises, schools, public buildings and medical facilities; places of work (other than certain community facilities) are excluded.

The statutory air quality criteria for the protection of human health that are relevant to this assessment are outlined in Table 2-1.

Table 2-1 Statutory Air Quality Criteria

Pollutant	Objective
NO_2	Hourly average concentration should not exceed 200 µg/m^3 more than 18 times a year Annual mean concentration should not exceed 40 µg/m^3
PM_{10}	24-hour mean concentration should not exceed 50 µg/m^3 more than 35 times a year Annual mean concentration should not exceed 40 µg/m^3
$PM_{2.5}$	UK (except Scotland): annual mean concentration should not exceed 25 µg/m^3 by 2010† Exposure reduction^ (UK urban areas): target of 15% reduction in concentrations at urban background between 2010 and 2020*
† EU limit value is 25 µg/m^3 to be met by 2015, with a requirement in urban areas to bring exposure down to below 20 µg/m^3 by 2015. ^ New European obligations for a target of 20% reduction * 25 µg/m^3 is a cap to be seen in conjunction with 15% reduction	

2.2.3. Ecological Limit Values

The EU has set a limit value for the protection of vegetation for NO_x based on the work of the United Nations Economic Commission for Europe (UNECE) and WHO. The limit value for the protection of vegetation is a annual mean oxides of nitrogen concentration of 30 µg/m^3 and is included in SI 2010 No 1001. The limit value for the protection of vegetation applies in locations more than 20 kilometres (km) from towns with more than 250,000 inhabitants or more than 5 km from other built-up areas, industrial installations or motorways.

As the UNECE and the WHO have set a critical level for NOx for the protection of vegetation, the Statutory Nature Conservation Agencies' (in England, Natural England) policy is to apply the criteria, on a precautionary basis, as a benchmark, in internationally designated conservation sites (Ramsar, Special Area of Conservation (SAC), Special Area of Protection (SPA)) and Sites of Special Scientific Interest (SSSI). In addition, critical loads for nitrogen and acid deposition have been set that represent (according to current

[5] Department for Environment, Food and Rural Affairs (DEFRA), 2007. The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. http://archive.defra.gov.uk/environment/quality/air/airquality/strategy/documents/air-qualitystrategy-vol1.pdf

knowledge) the exposure below which there should be no significant harmful effects on sensitive elements of the ecosystem.

2.2.4. Local Air Quality Management

Under Part IV of the Environment Act 1995 all local authorities are responsible for Local Air Quality Management (LAQM), the mechanism by which the Government's AQS objectives are to be achieved. As part of this LAQM role, local authorities are required to periodically review air quality in their area and to assess present and likely future air quality against the objectives defined in Regulations. Where a local authority anticipates an objective is expected to be breached within their area, they must designate an AQMA and develop an action plan to improve pollution levels. Under the current LAQM regime, a local authority is responsible for regular review and assessment of local air quality, reports on which are published following public consultation and review by the Department for Environment, Food and Rural Affairs (DEFRA).

Statutory responsibility for achieving EU limit values rests with the Secretary of State and local authorities have no responsibility for achieving the national air quality criteria, although they should contribute to this through local action plans designed to reduce pollution levels in AQMAs. Guidance concerning local air quality is given in DEFRA's Technical Guidance LAQM.TG(09)[6]; the guidance provides relevant methods concerning treatment and interpretation of data.

All 33 of the London local authorities have declared AQMAs. The London Borough of Redbridge declared the whole borough as an AQMA in 2003, due to exceedances of the annual mean NO_2 and the 24 hour mean PM_{10} criteria. The London Borough of Redbridge adopted their Air Quality Action Plan (AQAP)[7] in 2007 with the aim to reduce air pollutant concentrations. This AQAP sets out 57 key actions for reducing pollution concentrations within the London Borough of Redbridge administrative boundary. The AQAP identifies road traffic to be the primary source of air pollution and includes measures to both reduce the emissions from vehicles in the Borough and to reduce the amount of traffic on the roads.

2.3. Non-Statutory Guidance

2.3.1. Development Control

In 2010, the organisation "Environmental Protection UK" (EPUK) published development guidance for local planning authorities and consultants (2010 EPUK Development Control Guidance)[8]. The aim of the EPUK Development Control Guidance was to provide more specific, non-statutory guidance on air quality and the planning system. The 2010 EPUK Development Control Guidance has been widely accepted by consultants and local authorities as a useful reference when undertaking air quality assessments over the last five years.

In May 2015, an update to the 2010 EPUK Development Control Guidance was published by EPUK and the Institute of Air Quality Management (IAQM) (2015 EPUK / IAQM Land-Use Planning and Development Control Guidance)[9]. The May 2015 version of the guidance sets out to ensure that air quality is adequately considered in the land-use planning and development control processes. It comprises an initial screening stage to determine the need for an air quality assessment. If an assessment is required, a number of more stringent criteria are provided to help establish the need for further work, which may be either qualitative or quantitative, simple or detailed. It also provides a framework for describing the magnitude of changes in local air pollutant concentrations at individual receptors and gives advice on how overall significance may be assessed.

[6] DEFRA Local Air Quality Management Technical Guidance (LAQM.TG(09): https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69334/pb13081-tech-guidance-laqm-tg-09-090218.pdf

[7] The London Borough of Redbridge Air Quality Action Plan, 2007.

[8] EPUK (2010). Development Control, Planning For Air Quality (2010 Update): http://www.environmental-protection.org.uk/wp-content/uploads/2013/07/EPUK-Development-Control-Planning-for-Air-Quality-2010.pdf

[9] EPUK / IAQM (2015). Land-Use Planning & Development Control: Planning For Air Quality, May 2015: http://www.iaqm.co.uk/text/guidance/air-quality-planning-guidance.pdf

2.4. Air Quality Planning Policies

2.4.1. National Planning Policy

National Planning Policy Framework

The Government's planning guidance of general relevance for air quality is found within the National Planning Policy Framework (NPPF)[10]. It assists local authorities to incorporate air quality considerations into planning decisions and attempts to protect the environment and to promote sustainable growth. It states that:

> *"Planning policies should sustain compliance with and contribute towards EU limit values or national objectives for pollutants, taking into account the presence of Air Quality Management Areas[11] and the cumulative impacts on air quality from individual sites in local areas. Planning decisions should ensure that any new development in Air Quality Management Areas is consistent with the local air quality action plan."*

Planning Practice Guidance

Planning Practice Guidance (PPG)[12] is intended to support the NPPF and provide further detail to its policies. PPG indicates at paragraph 006 that information relating to air quality could be important to decision makers, and when there are concerns about air quality, the local planning authority may want to know about:

- "The 'baseline' local air quality;
- Whether the proposed development could significantly change air quality during the construction and operational phases; and/or
- Whether there is likely to be a significant increase in the number of people exposed to a problem with air quality, such as when new residential properties are proposed in an area known to experience poor air quality."

PPG also advocates (at paragraph 006) early engagement with the local planning and environmental health departments to establish the scope of any assessment. Guidance is also given on the level of detail required in an air quality assessment, and measures which could be employed to mitigate adverse effects.

2.4.2. Sub-regional Planning Policy

The London Plan

The London Plan (GLA, 2011)[13] is the overall spatial development strategy for Greater London. This sets out a fully integrated economic, environmental, transport and social framework for the development of London up to 2031. Policy 7.14: Improving Air Quality states that:

> *"The Mayor recognises the importance of tackling air pollution and improving air quality to London's development and the health and well-being of its people. He will work with strategic partners to ensure that the spatial, climate change, transport and design policies of this plan support implementation of his Air Quality and Transport strategies to achieve reductions in pollutant emissions and minimise public exposure to pollution."*

The Mayor's priorities for development proposals include:

- Designing of schemes so that they are at least 'air quality neutral' and designed to minimise the generation of air pollution;
- Minimising and mitigating against increased exposure to poor air quality;
- Selecting plant that meets the standards for emissions from combined heat and power and biomass plants; and

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[10] Dept for Communities and Local Government (2012), National Planning Policy Framework, 27 March 2012. https://www.gov.uk/government/publications/national-planning-policy-framework--2
[11] Air quality management areas are discussed under Local Planning Policy
[12] http://planningguidance.planningportal.gov.uk/blog/guidance/air-quality/
[13] Greater London Authority (GLA), The London Plan Spatial Development Strategy for Greater London, July 2011. https://www.london.gov.uk/priorities/planning/london-plan

- Reducing emissions from the demolition and construction of buildings by following the guidance set out in The Control of Dust and Emissions during Construction and Demolition Supplementary Planning Guidance (SPG)[14].

London's Air Quality Strategy
The Mayor of London's Air Quality Strategy (2010)[15] sets out specific policies and proposals to address the air quality issues, including reducing emissions from transport, reducing emissions from homes, business and industry and increasing awareness of air quality issues. The Mayor's Air Quality Strategy contains fourteen policies. Policy 1 to Policy 5 are aimed at reducing transport related air quality pollutants, Policy 6 to Policy 12 relate to non-transport measures and includes a policy on reducing emission for construction and Policy 13 and Policy 14 relate to implementation of the Air Quality Strategy including working with the Government, other authorities and London Boroughs.

2.4.3. Local Planning Policy

Redbridge Local Development Framework (LDF)
The Local Development Framework (LDF) is a portfolio of planning documents, individually known as Local Development Documents. The LDF for the London Borough of Redbridge delivers the spatial development strategy for the building on the London Plan for the London Borough of Redbridge.

Documents within the London Borough of Redbridge LDF addressing air quality consist of the:

- Core Strategy Development Plan Document;
- Borough Wide Primary Policies Development Plan Document;
- Sustainable Design and Construction Supplementary Planning Document; and
- Redbridge Local Plan 2015 - 2030

Core Strategy Development Plan Document
The London Borough of Redbridge Core Strategy Development Plan Document, adopted in 2008[16], sets out an overall spatial strategy for the Borough and provides general guidelines on the vision of types and location of future development.

The Core Strategy contains Strategic Objectives to guide the future planning of the Borough and help achieve its spatial vision. Twelve Strategic Policies are provided to help achieve the Strategic Objectives. They include the following objectives relevant to air quality:

- SP2: Green Environment which states that *"Nature conservation, protection and enhancement of open space and mitigation of climate change will be achieved by: ... (g) Minimising the release of pollutants (including CO_2) and other contaminants (including silt and sediment) into the Borough's air, waterways and soil.."* and
- SP6: Movement and Transport which states that "*A transport network that supports a prosperous economy and socially cohesive community, reduces car dependence, encourages sustainable transport, improves air quality and reduces greenhouse gas contributions to climate change will be achieved...".*

Borough Wide Primary Policies Development Plan Document
This Borough Wide Primary Policies Development Plan Document[17] translates the twelve strategic policies of the Core Strategy Development Plan Document into thirty-four policies to be applied in the detailed assessment of planning applications. Air Quality is directly addressed in E8 – Air Quality:

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[14] Greater London Authority, The Control of Dust and Emissions during Construction and Demolition Supplementary Planning Guidance, July 2014, available at: https://www.london.gov.uk/sites/default/files/Dust%20and%20Emissions%20SPG%208%20July%202014_0.pdf
[15] Greater London Authority, Cleaning the Air, The Mayor's Air Quality Strategy, December 2010. https://www.london.gov.uk/sites/default/files/Air_Quality_Strategy_v3.pdf
[16] London Borough of Redbridge, Local Development Framework, Core Strategy, Development Plan Document, March 2008 http://www2.redbridge.gov.uk/cms/planning_land_and_buildings/planning_policy__regeneration/local_development_framework.aspx#dpds
[17] London Borough of Redbridge, Local Development Framework, Borough Wide Primary Policies, Development Plan Document, May 2008 , available at:

- *"To complement the Air Quality Area Action Plan, the Council will:*
  1. *Require air quality assessments for major development proposals considered likely to have a significant and harmful impact on air quality*
  2. *Refuse development proposals which could cause significant deterioration in air quality or expose members of the public to poor air quality, unless appropriate mitigating measures are put into place*
  3. *Require developers to use the most up to date Best Practice Guidance for all stages of development, with particular reference to dust, vapours, plant and vehicle emissions."*

Sustainable Design and Construction Supplementary Planning Document

The London Borough of Redbridge Sustainable Design and Construction Supplementary Planning Document (SPD), adopted in 2012[18], provides guidance on how development in Redbridge should be designed, built and occupied in order to achieve best practice standards (or better) or sustainable design and construction. Guidance is provided for seven main areas including: "*Minimising air, land, water and noise pollution*". The following requirement is included for air quality:

> "*All new development should be 'air quality neutral' or better through the management and mitigation of emissions. An air quality assessment is required for all development:*
>
> > *(i)Likely to have a significant and harmful impact on air quality (i.e. it will increase pollutant concentrations) either through the operation of the proposed development or trip generation arising from the development.*
> > *(ii) Located in an area of poor air quality (i.e. it will expose future occupiers to unacceptable pollutant concentrations / new exposure).*
> > *(iii) If the demolition / construction phase will have a significant impact on the local environment (i.e. through fugitive dust and exhaust emissions). If this is the case, the Mayor of London's 'control of dust and emissions from construction and demolition' must be followed.*
> > *(iv) If the development prevents implementation of measures in the Air Quality Action Plan."*

Redbridge Local Plan 2015 - 2030

The London Borough of Redbridge Draft Local Plan 2015-2030 is currently being produced. It will set out where, when and how growth may take place across the borough.

Since the LDF was adopted in March 2008 a number of issues have emerged that will need to be addressed as part of the review, including changes to planning policy at national level; a new London Plan and the increasing need for housing, social and community infrastructure.

The Draft Local Plan is currently addressing the Preferred Option Report and this air quality assessment is in support of evidence for the Phase 1 High Level Transport Study.

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http://www2.redbridge.gov.uk/cms/planning_land_and_buildings/planning_policy__regeneration/local_development_framework.aspx

[18] London Borough of Redbridge, Planning and Regeneration Service, Sustainable Design and Construction, Supplementary Planning Document, January 2012
http://www2.redbridge.gov.uk/cms/planning_and_the_environment/planning_policy__regeneration/local_development_framework/supplementary_planning_doc.aspx

3. Baseline Conditions

The review of the existing air quality in the vicinity of the Development Sites and notable air pollution sources has been determined by reference to the following sources of information:

- London Borough of Redbridge LAQM review and assessment reports[19] [20];
- Monitoring data from the local authority and the London Air website[21];
- Background data from DEFRA's UK Air Information Resource (UK-AIR) website[22];
- London Atmospheric Emissions Inventory (LAEI)[23]; and
- Environment Agency's Pollution Inventory website[24].

3.1. Study Area

Both Development Sites lie within the London Borough of Redbridge area.

Site 1, the Oakfields Site, falls within the proposed Barkingside Investment Area, to the immediate north of Barkingside Centre. The surrounding area is predominantly residential housing, schools and open space. Site 1 is surrounded by suburban housing on three sides; north south and west and a raised railway embankment to the east. Fairlop London Underground station lies adjacent to the south-east corner of the Site. Frequent bus routes run along the A123 Fencepiece Road located immediately to the west of the Site. The Site itself is currently occupied by the Redbridge Sports and Leisure Centre at the eastern end; the Frenford sports pitches to the northern end and the Old Parkonians sports pitches within the south side of the Site.

Site 2, the Goodmayes Site, falls within land in and around King George and Goodmayes Hospitals, including the Ford Sports Ground and the Seven Kings Park located at the south western end of the Site. The surrounding area of the Goodmayes Site is predominantly residential housing, schools and open space. The A12 passes immediately to the north of the Site and the B177 along its eastern boundary.

The nearest air quality sensitive receptors to the Development Sites with relevant public exposure include residential properties adjacent to the boundaries of the Development Sites. There are no statutory designated ecological sites located within one kilometre of the Site boundaries and this type of air quality sensitive receptor is not considered further in the assessment.

The Development Sites are within the boundary of the London Borough of Redbridge AQMA declared for exceedances of the annual mean NO_2 and 24 hour mean PM_{10} Government criteria. The Development Sites are shown in Figure 3-1 with air quality constraints such as roads and local monitoring sites also shown.

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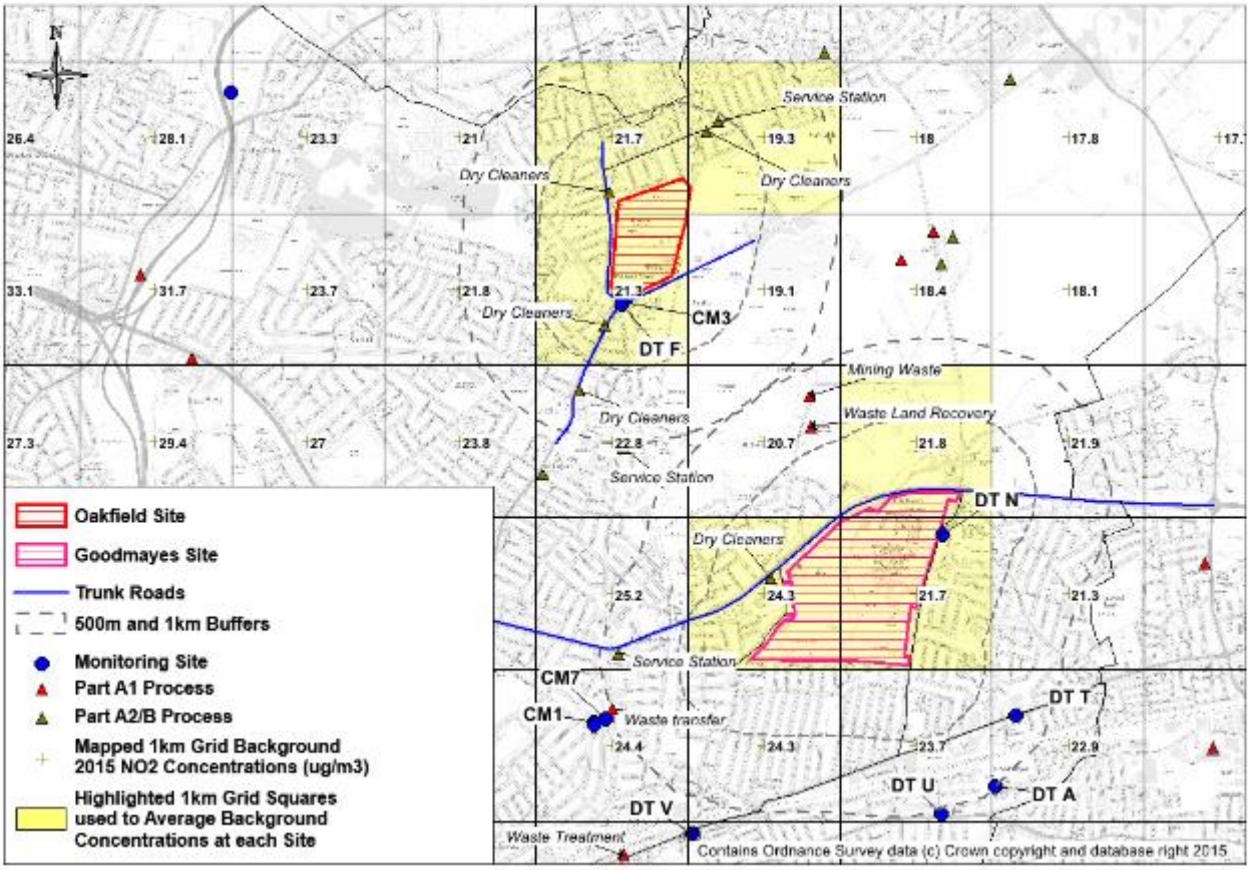
[19] 2014 Air Quality Progress Report for London Borough of Redbridge, February 2015
[20] 2012 Air Quality Updating and Screening Assessment for London Borough of Redbridge, November 2012
[21] London Air, Environmental Research Group, King's College London: www.londonair.org.uk
[22] UK-Air: Air Information Resource, DEFRA, 2015. http://uk-air.defra.gov.uk/
[23] GLA, London Atmospheric Emissions Inventory (LAEI): http://www.cleanerairforlondon.org.uk/londons-air/air-quality-data/london-emissions-laei/gla-emissions-summary
[24] http://maps.environment-agency.gov.uk/wiyby/wiybyController?ep=maptopics&lang=_e

Figure 3-1 Local Air Quality Constraints Map



Not to Scale.

3.2. Local Air Quality Monitoring

There are currently two continuous monitoring stations (CMS) in operation within the London Borough of Redbridge boundary. These sites are:

- CM1 – Redbridge 1: An urban background site located around Perth Terrace. This site was on Perth Terrace, but relocated nearby to Ley Street in May 2014 and renamed CM7. This site is 2.8 kilometres south of the Oakfields Site and 1.2 kilometres south west of the Goodmayes Site; and
- CM4 – Redbridge 4: A roadside site close to the A12 located, 4.2 kilometres south west of the Oakfields Site and 4.6 kilometres west of the Goodmayes Site.

The Council previously operated three other CMS in the Borough:

- CM2 - Redbridge 2: A roadside site on Ilford Broadway, over 2 kilometres south from the Development Sites). This site was closed in 2003;
- CM3 - Redbridge 3: A kerbside site at Fulwell Cross, located 40 metres south of the Oakfields Site. This site closed in 2012; and
- CM5 - Redbridge 5: A roadside site in South Woodford, located over 4 kilometres west from the Development Sites). This site closed in 2012.

Given the distance and years of operation of CM2, CM4 and CM5 monitoring sites these are not considered further in this assessment. CM1, CM3 and CM7 are considered relevant to the assessment. CM3 is located within one kilometre of the Oakfields Site. CM1 and CM7 are within 1.2 kilometres of the Goodmayes Site. The locations of CM1/CM7 and CM3 are shown in Figure 3-1.

Recent CMS data, shown in Table 3-1 and Table 3-2, show that annual mean NO_2 concentrations are exceeding at roadside sites and below the objective at urban background sites, whilst NO_2 hourly mean and annual and 24 hour mean PM_{10} concentrations are below their respective objectives.

The London Borough of Redbridge also operates a network of passive NO_2 diffusion tubes at 22 locations across the Borough. Relevant NO_2 diffusion tube monitoring locations are shown in Figure 3-1. The nearest diffusion tube monitoring sites are located 40 metres away from each of the Development Sites (DT F for the Oakfields Site and DT N for the Goodmayes Site). The most recently available, bias adjusted data, are for the year 2014.

The diffusion tube site nearest to the Oakfields Site, the roadside DT F at Fullwell Cross, has monitored exceedances of the annual mean Government criterion in the past five years. The nearest diffusion tube site to the Goodmayes Site 2, the ‘near roadside’ DT N, has monitored concentrations below the annual mean Government criterion. Concentrations at the boundaries of both Development Sites, which will be located approximately 10 metres from the nearest monitoring sites, are expected to be similar to those monitored at the nearest diffusion tube sites, but are expected to decrease with increasing distance from the roads.

Trend analysis of the monitored concentrations has been undertaken. This analysis indicates that there are no statistically significant trends in concentrations at any of the monitoring sites. Further details of this analysis are presented in Appendix A.

Table 3-1 Nitrogen Dioxide Annual Mean Concentrations (µg/m^3) (Hourly Exceedances in Brackets)

Name of Monitoring Site and Type	Distance from nearest Site (km)	Grid Reference	2010	2011	2012	2013	2014
CM1 – UB Perth Terrace	1.2 (SW of Goodmayes)	544381,187649	33.0 (0)	33.3 (0)	36.8 (0)	35.4 (1)	32.8* (0)
CM7 – UB Ley Street	1.2 (SW of Goodmayes)	544455,187682	closed	closed	closed	closed	34.6* (0)
CM4 – R Gardner Close	4.2 (SW of Oakfields)	540828,188368	**47.9** (1)	**49.2** (0)	**48.3** (8)	**45.0** (1)	**48.3*** (0)
CM3 – K Fulwell Cross	0.04 (S of Oakfields)	544570, 190420	**51.1** (0)	**52.0** (1)	closed	closed	closed
DT F – R Winston Way Primary School	0.04 (S of Oakfields)	544561,190400	**52.4**	**49.0**	**52.5**	**44.0**	**42.3**
DT N – NR Ethel Davis School	0.04 (E of Goodmayes)	546676,188885	31.4	28.5	31.9	32.9	25.8
DT T – K Chadwell Heath Primary School	0.8 (SE of Goodmayes)	547158, 187699	closed	closed	closed	**47.2**	**41.4**
DT A – UB Mayfield School	1.0 (SE of Goodmayes)	547022,187232	26.3	26.2	28.7	24.1	24.2*
DT U – R Goodmayes Primary School	1.0 (S of Goodmayes)	546665,187046	closed	closed	closed	35.6	34.3
DT V – NR Isaac Newton Academy	1.2 (S of Goodmayes)	545030,186920	closed	closed	closed	34.7	36.0

Diffusion Tube data adjustment factors: 2010 – 0.79; 2011 – 0.87; 2012 – 0.86; 2013 – 0.80; 2014 – 0.76
* data was annualised by London Borough of Redbridge as data capture was less than 75%
Exceedances of air quality criteria are highlighted in bold.

Definition of monitoring types:
- DT - diffusion tube
- CM = continuous monitoring site
- K = Kerbside sites - Sample inlets within 1 metre of the edge of a busy road.
- R = Roadside sites - Sample inlets between 1 metre of the kerbside of a busy road and the back of the pavement. Typically this will be within 5 metres of the kerbside.
- NR = Near Road sites – Sample inlets beyond roadside location, typically within 40 metres of the kerbside.

- UB = Urban Background sites - Urban locations distanced from sources and broadly representative of city-wide background concentrations e.g. elevated locations, parks and urban residential areas.

Table 3-2 PM_{10} Annual Mean Concentrations (µg/m^3) (No. of Exceedances of the 24 Hour Mean are in Brackets)

Name of Monitoring Site and Type	Distance from Site (km)	Grid Reference	2010	2011	2012	2013	2014
CM1 – UB	1.2 (SW of Goodmayes)	544381,187649	14.7 (0)	16.3 (5)	14.9 (2)	17.7 (2)	16.9* (5)
CM7 – UB	1.2 (SW of Goodmayes)	544455,187682	closed	closed	closed	closed	22.9* (7)
CM4 – R	4.2 (SW of Oakfields)	384310, 398337	31.1 (18)	25.9 (11)	27.0 (18)	30.3 (23)	25.4 (9)
CM3 – K	0.04 (S of Oakfields)	544570, 190420	30.9 (17)	28.9 (29)	closed	closed	closed

* data was annualised by London Borough of Redbridge as data capture was less than 75%

Definition of monitoring types:
- CM = continuous monitoring site
- K = Kerbside sites - Sample inlets within 1 metre of the edge of a busy road.
- R = Roadside sites - Sample inlets between 1 metre of the kerbside of a busy road and the back of the pavement. Typically this will be within 5 metres of the kerbside.
- UB = Urban Background sites - Urban locations distanced from sources and broadly representative of city-wide background concentrations e.g. elevated locations, parks and urban residential areas.

3.3. Background Pollution Mapping

Estimates of background pollutant concentrations in the UK are available on the DEFRA UK-AIR website. The background estimates, which are a combination of measured and modelled data, are available for each one km grid square throughout the UK for a base year of 2011, which is the basis for the future year estimates up to 2030.

The estimated annual mean background concentrations of relevant pollutants averaged for the grid squares in which each Development Site is located (Site 1: 544500, 190500; 544500, 191500 and 545500, 191500; and Site 2: 546500, 18850; 545500, 188500 and 546500, 189500; as shown in Figure 3-1) are provided in Table 3-3, for the years 2014 and 2015. The estimated average background annual mean concentrations are below relevant air quality criteria.

Table 3-3 Background Annual Mean Concentrations at the Development Sites for 2014, and in 2015 (µg/m^3)

	2014		2015	
Pollutant	**Site 1**	**Site 2**	**Site 1**	**Site 2**
NO_x	32.3	34.8	31.3	33.8
NO_2	21.3	23.2	20.8	22.6
PM_{10}	19.3	20.6	19.0	20.3

3.4. Local Emissions Sources

The London Atmospheric Emissions Inventory (LAEI) contains emissions estimates on a 1 km square basis for the GLA Area. The emissions are provided for source sectors split into broad types (e.g. road transport, domestic gas combustion, industry, aviation) as well as into a more detailed breakdown of the road transport sector by vehicle type (e.g. petrol car, bus, motorcycle). Table 3-4 presents the NO_x and PM_{10} emission estimates for the averaged three kilometre grid squares encompassing each development site (highlighted in Figure 3-1). The data are presented for 2015, the latest year available.

The greatest contributor to both NO_x and PM_{10} emissions within the grid squares of interest at both Sites is road transport, contributing to an average of 73% of all NO_x emissions and 63% of all PM_{10} emissions at the Oakfields Site and an average of 64% of all NO_x and 43% of all PM_{10} emissions at Goodmayes Site in 2015.

The next three largest contributors to emissions are 'Domestic Gas', 'Non-Domestic Gas' and Part B industrial sources, the latter in particularly effecting contributing to the emissions at the Goodmayes Site. All of these sectors are accounted for in the background pollutant concentrations used in the air quality assessment and are further discussed below.

Table 3-4 2015 Emissions of Pollutants (tonnes) at the Development Sites by Source Type

Sector	NO_x		PM_{10}	
	Site 1	Site 2	Site 1	Site 2
Road Transport	**6.31**	**11.16**	**0.42**	0.82
Gas - Domestic	1.47	1.44	0.03	0.03
Gas - Non-Domestic	0.69	1.63	0.01	0.03
Industry Non Road Mobile Machinery	0.07	0.01	0.00	0.00
Agriculture: Stat and Mach	0.07	0.10	0.01	0.02
Household and Garden	0.04	0.02	0.00	0.00
Domestic Oil	0.02	0.02	0.00	0.00
Fires	0.01	0.01	0.03	0.03
Waste	0.01	0.01	0.08	0.05
Non-Domestic Coal	0.01	0.02	<0.01	0.01
Aviation	<0.01	<0.01	<0.01	<0.01
Domestic Coal	<0.01	<0.01	<0.01	<0.01
Part B Industrial	<0.01	3.13	0.05	**0.87**
Non-Domestic Oil	<0.01	0.20	<0.01	0.01
Resuspension	0	0	0.01	0.02
Highest emission source for each pollutant is in **bold** type				

Industrial processes can be classified as Part A1, A2 and B processes, according to the regulatory body under which they are permitted. Part A processes are permitted by the Environment Agency and Part A2 and B processes by the local authority. Data available from the Environment Agency[25] and the Redbridge Public Register[26] have been used to identify potential air quality constraints to the development.

The London Borough of Redbridge's latest LAQM report indicates that there are no Part A processes in the Borough. The London Borough of Redbridge permits more than 70 smaller Part B industrial and other minor installations, the majority of which are dry cleaning processes. A review of the Environment Agency's website confirms that there are no Part A1 processes within 500 metres of either Development Site, however waste transfer, waste land recovery and mining waste processes were found within one kilometre of the Goodmayes Site. The London Borough of Redbridge public register indicates that there are five Part A2/B processes within one kilometre of the Oakfields Site and two within one kilometre of the Goodmayes Site. These processes are petrol stations and dry cleaning services and are shown Figure 3-1. These regulated processes are unlikely to be a constraint on the Development Sites.

3.5. Baseline Conditions Summary

The Development Site lie within the Redbridge AQMA, a borough wide AQMA declared for exceedances of the annual mean NO_2 and 24 hour PM_{10} Government criteria.

Air quality monitoring data indicates that concentrations of NO_2 are above air quality criteria at roadside monitoring locations. Background pollution mapping data from DEFRA and the air quality monitoring data for the urban background monitoring sites, both indicate that background concentrations are currently below relevant air quality criteria. The Oakfields Site is located in the vicinity of Fullwell Cross, an area where

[25] https://www.gov.uk/check-local-environmental-data
[26] http://emissions.redbridge.gov.uk/asp/processes.asp?level=All&DryClean=N&processName=First&view=

recent monitoring data indicates exceedances of annual mean NO_2 government air quality criterion at roadside locations. The Goodmayes Site is not in the vicinity of an area of exceedance of the annual mean NO_2 government air quality criterion.

The PM_{10} air quality criteria are have not been exceeded at any location within the London Borough of Redbridge.

Road transport emissions are the primary source of air pollutant emissions in the vicinity of the Development Sites. The nearest major road to the Oakfields Site is the A123 Fencepiece Road, which lies immediately west of the Development Site. The nearest major road to the Goodmayes Site is the A12 Eastern Avenue, which lies immediately north of the Development Site. There are a number of regulated industrial processes within one kilometre of the boundaries of the Development Sites Boundaries, but these processes are unlikely to be a constraint to either of the Development Sites.

4. Potential Effects

4.1. Operational Effects

Once complete, the Developments Sites may result in changes in traffic emissions and changes concentrations of air pollutants at air quality sensitive receptors around the Development Sites. In order to assess the potential impact, an assessment of local air quality has been undertaken for the operation of the Development Sites.

4.1.1. Methodology

The need for assessment of operational impacts of the Development Sites has been determined based on the criteria given in the 2015 EPUK / IAQM Land-Use Planning and Development Control Guidance. An air quality assessment is required if the development comprises:

- 10 or more residential units or a site area of more than 0.5 ha; or
- More than 1,000 m^2 of floor space for all other uses or a site area greater than 1 ha; and either:
- More than 10 parking spaces; or
- A centralised energy facility or other centralised combustion process.

One or more of these criteria were exceeded and further screening was undertaken using traffic change criteria in the 2015 EPUK / IAQM Land-Use Planning and Development Control Guidance to determine the need for an air quality assessment of the impact of the operation of the Development Sites due to changes in traffic flow, composition and speed. The relevant traffic change criteria are:

- Change of light duty vehicles (LDV) of 100 AADT or more within or adjacent to an AQMA; and
- Change of heavy duty vehicles (HDV) of 100 AADT or more within or adjacent to an AQMA;

Traffic data were provided by the project transport consultant (Atkins Transportation) for four roads around each of the Development Sites:

- The roads in around the Oakfields Site were: the New North Road, Forest Road, the A123 High Street and Fencepiece Road; and
- The roads around the Goodmayes Site were: the A118 High Road, Barley Lane North, B177 Barley Lane South and Aldborough Road South.

The traffic data was estimated from automatic traffic count (ATC) data collected for a full typical week commencing on the 10th of July 2015 and factored to provide future flows with and without the Development Sites completed and operational in the future year of 2030[27]. Changes in traffic flows meet the criteria given in the 2015 EPUK / IAQM Land-Use Planning and Development Control Guidance on all of the eight roads where data was available.

Given the proximity of the A12 Eastern Avenue to the Goodmayes Site, traffic data for the A12 was also included in the air quality model. The DfT provides street-level data for every junction-to-junction link on the ‘A’ road and motorway network in the UK. 24 hour Annual Average Daily Traffic (AADT) flows and percentages of heavy duty vehicles (HDVs) for the A12 were obtained from the Department for Transport (DfT) website[28] and factored to 2030 using Tempro factors.

Traffic data used in the assessment are presented in Appendix B.

Given the location of the Development Sites within an AQMA, assessment of the operational traffic emissions was undertaken using the dispersion modelling software, ADMS-Roads (version 3.4). The model uses information on traffic flows, speeds and composition, vehicle emission rates, road alignment and width, and local meteorological data to estimate local air pollutant concentrations at identified receptor locations.

[27] Future year flows were estimated for the Development Sites under Low Yield, a Medium Yield and a High Yield. For the purpose of the air quality assessment only the worst case scenarios was assessed. For the Oakfields Site this was Medium Yield (High Yield was not an option for this site) and for the Goodmayes Site this was High Yield. Further information is provided in the Transport Assessment.

[28] Department for Transport Traffic Counts: http://www.dft.gov.uk/traffic-counts/

4.1.1.1. Assessment Scenarios

Pollutant concentrations were determined for the following three scenarios:

- Base year (2014) to permit model verification using local monitoring data;
- Future year (2030) without the Development Sites; and
- Future year (2030) with the Development Sites.

The future year of 2030 was assessed at this stage as it is the year used in the High Level Transport Study and reflects the end year of the impending Redbridge Local Plan covering the period 2015 to 2030. The traffic data for the year 2030 assumed traffic growth based on the relevant TEMPRO growth factors for London Borough of Redbridge and additional trips generated by relevant committed developments.

4.1.1.2. Emission Factors

Vehicle exhaust emissions of NO_x and particulate (PM_{10} and $PM_{2.5}$) matter for each road link in each scenario were calculated within the ADMS-Roads model, which incorporates Defra's latest Emissions Factors Toolkit (EFT, version 6.0.2, November 2014), using traffic data provided for the Development Sites by Atkins Transportation. The emission calculations assumed a "London - Outer" road type for all modelled roads.

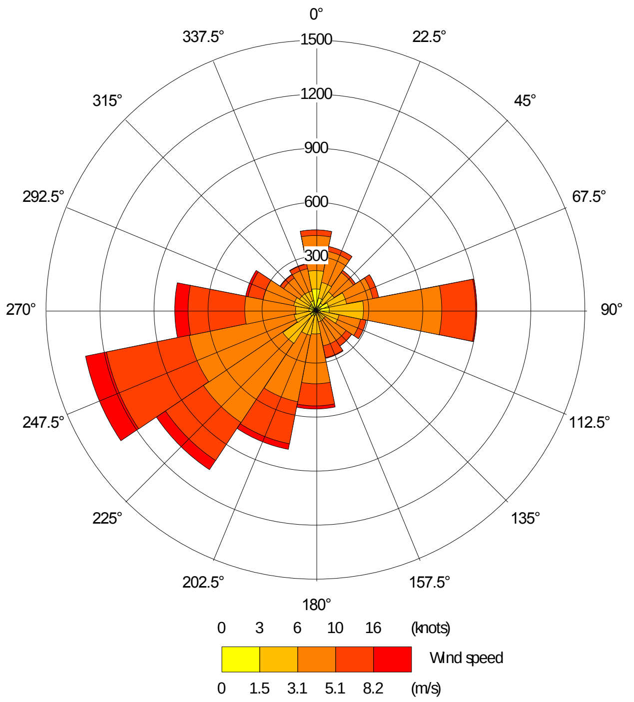
4.1.1.3. Meteorological Data

Hourly sequential meteorological data were taken for the nearest suitable weather station, in this case London City Airport, for the year 2014 (the base year in the assessment). The London City Airport weather station is located approximately 8 kilometres to the south of the Development Sites. The basic data include: date, hour, direction that the wind is blowing from, wind speed, how many eighths ('oktas') of the sky are covered by cloud, and surface air temperature.

A windrose for the London City Airport weather station is presented in Figure 4-1; this shows winds predominantly blowing from the south west.

When the dispersion model is run, the meteorological data are processed an hour at a time to generate values for other parameters that describe atmospheric turbulence. These data are then used to calculate dispersion and thus estimate pollutant concentrations in ambient air.

Figure 4-1 London City Airport 2014 Windrose



4.1.1.4. Receptors

A total of 63 discrete receptors were included in the model. These comprise 19 human health receptors (residential properties and schools), four air quality monitoring locations (for use in model verification) and 40 points along four transects within the Development Sites at increased distance away from road sources. The assessed receptors are listed in Table 4-1 and are shown in Figure 4-2. Model verification is discussed in detail in Appendix D.

The height of all human health receptors and transects was set at 1.5 metres above ground level to represent breathing height, whilst the height of the monitoring sites were taken from the London Borough of Redbridge's most recent LAQM Report[19]. The heights of the monitoring locations were at a height of 1.7 metres for DT F, a height of 2.6 metres for DT V and a height of 2.8 metres for DT N and DT T.

Table 4-1 Receptors Included in the Air Quality Model

Receptor Ref	Description	Easting, X	Northing, Y
Existing Sensitive Receptors			
R1_1	Fairlop Primary School/ John Savage Centre, adjacent to the A123	544439	191047
R1_2	91-110 Henry's Walk, adjacent to New Road North	544467	191275
R1_3	Ilford Jewish Primary School, adjacent to Forest Road	544630	190411
R1_4	8-10 State Parade, High Street	544497	190367
R1_5	Forest Farm Cottages, adjacent to Forest Road	545169	190711
R1_6	143 High Street	544446	190246
R1_7	61 New North Road	544687	191395
R1_8	102 Fencepiece Road, adjacent to the A123	544505	190918
R1_9	49 Forest Road	544732	190495
R2_1	William Torbitt Primary School, adjacent to the A12	545504	188663
R2_2	232 Aldborough Road	545624	188632
R2_3	339 Aldborough Road	545416	188127
R2_4	Barley Lane Primary School, adjacent to B177	546494	187789
R2_5	179 Barley Lane, adjacent to B177	546622	188701
R2_6	Farnham Green Primary School, adjacent to B177	546210	188023
R2_7	Eastcourt Independent School, adjacent to A118	546285	187447
R2_8	Ilford Preparatory School, adjacent to A118	546104	187353
R2_9	79 Barley Road	546428	187860
R2_10	809 A118 High Road	546222	187362
Monitoring Sites			
DT F*	Fulwell Cross, Roadside Diffusion Tube	544560	190403
DT N*	Ethel Davis School, Near Roadside Diffusion Tube	546677	188884
DT V*	Isaac Newton Academy, Near Roadside Diffusion Tube	545030	186920
DT T*	Chadwell Heath Primary School, Kerbside Diffusion Tube	547160	187696
Development Site Transects			
1_T1_25	Site1, Transect 1, 25m from Road Source	544515	190807
1_T1_40	Site1, Transect 1, 40m from Road Source	544528	190807
1_T1_60	Site1, Transect 1, 60m from Road Source	544548	190806
1_T1_80	Site1, Transect 1, 80m from Road Source	544588	190806
1_T1_100	Site1, Transect 1, 100m from Road Source	544568	190806
1_T1_120	Site1, Transect 1, 120m from Road Source	544608	190806
1_T1_140	Site1, Transect 1, 140m from Road Source	544628	190806
1_T1_160	Site1, Transect 1, 160m from Road Source	544647	190806
1_T1_180	Site1, Transect 1, 180m from Road Source	544669	190806

Receptor Ref	Description	Easting, X	Northing, Y
1_T1_200	Site1, Transect 1, 200m from Road Source	544688	190806
1_T2_25	Site1, Transect 2, 25m from Road Source	544630	190460
1_T2_40	Site1, Transect 2, 40m from Road Source	544623	190474
1_T2_60	Site1, Transect 2, 60m from Road Source	544614	190491
1_T2_80	Site1, Transect 2, 80m from Road Source	544604	190509
1_T2_100	Site1, Transect 2, 100m from Road Source	544595	190527
1_T2_120	Site1, Transect 2, 120m from Road Source	544586	190543
1_T2_140	Site1, Transect 2, 140m from Road Source	544577	190559
1_T2_160	Site1, Transect 2, 160m from Road Source	544567	190579
1_T2_180	Site1, Transect 2, 180m from Road Source	544557	190597
1_T2_200	Site1, Transect 2, 200m from Road Source	544548	190617
2_T1_10	Site1, Transect 1, 10m from Road Source	546460	188080
2_T1_25	Site2, Transect 1, 25m from Road Source	546445	188081
2_T1_40	Site2, Transect 1, 40m from Road Source	546431	188081
2_T1_60	Site2, Transect 1, 60m from Road Source	546410	188081
2_T1_80	Site2, Transect 1, 80m from Road Source	546390	188081
2_T1_100	Site2, Transect 1, 100m from Road Source	546370	188081
2_T1_120	Site2, Transect 1, 120m from Road Source	546348	188081
2_T1_140	Site2, Transect 1, 140m from Road Source	546329	188081
2_T1_160	Site2, Transect 1, 160m from Road Source	546310	188081
2_T1_180	Site2, Transect 1, 180m from Road Source	546287	188081
2_T1_200	Site2, Transect 1, 200m from Road Source	546268	188080
2_T2_15	Site2, Transect 2, 15m from Road Source	545636	188577
2_T2_25	Site2, Transect 2, 25m from Road Source	545648	188577
2_T2_40	Site2, Transect 2, 40m from Road Source	545665	188577
2_T2_60	Site2, Transect 2, 60m from Road Source	545683	188577
2_T2_80	Site2, Transect 2, 80m from Road Source	545703	188577
2_T2_100	Site2, Transect 2, 100m from Road Source	545721	188578
2_T2_120	Site2, Transect 2, 120m from Road Source	545743	188578
2_T2_140	Site2, Transect 2, 140m from Road Source	545762	188578
2_T2_160	Site2, Transect 2, 160m from Road Source	545782	188577
2_T2_180	Site2, Transect 2, 180m from Road Source	545802	188577
2_T2_200	Site2, Transect 2, 200m from Road Source	545821	188578
*Included for model verification only			

Figure 4-2 Oakfields Site - Modelled Roads and Receptors Included in the Air Quality Model

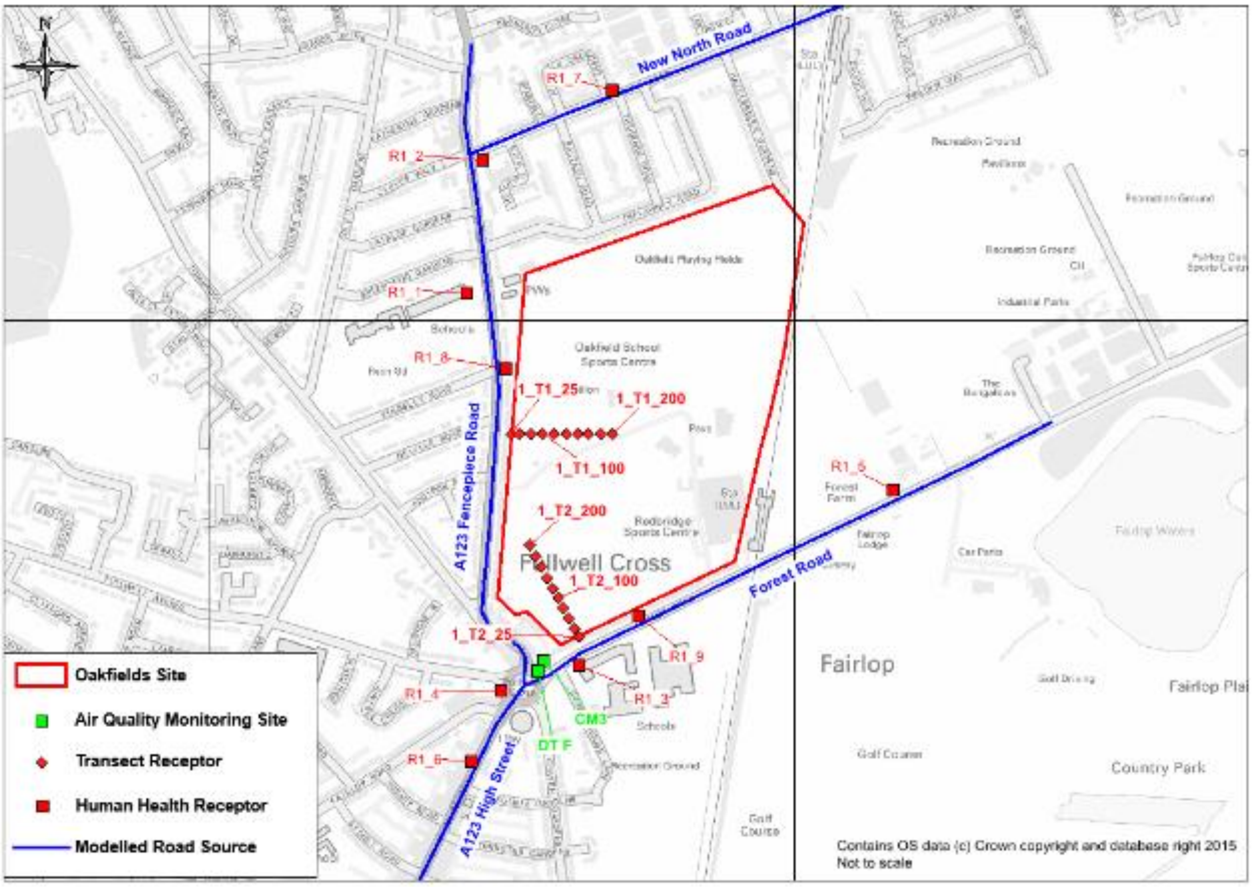
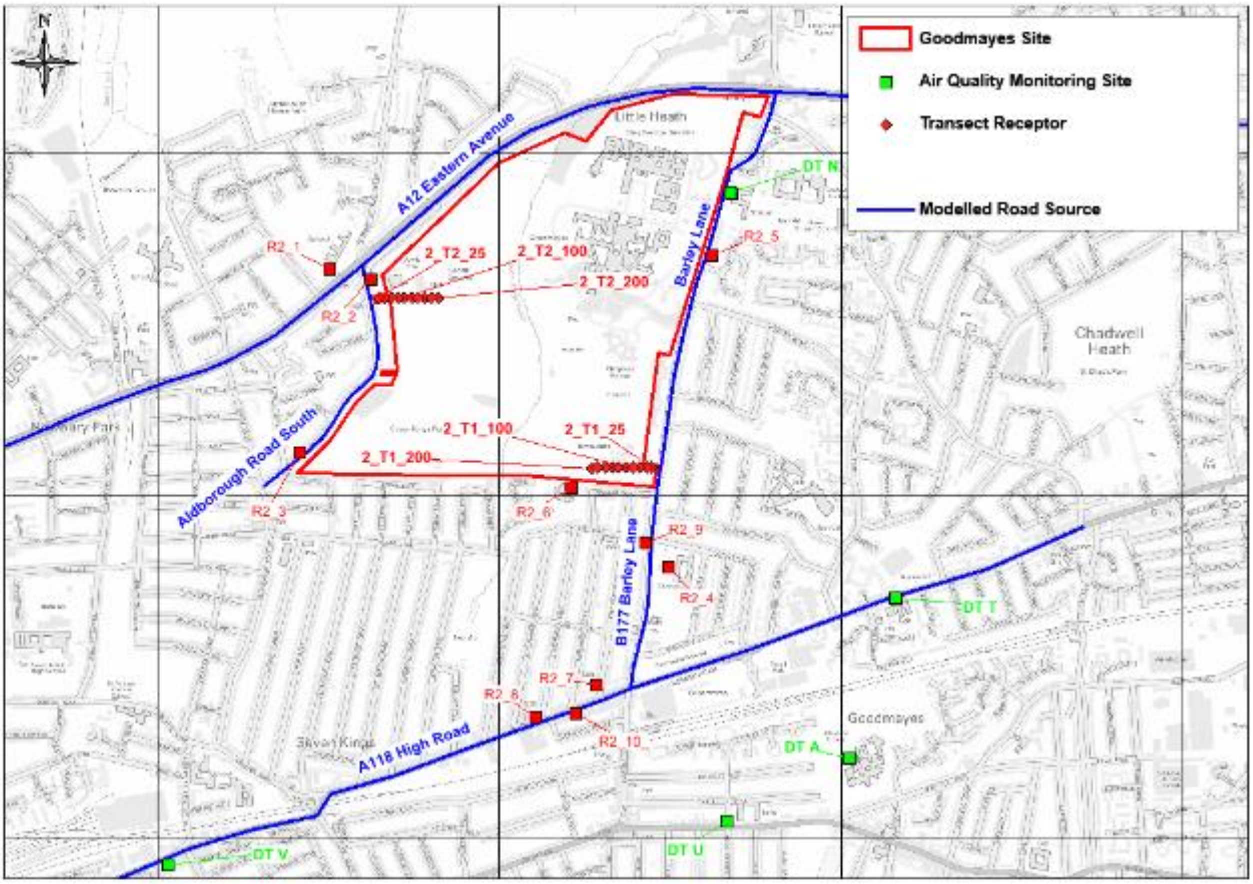


Figure 4-3 Goodmayes Site - Modelled Roads and Receptors Included in the Air Quality Model



4.1.1.5. Background Concentrations

The air quality dispersion modelling provides an estimate of the contribution of a road to total pollutant concentrations; it does not take into account existing background concentrations. A background contribution must therefore be added to the modelled road contribution in order to derive the total pollutant concentration.

Estimates of current and future year background pollutant concentrations in the UK are available on the Defra UK-AIR website. Background estimates are available for one km grid squares throughout the UK for years between 2010 and 2030.

Estimated annual mean background concentrations for the years 2014 (the assessment base year) for NO_2 and PM_{10} were obtained from the background mapping provided on the Defra UK-AIR website (Table 3-3) and compared with 2014 monitoring data from the urban background sites (CM1 site in Table 3-1 and Table 3-2). Table 4-2 presents the comparison of NO_2 and Table 4-3 the comparison for PM_{10}. The Defra background mapping consistently underestimates by between 3% and 24% for NO_2 and overestimates by 20% for PM_{10}. Defra background mapping has been verified as within 30% of Automatic Urban and Rural Network (AURN) CMS sites operated by Defra[29]. The underestimation of concentrations of the background mapping is less than 30% and therefore the background mapping is considered suitable to use in the air quality model for this assessment.

No statistically significant trend in monitored background concentrations was observed in background monitoring data therefore the background NO_2 and PM_{10} concentrations are assumed to remain constant for the 2030 future year.

Table 4-4 presents the background concentrations used in the air quality model for each of the receptors described above in Table 4-1.

Further detail on background concentrations is provided in the Baseline Conditions Section and Appendix A.

Table 4-2 Comparison of Annual Mean NO_2 Pollutant Concentrations (µg/m^3) for Defra Background Mapping and Urban Background Monitoring Sites

Site ID	x	y	grid square x,y	Defra Background	Monitored Background	Defra Mapping - Monitored	Defra Mapping / Monitored	% Difference
CM1	544381	187659	544500, 187500	25.0	32.8	-7.8	0.76	-24%
DT A	547022	187232	547500, 187500	23.5	24.2	-0.7	0.97	-3%
DT D	544381	187638	544500, 187500	25.0	31.7	-6.7	0.79	-21%

Table 4-3 Comparison of Annual Mean PM_{10} Pollutant Concentrations (µg/m^3) for Defra Background Mapping and Urban Background Monitoring Sites

Site ID	x	y	grid square x,y	Defra Background	Monitored Background	Defra Mapping - Monitored	Defra Mapping / Monitored	% Difference
CM1	544381	187659	544500, 187500	20.3	16.9	3.4	1.20	20%

[29] DEFRA, 2011, UK modelling under the Air Quality Directive (2008/50/EC) for 2010 covering the following air quality pollutants: SO_2, NO_X, NO_2, PM_{10}, $PM_{2.5}$, lead, benzene, CO, and ozone http://laqm.defra.gov.uk/documents/0905061048_dd12007mapsrep_v8.pdf

Table 4-4 Background Annual Mean Pollutant Concentrations (µg/m^3) for Receptors Included in the Air Quality Model

Receptor Ref	2014		2030	
	NO_2	PM_{10}	NO_2	PM_{10}
R1_1	22.3	19.8	22.3	19.8
R1_2	22.3	19.8	22.3	19.8
R1_3	21.9	19.5	21.9	19.5
R1_4	21.9	19.5	21.9	19.5
R1_5	19.6	18.6	19.6	18.6
R1_6	21.9	19.5	21.9	19.5
R1_7	22.3	19.8	22.3	19.8
R1_8	21.9	19.5	21.9	19.5
R1_9	21.9	19.5	21.9	19.5
R2_1	24.9	20.7	24.9	20.7
R2_2	24.9	20.7	24.9	20.7
R2_3	24.9	20.7	24.9	20.7
R2_4	24.3	20.9	24.3	20.9
R2_5	22.3	20.5	22.3	20.5
R2_6	22.3	20.5	22.3	20.5
R2_7	24.3	20.9	24.3	20.9
R2_8	24.3	20.9	24.3	20.9
R2_9	24.3	20.9	24.3	20.9
R2_10	24.3	20.9	24.3	20.9
DT F	21.9	19.5	21.9	19.5
DT N	22.3	20.5	22.3	20.5
DT V	25.2	20.5	25.2	20.5
DT T	23.5	20.4	23.5	20.4
Site 1_Transect 1	21.9	19.5	21.9	19.5
Site 1_Transect 2	21.9	19.5	21.9	19.5
Site 2_Transect 1	22.3	20.5	22.3	20.5
Site 2_Transect 2	24.9	20.7	24.9	20.7

4.1.1.6. Model Inputs and Assumptions

The air quality model scenarios were based on the following key inputs and assumptions:

- Traffic conditions vary throughout the day; hence diurnal profiles have been applied in the model to improve the approximation of vehicle emissions in each hour of the year based on traffic data provided by Atkins Transportation. Average diurnal profiles were calculated for an average weekday (Monday to Friday), Saturday and Sunday for A-roads and for all other roads based on traffic count data. The A-road profile was applied to all A-roads in the air quality model (A12, A118 and A123) and all other profile was applied to other links in the model.
- Ordnance Survey mapping was used to define the modelled road geometry and receptor locations;
- Road widths were taken to be 3.65 metres per lane in the absence of specific data. The number of lanes was determined from aerial photography;
- Hourly sequential meteorological data for 2014 (the assessment base year) was taken from the London City Airport meteorological station;

- Surface roughness has been defined as 0.5 metres for the study area and 0.5 metres for the weather station[30]. The surface roughness used is considered appropriate given the study area and weather station are surrounded by open parkland areas and low density residential areas of predominantly low structures (buildings of 2 to 3 storeys).
- Values for surface albedo, minimum Monin-Obukhov length and Priestly-Taylor parameter were assumed to be as per the model default except for the Monin-Obukhov length for the study area, which was assumed to be 100 metres (large conurbations with more than 1 million inhabitants)[31].

4.1.1.7. Model Uncertainty

Any air quality dispersion model has inherent areas of uncertainty, including:

- Traffic data;
- Appropriateness of emissions data;
- Simplifications in model algorithms and empirical relationships that are used to simulate complex physical and chemical processes in the atmosphere;
- Appropriateness of background concentrations; and
- Appropriateness of meteorological data.

Uncertainly associated with traffic data has been minimised by using traffic data provided by the project transport consultant (Atkins Transportation) which has been derived from traffic count surveys undertaken for roads around the Development Sites in 2015.

Uncertainty associated with emissions data has been minimised by using the most recent version of the ADMS-Roads modelling software (version 3.4) and Defra emission factors (EFT v6.0.2).

Uncertainty associated with model algorithms and empirical relationships have been minimised by using algorithms and relationships within a dispersion model (ADMS-Roads) that has been independently validated and judged as fit for purpose.

Uncertainty associated with background data has been minimised by verifying DEFRA background concentrations against local monitoring data and determine trend in background concentrations from a time series of historical local monitoring data.

Another uncertainty is with using historical meteorological data to estimate future concentrations. The key limiting assumption is that conditions in the future will be the same as in the past; however, in reality no two years are the same. Defra's Technical Guidance LAQM.TG(09) reviewed a number of studies examining inter-annual variability of meteorological data and the effect on dispersion model output and concluded that variability in source contribution should be no more than 30% between any two years.

Given the above, the approach taken to this assessment is considered to be sufficiently robust.

4.1.1.8. Model Verification

Model verification is the process of determining the local area performance of the base year model in comparison with measured data. The verification step involves comparison of modelled pollutant concentrations at suitable monitoring sites with monitored values that are representative of the base model period (in this case 2014). Where there is a disparity between the predicted and the measured concentrations, and where further improvements to input data are not possible, then if required an appropriate adjustment factor is determined to correct systematic bias. This adjustment is applied to the base year and future year model output. Model verification and adjustment is discussed in detail in Appendix C.

4.1.1.9. Comparison with Air Quality Criteria (NO_2)

To derive total NO_2 concentrations from modelled road NO_x concentrations, and hence to allow a comparison with the air quality criteria, the method described in Defra's Technical Guidance LAQM.TG(09) was used. Total annual mean NO_2 concentrations were calculated from modelled road NO_x and background NO_2 concentrations, using the latest version of the 'NO_x to NO_2 conversion spreadsheet' (version 4.1) available from the Defra UK-AIR website.

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[30] Surface roughness length is a measure of the vertical height of obstacles to wind flow at the earth's surface.
[31] Model default surface albedo = 0.23 (not snow covered); model default Priestly-Taylor parameter = 1 (moist grassland); model default minimum Monin-Obukhov length = calculated by model based on surface roughness; the Monin-Obukhov length is a parameter that limits occasions of very stable conditions with minimal thermal turbulence.

In addition to the modelled road NO_x and background NO_2 data, Defra's NO_x to NO_2 conversion spreadsheet requires a local authority area to be specified to determine regional oxidant concentrations, and a traffic mix to determine the proportion of primary NO_2. The local authority specified in the conversion tool was "Redbridge"; the traffic mix selected was "All London traffic" for all modelled roads.

For NO_2, as only annual mean NO_2 estimates have been generated using the air quality dispersion model, commentary on potential impacts on hourly mean NO_2 concentrations, which has its own criterion, is possible with reference to Defra's Technical Guidance LAQM.TG(09). The guidance suggests that if annual mean concentrations of NO_2 do not exceed 60 µg/m^3 then it is unlikely that hourly mean concentrations would exceed the relevant criterion.

4.1.1.10. Comparison with Air Quality Criteria (Particulate Matter)

To determine total annual mean concentrations of PM_{10} at human health receptors, the modelled road contribution is added to the background concentration to give the total concentration for comparison with the annual mean assessment criterion.

Annual mean PM_{10} concentrations can also be used to derive the number of exceedances of the 24-hour mean PM_{10} criterion, of which 35 are allowed. The method described in Defra's Technical Guidance LAQM.TG(09) was applied. This method is based on the relationship between the number of 24-hour exceedances of 50 µg/m^3 and the annual mean concentration derived from UK Automatic Network Sites. This is described in Equation 1 below:

Equation 1: Number of exceedances of 24-hour mean of 50 µg/m^3 = $-18.5 + 0.00145 * a^3 + (206/a)$

where 'a' = total annual mean PM_{10} concentration.

4.1.1.11. Impact Significance

Descriptors for magnitude of change due to changes in ambient concentrations of pollutants at receptors, and guidance for the interpretation of the significance of these effects, are provided in the 2015 EPUK / IAQM Land-Use Planning and Development Control Guidance. Changes in concentration are grouped according to the percentage change relative to an Air Quality Assessment Level (AQAL), and the description of that change, in terms of whether it is slight, moderate or substantial, or negligible, depends upon the absolute concentration without the Development Sites (if concentrations decrease with the Development Sites relative to without) or with the Development Sites (if concentrations decrease with the Development Sites relative to without) relation to the air quality objective of interest. The term AQAL is used to include air quality objectives or limit values, where these exist. Percentage values are rounded to zero decimal places before application of the impact descriptors. The descriptors are provided in Table 6.3 in the guidance (repeated in Table 4-5 below for application to annual mean NO_2 and particulate matter).

Table 4-5 Impact Descriptors for Changes in Annual Mean NO_2 and Particulate Matter Concentrations

Long Term Average Concentration at Receptor	Percentage Change in Concentration Relative to AQA			
	1	2 – 5	6 – 10	>10
75% or less of AQAL	Negligible	Negligible	Slight	Moderate
76 – 94% of AQAL	Negligible	Slight	Moderate	Moderate
95 – 102% of AQAL	Slight	Moderate	Moderate	Substantial
103 – 109% of AQAL	Moderate	Moderate	Substantial	Substantial
110% or more of AQAL	Moderate	Substantial	Substantial	Substantial

For the purposes of this assessment, changes of negligible or slight impact are deemed – individually – to be not significant. However, as explained in the 2015 EPUK / IAQM Land-Use Planning and Development Control Guidance, any judgement on the overall significance of effect of a development must take into account such factors as:

- The existing and future air quality in the absence of the Development Sites;
- 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.

4.1.2. Air Quality Modelling Results

The findings from the local air quality assessment for the 2014 base year and 2030 future year are provided in this section. Modelled concentrations at all receptors have been combined with background concentrations and compared with relevant air quality thresholds to determine whether there are likely to be any exceedances. In addition, the magnitude of change in concentrations have been analysed and the significance of these changes has been interpreted in line with the current 2015 EPUK / IAQM Land-Use Planning and Development Control Guidance.

4.1.2.1. Potential Local Air Quality Impacts

Modelled total concentrations and changes in concentrations of annual mean NO_2 and PM_{10} for all modelled receptors are presented in Table 4-6 to Table 4-7 respectively and for the PM_{10} 24 hour mean in Table 4-8.

Modelled concentrations at all receptors are expected to be below relevant annual mean AQS objectives and EU limit value thresholds both without and with the Development Sites in 2030. All assessed receptors are expected to experience 'negligible' impacts in relation to annual mean NO_2 concentrations and annual mean PM_{10} concentrations according to the 2015 EPUK / IAQM Land-Use Planning and Development Control Guidance.

For the 1-hour mean AQS objective for NO_2, DEFRA advises that if the annual mean NO_2 concentration is less than 60 µg/m^3 the hourly mean objective is unlikely to be exceeded. The maximum annual mean NO_2 concentration modelled at any receptor in either the without or with the Development Sites is 31.2 µg/m^3, and as such the 1-hour mean threshold is unlikely to be exceeded.

There are no receptors which will exceed the PM_{10} 24 hour mean threshold in the 2030 without and with the Development Sites. There is a maximum of 6 exceedances of the 24 hour mean concentration of 50 µg/m^3 predicted at any given receptor.

Table 4-6 Local Air Quality Modelling Results and Impact: Annual Mean NO_2 Concentrations ($\mu g/m^3$)

Receptor ID	2014 Base	2030 Without Development Sites	2030 With Development Sites	2030 Change	Impact
R1_1	24.4	24.7	24.8	0.1	Negligible
R1_2	27.8	28.3	28.4	0.1	Negligible
R1_3	25.9	26.9	27.0	0.1	Negligible
R1_4	25.8	26.0	26.1	0.1	Negligible
R1_5	22.8	23.5	23.6	0.1	Negligible
R1_6	28.7	28.7	28.9	0.2	Negligible
R1_7	27.5	27.6	27.6	0.0	Negligible
R1_8	27.4	28.1	28.2	0.1	Negligible
R1_9	26.7	28.0	28.1	0.1	Negligible
R2_1	28.2	29.1	29.1	0.0	Negligible
R2_2	29.8	30.8	31.2	0.4	Negligible
R2_3	27.5	28.0	28.4	0.4	Negligible
R2_4	26.1	26.1	26.2	0.1	Negligible
R2_5	26.6	26.6	26.8	0.2	Negligible
R2_6	22.8	22.9	22.9	0.0	Negligible
R2_7	27.0	27.3	27.4	0.1	Negligible
R2_8	29.3	29.9	30.0	0.1	Negligible
R2_9	28.0	28.1	28.3	0.2	Negligible
R2_10	30.5	31.1	31.2	0.1	Negligible
Site 1_Transect 1	22.6 to 25.3	22.7 to 25.7	22.7 to 25.8	Up to 0.1	Negligible
Site 1_Transect 2	23.4 to 25.1	23.6 to 25.9	23.6 to 26	Up to 0.1	Negligible
Site 2_Transect 1	23 to 25	23 to 25	23.1 to 25.2	Up to 0.2	Negligible
Site 2_Transect 2	25.5 to 26.9	25.6 to 27.2	25.7 to 27.5	Up to 0.3	Negligible

Table 4-7 Local Air Quality Modelling Results and Impact: Annual Mean PM_{10} Concentrations ($\mu g/m^3$)

Receptor ID	2014 Base	2030 Without Development Sites	2030 With Development Sites	2030 Change	Impact
R1_1	20.1	20.1	20.1	0.0	Negligible
R1_2	20.5	20.5	20.5	0.0	Negligible
R1_3	20.1	20.1	20.1	0.0	Negligible
R1_4	20.0	20.0	20.0	0.0	Negligible
R1_5	19.1	19.1	19.1	0.0	Negligible
R1_6	20.3	20.3	20.3	0.0	Negligible
R1_7	20.5	20.5	20.5	0.0	Negligible
R1_8	20.2	20.2	20.2	0.0	Negligible
R1_9	20.2	20.3	20.3	0.0	Negligible
R2_1	21.3	21.4	21.4	0.0	Negligible
R2_2	21.5	21.6	21.6	0.0	Negligible
R2_3	21.1	21.1	21.1	0.0	Negligible
R2_4	21.1	21.1	21.1	0.0	Negligible
R2_5	21.1	21.1	21.2	0.1	Negligible
R2_6	20.6	20.6	20.6	0.0	Negligible
R2_7	21.2	21.2	21.2	0.0	Negligible
R2_8	21.5	21.5	21.5	0.0	Negligible
R2_9	21.4	21.4	21.4	0.0	Negligible
R2_10	21.7	21.7	21.7	0.0	Negligible
Site 1_Transect 1	19.6 to 19.9	19.6 to 19.9	19.6 to 19.9	0.0	Negligible
Site 1_Transect 2	19.7 to 20.0	19.7 to 20.0	19.7 to 20.0	Up to 0.1	Negligible
Site 2_Transect 1	20.6 to 20.9	20.6 to 20.9	20.6 to 20.9	Up to 0.1	Negligible
Site 2_Transect 2	20.8 to 21.0	20.8 to 21.0	20.8 to 21.0	Up to 0.1	Negligible

Table 4-8 Local Air Quality Modelling Results and Impact: Number of Exceedances of PM_{10} 24 Hour Mean (days)

Receptor ID	2014 Base	2030 Without Development Sites	2030 With Development Sites	2030 Change	Impact
R1_1	4	4	4	0	Negligible
R1_2	4	4	4	0	Negligible
R1_3	4	4	4	0	Negligible
R1_4	3	3	3	0	Negligible
R1_5	2	2	2	0	Negligible
R1_6	4	4	4	0	Negligible
R1_7	4	4	4	0	Negligible
R1_8	4	4	4	0	Negligible
R1_9	4	4	4	0	Negligible
R2_1	5	5	5	0	Negligible
R2_2	5	6	6	0	Negligible
R2_3	5	5	5	0	Negligible
R2_4	5	5	5	0	Negligible
R2_5	5	5	5	0	Negligible
R2_6	4	4	4	0	Negligible
R2_7	5	5	5	0	Negligible
R2_8	5	5	5	0	Negligible
R2_9	5	5	5	0	Negligible
R2_10	6	6	6	0	Negligible
Site 1_Transect 1	3	3	3	0	Negligible
Site 1_Transect 2	3	3	3	0	Negligible
Site 2_Transect 1	4 to 5	4 to 5	4 to 5	0	Negligible
Site 2_Transect 2	4 to 5	4 to 5	4 to 5	Up to 1	Negligible

4.1.2.2. Assessment Conclusions

The results of the local air quality assessment indicate that concentrations of key air pollutants are expected to be below relevant AQS objective and EU limit value thresholds in the 2030 future year at all assessed receptor locations, both with and without the Developments Sites being in place.

Changes in pollutant concentrations as a result of the operation of the Development Sites in 2030 are expected to result in ‘negligible’ impacts at all assessed receptor locations. For the assessment, NO_2 background concentrations were unchanged to those apparent in the 2014 base year.

It is therefore concluded that, overall, the Development Sites, even at their highest yield scenario, are not likely to have a significant effect on local air quality at existing receptors and that the introduction of new sensitive receptors associated with the Development Sites in 2030 is unlikely to result in exposure to pollutant concentrations in excess of relevant AQS objective and EU limit value thresholds.

5. Mitigation

5.1. Mitigation during Operation

The results of the local air quality assessment indicate that the operational development is not likely to have a significant adverse effect on local air quality and that the introduction of new sensitive receptors associated with the Developments Sites in 2030 is unlikely to result in exposure to pollutant concentrations in excess of relevant AQS objective and EU limit value thresholds. On this basis it is considered that specific mitigation measures to control emissions associated with the Development Sites are not required.

Nonetheless, the overall masterplan for the Development Sites should include cycle parking provisions encouraging the uptake of sustainable modes of transport; a Framework Travel Plan to be prepared which seeks to reduce vehicle trips made by residents, staff, students and visitors. The Framework Travel Plan for the Proposed Developments should aim to keep the numbers of additional vehicle movements generated by the development to a minimum, for example by encouraging the use of sustainable means of transport.

6. Summary and Recommendations

An air quality assessment for the Development Sites currently under consideration in the London Borough of Redbridge Phase 1 High Level Transport Study at Oakfields and Goodmayes in Redbridge has been undertaken. Road transport emissions are the primary source of air pollutant emissions in the vicinity of both Sites.

The Sites lie within the Redbridge borough-wide AQMA which has been declared for annual mean NO_2 and PM_{10} 24 hour exceedences, indicating that concentrations for NO_2 and PM_{10} may be above air quality criteria within at both locations. Background pollution mapping data from DEFRA and urban background monitoring in the Borough indicate that background concentrations are currently below relevant air quality criteria, however, nearby diffusion tube monitoring data, also located within the AQMA, show that concentrations are currently below relevant air quality criteria. Background and monitored PM_{10} concentrations are all below the relevant air quality criteria.

There may be an effect on local air quality in the area surrounding the Development Sites. Air quality sensitive receptors in the surrounding area include residential properties and schools. There are no relevant ecological receptors.

The air quality assessment considered the future year of 2030. This reflects the end year of the impending Redbridge Local Plan which covers the period 2015 to 2030. The results of the assessment of the operational phase of the Development Sites indicate that there is not likely to be a significant adverse effect on local air quality at existing air quality sensitive receptors and that the introduction of new air quality sensitive receptors associated with the Development Sites in 2030 is unlikely to result in exposure to pollutant concentrations in excess of relevant AQS objective and EU limit value thresholds. Specific mitigation measures to control emissions associated with the operational development are considered not to be required.

Should the Development Sites be taken forward, further air quality assessment should be undertaken as part of the planning application process to reflect the detailed layouts for the Development Sites and the actual opening years.

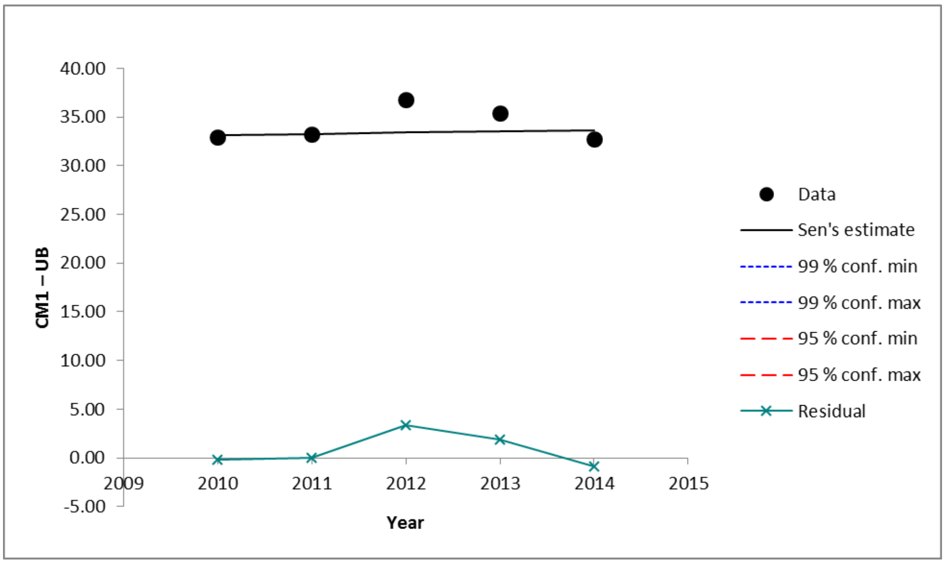
Appendix A. Trends in Monitored Air Pollutant Concentrations

Trend analysis of NO_2 and PM_{10} concentrations was undertaken for monitoring sites relevant to the Development Sites. The analysis has been undertaken using the Finnish Meteorological Institute MAKESENS (v1) spreadsheet for annual mean time series data.

In order to conduct the statistical analysis 5 or more series of data must be present for each site. On this basis the analysis has been undertaken for sites CM1 and CM4 for NO_2 and PM_{10} and DT F, DT N and DT A for NO_2.

A.1. Nitrogen Dioxide

Figure A-1 Site CM1 - Mann-Kendall and Sen Estimate of Annual Mean NO_2 Trend

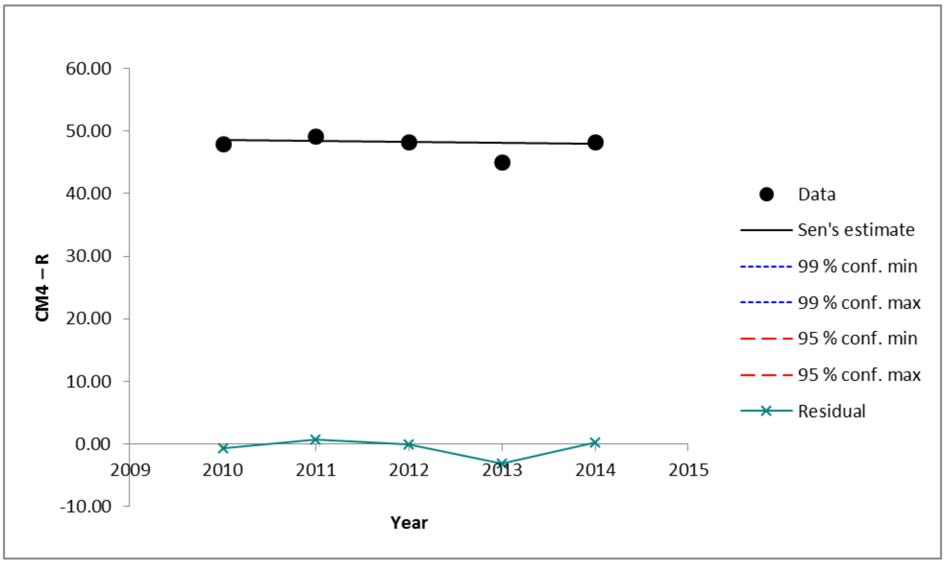


The trend analysis of site CM1 consisted of five data points. The Sen's slope[32] estimate of the linear trend line (shown above as a solid black line) is 0.125. This means that over five years there appears to be a general increase in NO_2 concentration by 0.125 µg per year. The plot of the residual concentrations[33] (shown as a solid light blue line) shows some variation year on year.

The Mann-Kendall test statistic (S) is expressed as a whole number; for site CM1 this is 0. For the null hypothesis of a random distribution of the data to be rejected, where the number of data is only five, the value of S [34] would have to be equal to or greater than an absolute value of 8 (equivalent to a probability of less than 0.1 or 10%). For five data points, only S values of 8 or more give a reasonably robust indication of a significant monotonic trend. Evidence of a monotonic trend is therefore weak for site CM1.

[32] The "Sen Slope" refers to the equation of the linear trend line and give the rate of change per year.
[33] The difference in the actual monitored concentration compared to the concentration indicated by the trend line.
[34] Nielsen, D. M. (Ed.). (2005). Practical handbook of environmental site characterization and ground-water monitoring. CRC press.

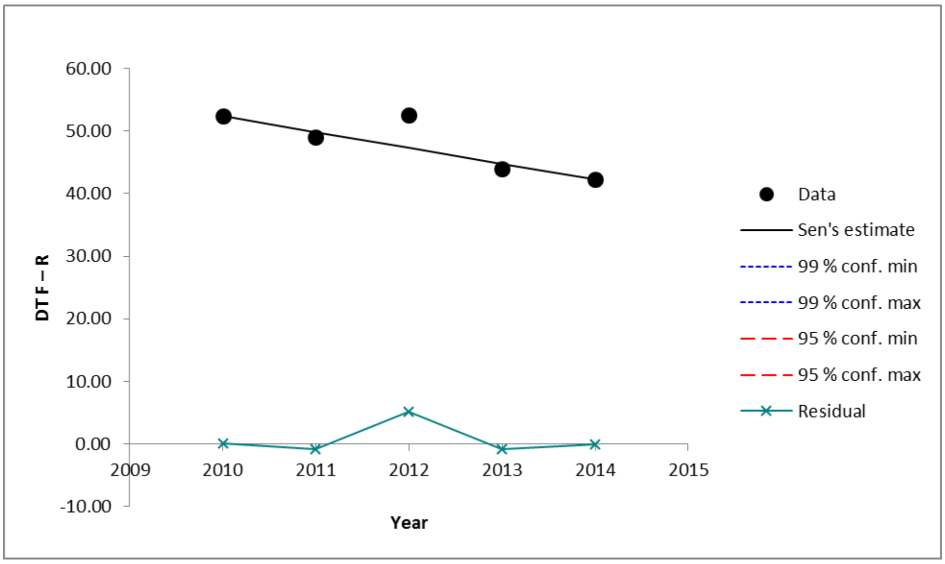
Figure A-2 Site CM4 - Mann-Kendall and Sen Estimate of Annual Mean NO_2 Trend



The trend analysis of site CM4 consisted of five data points. The Sen's slope estimate of the linear trend line (shown above as a solid black line) is -0.150. This means that over five years there appears to be a general decrease in NO_2 concentration by 0.150 µg per year. The plot of the residual concentrations (shown as a solid light blue line) shows some variation year on year.

The Mann-Kendall test statistic (S) is expressed as a whole number; for site CM4 this is -1. For the null hypothesis of a random distribution of the data to be rejected, where the number of data is only five, the value of S would have to be equal to or greater than an absolute value of 8 (equivalent to a probability of less than 0.1 or 10%). For five data points, only S values of 8 or more give a reasonably robust indication of a significant monotonic trend. Evidence of a monotonic trend is therefore weak for site CM4.

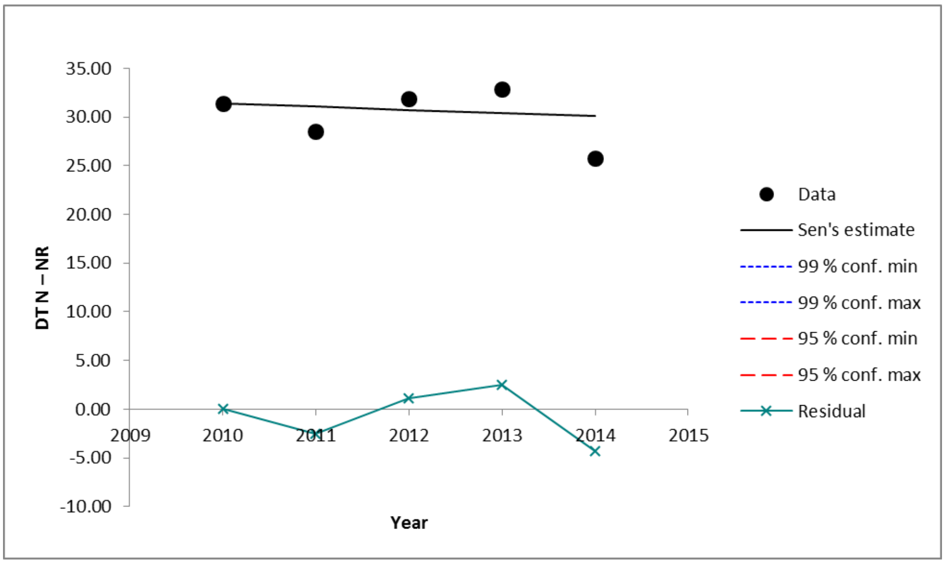
Figure A-3 Site DT F - Mann-Kendall and Sen Estimate of Annual Mean NO_2 Trend



The trend analysis of site DT F consisted of five data points. The Sen's slope estimate of the linear trend line (shown above as a solid black line) is -2.513. This means that over five years there appears to be a general decrease in NO_2 concentration by 2.513 µg per year. The plot of the residual concentrations (shown as a solid light blue line) shows some variation year on year.

The Mann-Kendall test statistic (S) is expressed as a whole number; for site CM4 this is -6. For the null hypothesis of a random distribution of the data to be rejected, where the number of data is only five, the value of S would have to be equal to or greater than an absolute value of 8 (equivalent to a probability of less than 0.1 or 10%). For five data points, only S values of 8 or more give a reasonably robust indication of a significant monotonic trend. Evidence of a monotonic trend is therefore weak for site DT F.

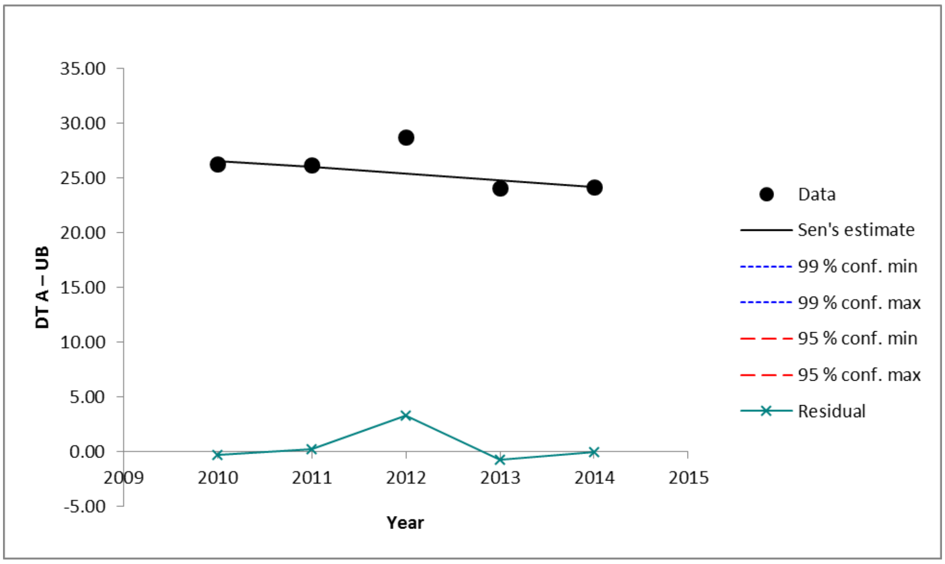
Figure A-4 Site DT N - Mann-Kendall and Sen Estimate of Annual Mean NO_2 Trend



The trend analysis of site DT N consisted of five data points. The Sen's slope estimate of the linear trend line (shown above as a solid black line) is -0.325. This means that over five years there appears to be a general decrease in NO_2 concentration by 0.325 µg per year. The plot of the residual concentrations (shown as a solid light blue line) shows some variation year on year.

The Mann-Kendall test statistic (S) is expressed as a whole number; for site CM4 this is 0. For the null hypothesis of a random distribution of the data to be rejected, where the number of data is only five, the value of S would have to be equal to or greater than an absolute value of 8 (equivalent to a probability of less than 0.1 or 10%). For five data points, only S values of 8 or more give a reasonably robust indication of a significant monotonic trend. Evidence of a monotonic trend is therefore weak for site DT N.

Figure A-5 Site DT A - Mann-Kendall and Sen Estimate of Annual Mean NO_2 Trend

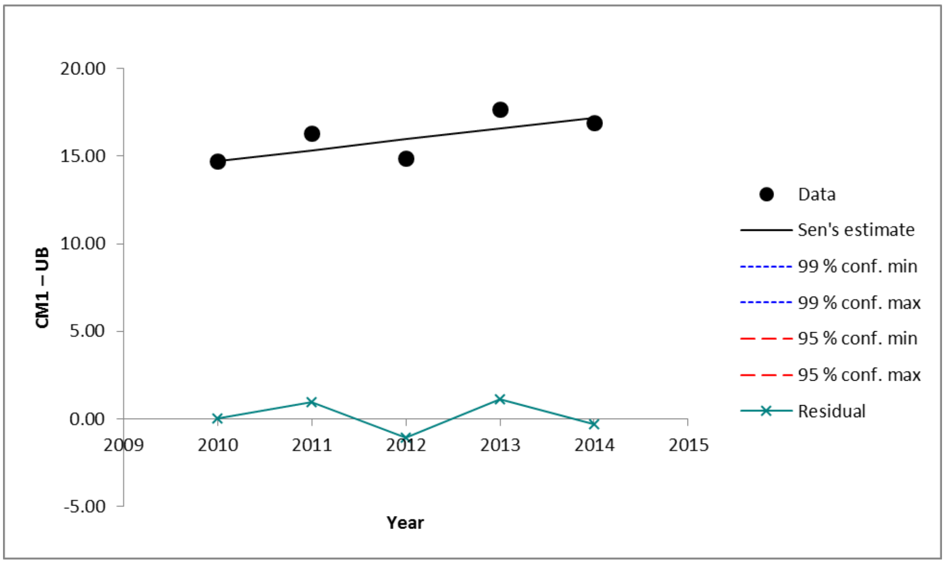


The trend analysis of site DT A consisted of five data points. The Sen's slope estimate of the linear trend line (shown above as a solid black line) is -0.596. This means that over five years there appears to be a general decrease in NO_2 concentration by 0.596 µg per year. The plot of the residual concentrations (shown as a solid light blue line) shows some variation year on year.

The Mann-Kendall test statistic (S) is expressed as a whole number; for site CM4 this is -4. For the null hypothesis of a random distribution of the data to be rejected, where the number of data is only five, the value of S would have to be equal to or greater than an absolute value of 8 (equivalent to a probability of less than 0.1 or 10%). For five data points, only S values of 8 or more give a reasonably robust indication of a significant monotonic trend. Evidence of a monotonic trend is therefore weak for site DT A.

A.2. PM_{10}

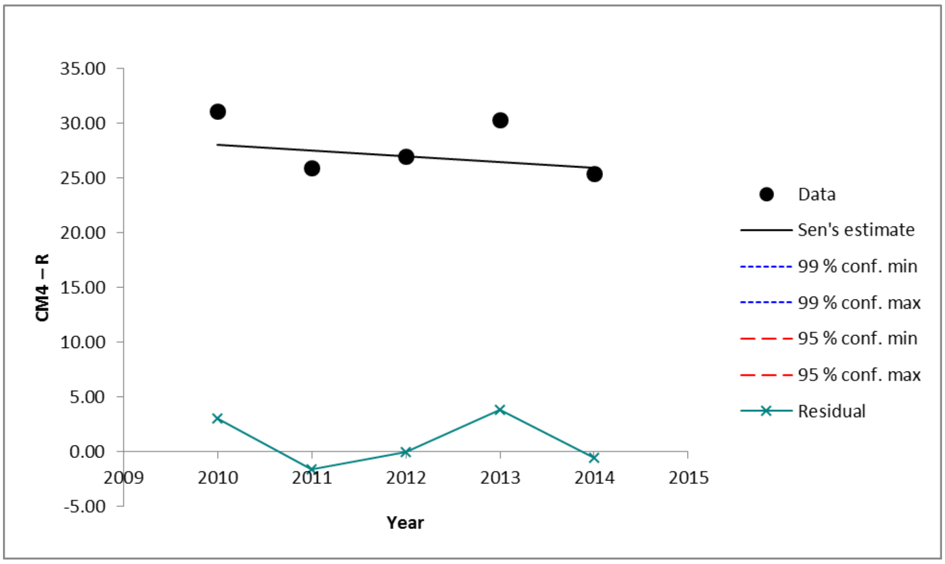
Figure A-6 Site CM1 - Mann-Kendall and Sen Estimate of Annual Mean PM_{10} Trend



The trend analysis of site CM1 consisted of five data points. The Sen's slope estimate of the linear trend line (shown above as a solid black line) is 0.625. This means that over five years there appears to be a general increase in NO_2 concentration by 0.625 µg per year. The plot of the residual concentrations (shown as a solid light blue line) shows some variation year on year.

The Mann-Kendall test statistic (S) is expressed as a whole number; for site CM1 this is 6. For the null hypothesis of a random distribution of the data to be rejected, where the number of data is only five, the value of S would have to be equal to or greater than an absolute value of 8 (equivalent to a probability of less than 0.1 or 10%). For five data points, only S values of 8 or more give a reasonably robust indication of a significant monotonic trend. Evidence of a monotonic trend is therefore weak for site CM1.

Figure A-7 Site CM4 - Mann-Kendall and Sen Estimate of Annual Mean PM_{10} Trend



The trend analysis of site CM4 consisted of five data points. The Sen's slope estimate of the linear trend line (shown above as a solid black line) is -0.533. This means that over five years there appears to be a general decrease in NO_2 concentration by 0.533 µg per year. The plot of the residual concentrations (shown as a solid light blue line) shows some variation year on year.

The Mann-Kendall test statistic (S) is expressed as a whole number; for site CM4 this is -4. For the null hypothesis of a random distribution of the data to be rejected, where the number of data is only five, the value of S would have to be equal to or greater than an absolute value of 8 (equivalent to a probability of less than

0.1 or 10%). For five data points, only S values of 8 or more give a reasonably robust indication of a significant monotonic trend. Evidence of a monotonic trend is therefore weak for site CM4.

Appendix B. Traffic Data Used in Air Quality Assessment

Table B-1 Traffic Data Used in the Air Quality Assessment

Link ID	Description	LDV (AADT)			HDV (AADT)			Speed (km/hr)
		Base	Without	With	Base	Without	With	All
1_1	New North Road	11,273	14,073	14,251	1,127	1,407	1,407	40
1_2	Forest Road	19,345	24,150	24,797	517	646	646	40
1_3	A123 High Street	15,329	19,136	19,972	1,738	2,170	2,170	32
1_4	A123 Fencepiece Road	17,797	22,217	22,751	1,133	1,414	1,414	32
2_1	A118 High Road	19,122	23,871	24,394	1,288	1,608	1,608	32
2_2	Barley Lane	13,670	17,065	18,663	1,557	1,943	1,943	40
2_3	B177 Barley Lane	12,957	16,175	17,357	1,278	1,595	1,595	40
2_4	Aldborough Road South	8,083	10,090	12,030	431	538	538	32
2_5	A12	52,128	66,224	66,224	1,808	2,297	2,297	64

Appendix C. Local Air Quality Model Verification and Adjustment

It is good practice to compare modelled estimates of pollutant concentrations with real-world monitoring to assess the model's performance for a base year and to inform the interpretation of model results for future years. Verification of the 2014 air quality base model has been undertaken with comparison of modelled concentrations against those derived from monitoring at four diffusion tube monitoring sites located near to the Development Sites, as shown in Figure 4-2 and Figure 4-3.

An air quality model can be considered to perform reasonably well where modelled concentrations are within 25% of monitored concentrations at 95% of sites, in accordance with Defra's Technical Guidance LAQM.TG(09). The root mean square error (RMSE) is acceptable if it is well below 25% of the AQS objective at 10 µg/m^3 (a requirement), and is ideal if below 10% of the AQS objective i.e. an RMSE of 4 µg/m^3.

Step 1

Firstly, unadjusted modelled estimates of total annual mean NO_2 concentrations have been compared against monitored annual mean concentrations as shown in Table C-1. The model estimate matches monitored concentrations at site DT N, the site closest to the Goodmayes Site. At other monitoring locations the model estimates underestimate compared to monitored concentrations by over 10%. Unadjusted model statistics are shown in Table C-2. The RMSE over 10% of the AQS objective. The Fractional Bias (FB) is above the ideal value of 0, indicating that the model tends to underestimate.

Table C-1 Comparison of Modelled and Measured NO_2 Concentrations (µg/m^3), Unadjusted

Site Name	Background Annual Mean NO_2 (µg/m^3)	Monitored Annual Mean Total NO_2 (µg/m^3)*	Modelled Annual Mean Total NO_2 (µg/m^3)	Modelled NO_2 Minus Monitored NO_2 (µg/m^3)	% Difference (unadjusted modelled NO_2 - monitored NO_2) / monitored NO_2 * 100
DT N	22.3	25.8	25.9	0.1	0%
DT F	21.9	42.3	29.1	-13.2	-31%
DT V	25.2	36.0	28.5	-7.5	-21%
DT T	23.5	41.4	28.8	-12.6	-30%
*See Table 3-1.					

Table C-2 Model Statistics Pre-Adjustment

RMSE[i]	FB[ii]	r[iii]
9.88	0.26	0.971
Notes: [i] Root Mean Square Error: RMSE is used to define the average error or uncertainty of the model (units µg/m^3). In the case of modelled annual mean NO_2 a value of less than 10 is acceptable and less than 4 is the ideal [ii] Fractional Bias: FB is used to identify if the model shows a systematic tendency to over or under estimate. Ideal value is 0 [ii] Correlation coefficient: r is used to measure the linear relationship between modelled and observed data. Ideal value is 1		

Step 2

The model itself does not provide annual mean NO_2, this is determined using LAQM.TG(09) methods. The second comparison is thus of modelled estimates of road contributed annual mean NO_x with the road NO_x component derived from monitoring data, as presented in Table C-3. This analysis requires the estimation of the monitored road NO_x component from the measured total annual mean NO_2 concentration. This is undertaken using Defra's NO_x to NO_2 calculator.

Table C-3 Comparison of Modelled and Measured NO_x Concentrations ($\mu g/m^3$), Unadjusted

Site Name	Monitored Annual Mean Roads NOx ($\mu g/m^3$)	Modelled Annual Mean Roads NOx ($\mu g/m^3$)	Modelled NOx Minus Monitored NOx ($\mu g/m^3$)	Monitored Roads NOx / Modelled Roads NOx	% Difference (unadjusted modelled NOx - monitored NOx) / monitored NOx * 100
DT N	7.2	7.4	0.2	0.97	3%
DT F	46.7	14.9	-31.8	3.13	-68%
DT V	23.7	7.0	-16.7	3.39	-70%
DT T	40.7	11.1	-29.6	3.67	-73%
Adjustment factor derived from linear regression of sites DTF, DT V & DT T				**3.3**	n/a

The results from the three diffusion tubes which were underestimating have been used to derive an adjustment factor of 3.3, as shown above in Table C-3.

Step 3

The third comparison of the adjusted modelled estimates of total annual mean NO_2 with monitored concentrations is presented in Table C-4. The adjustment factor was applied to all sites, as such site DT N overestimates the monitored concentration by 30%. However the other three sites are now within 10% of monitored concentrations. The model statistics post-adjustment are presented in Table C-5. The RMSE is improved and is just over the ideal of 10% of the AQS objective (i.e. an RMSE of 4 $\mu g/m^3$). The FB is improved and is marginally below the ideal value (0), indicating that the model tends to slightly overestimate.

Table C-4 Comparison of Adjusted Modelled and Measured NO_2 Concentrations ($\mu g/m^3$)

Site Name	Background Annual Mean NO_2 ($\mu g/m^3$)	Monitored Annual Mean Total NO_2 ($\mu g/m^3$)*	Modelled Annual Mean Total NO_2 ($\mu g/m^3$)	Modelled NO_2 Minus Monitored NO_2 ($\mu g/m^3$)	% Difference (unadjusted modelled NO_2 - monitored NO_2) / monitored NO_2 * 100
DT N	22.3	25.8	33.7	7.9	31%
DT F	21.9	42.3	43.4	1.1	3%
DT V	25.2	36.0	35.9	-0.2	0%
DT T	23.5	41.4	39.9	-1.5	-4%
*See Table 3-1.					

Table C-5 Model Statistics Post-Adjustment

RMSE[i]	FB[ii]	r[iii]
4.04	-0.05	0.896
Notes: [i] Root Mean Square Error: RMSE is used to define the average error or uncertainty of the model (units $\mu g/m^3$). In the case of modelled annual mean NO_2 a value of less than 10 is acceptable and less than 4 is the ideal [ii] Fractional Bias: FB is used to identify if the model shows a systematic tendency to over or under estimate. Ideal value is 0 [ii] Correlation coefficient: r is used to measure the linear relationship between modelled and observed data. Ideal value is 1		