Issue

Gatwick Airport Limited
Expansion to 95mppa
Air Quality Assessment

Arup

Issue | 10 July 2014

Job number 235135-00

Ove Arup & Partners Ltd
13 Fitzroy Street
London
W1T 4BQ
United Kingdom
www.arup.com

ARUP

Contents

Tables

Figures

Appendices

Executive Summary

This report examines the changes in air quality that would occur if a second runway was built at Gatwick Airport. This report has been prepared in connection with Gatwick's updated scheme design submission to the Airports Commission. As such, the air quality impacts of the proposed second runway have to be considered both in terms of the impacts on local air quality but comparisons also have to be made with the air quality impacts of the two other options for a further runway shortlisted by the Airports Commission, i.e. two options at Heathrow. This study examines an increased capacity of 95mppa in 2050 and is an update to the previous assessment which was based on a capacity of 87mppa in 2050.

Increasing the size of an airport, in terms of passenger numbers and aircraft movements, will always increase emissions to atmosphere relative to the base case of 'business as usual'. The proposal for a second runway at Gatwick therefore requires an assessment of the future impacts on local air quality and it must ensure that compliance with UK air quality objectives and EU limit values is achieved. The context for the assessment, however, is not simply a comparison with the option of a single runway for Gatwick, but also the alternative of additional capacity at Heathrow. If Gatwick is not to have a second runway then there will be an additional runway at Heathrow with its own impacts on local air quality. One of the main factors to be accounted for in the selection of the location of a new runway is its ability to minimise the effects of these emissions on the population and to meet overall the Commission's air quality objective to 'improve air quality'.

At present, large parts of London and some parts of south east England experience long term average concentrations of NO_2 that are in excess of the EU limit value of 40µg/m^3. These concentrations have not been declining in recent years at a rate that is consistent with the reduction in estimated national NOx emissions. Indeed, at some locations, such as the monitoring station near the M4 in Hillingdon, concentrations have been rising slightly. In the area around Gatwick, the concentrations of NO_2 have shown some improvement in recent years and there are currently no locations where NO_2 concentrations exceed 40µg/m^3, including locations within the Horley Air Quality Management Area. By 2030 and beyond, it is expected that NO_2 concentrations will be well below the limit value both with and without R2, as will other regulated pollutants, such as PM_{10} and $PM_{2.5}$. Local air quality is not, therefore, a constraint to the proposed scheme at Gatwick, insofar as compliance with legislation is concerned.

The assessment presented here is, in large part, a conventional one, in that the impact is considered primarily for local receptors around Gatwick airport and is quantified as the increase in pollutant concentrations over the base case of a single runway airport serving some 45mppa in 2040. In doing so, however, it recognises that the implications for future air quality are wider than simply whether pollutant concentrations at individual locations are within limit values. Air quality in 10-15 years is likely to be much better than it is today, especially for NO_2 concentrations. In these circumstances there will be a focus for policy makers on reducing the exposure of people to pollutants, especially those pollutants with the greatest consequences for human health. Currently, the pollutant that best fits this category is $PM_{2.5}$, for which a reduction in human exposure is required by the EU Directive on ambient air quality.

The outcome of this assessment is an important input to the Quality of Life assessment and the Economic Appraisal, which evaluate the implications for health outcomes and the monetary values attached to these. A proper assessment of the health effects of atmospheric emissions needs to be based on the exposure of the surrounding population to pollutants and not simply on the basis of the mass of pollutants emitted, an approach which makes the impact artificially independent of source location.

A comprehensive and detailed assessment of the local air quality impacts has been undertaken using the ADMS-Airports dispersion model and an appropriate emission inventory for all sources, including the local road network. The assessment shows that concentrations of NO_2 and PM_{10} with R2 increase by very small amounts around the airport in future years, relative to the base case, and that these increased concentrations affect a relatively small population. There are no locations where the members of the public would be exposed on a routine basis to NO_2, PM_{10} and $PM_{2.5}$ concentrations in excess of the EU limit value and UK air quality objective.

The assessment has used very conservative values for some of the emission sources and has assumed low levels of mitigation for many of these sources. For instance, the transport figures used have not taken into account the measures to encourage access by public transport, nor other measures such as reduced engine taxiing. The predicted impacts are therefore considered to be worst case and there is significant scope for reducing these further with a range of proven measures already in use on airports around the world. Some mitigation scenarios have been assessed and are presented as an Appendix to this report. Whilst the largest single contributor to NOx emissions is the aircraft movements, especially during take-off, the impact of these elevated emissions is reduced for ground level concentrations. Even though they are minor sources in comparison with aircraft take-offs, ground level sources of NOx provide an opportunity for mitigating impacts through the use of alternative low emission equipment or support vehicles and by placing some of the sources away from residential receptors. The location of the New Terminal is a good example of this approach. The proposed scheme inherently minimises the exposure of local people to air pollutants as the main sources of air pollutants are located at some distance from residential receptors and there is scope to reduce the predicted impacts still further.

Impacts on local air quality would also occur during the construction phases of the project. Construction activities can have an impact on local air quality through the use of construction equipment, additional traffic generated and additional traffic congestion as a result of temporary works. This impact has not been assessed quantitatively here, but is relevant because large infrastructure projects are known to have air quality impacts. These are not confined to the particulate matter generated on-site. These may be significant if the project requires a modification to the local road network that indirectly results in increased congestion and queuing of traffic, especially when these impacts are likely to occur for a an extended period of time as can frequently be the case with major infrastructure projects. Emissions increase substantially in these circumstances and the additional HGV traffic from construction activity may add to this problem if it also uses the affected network. The proposed scheme for Gatwick requires only minor modifications to the existing road network and the associated traffic flows are not expected to be materially affected. It is not anticipated that the construction phase will have any significant impacts on local air quality.

In summary, the proposed scheme will have a very small impact on local air quality and one that will be experienced by a small population. It will be compliant with air quality limit values, as currently legislated. Opportunities exist to reduce these impacts still further with proven mitigation methods that have been adopted elsewhere and are included in the Gatwick proposals.

Abbreviations

APU	Auxiliary Power Unit
AQMA	Air Quality Management Area
COMEAP	Committee on the Medical Effects of Air Pollution
Defra	Department for Environment, Food and Rural Affairs
EAT	End around taxiway
EPUK	Environmental Protection UK
FEGP	Fixed Electrical Ground Power
GAL	Gatwick Airport Limited
GSE	Ground Support Equipment
HGV	Heavy Goods Vehicle
HNO_3	Nitric acid
IAQM	Institute of Air Quality Management
ICAO	International Civil Aviation Organization
kph	kilometres per hour
LAEI	London Atmospheric Emissions Inventory
LGV	Light Goods Vehicle
LTO	Landing and take-off
mph	miles per hour
mppa	million passengers per annum
MSCP	Multi-Storey Car Park
N_2O	Nitrous oxide
NAEI	National Atmospheric Emissions Inventory
NAQS	National Air Quality Strategy
NO	Nitric oxide
NO_2	Nitrogen dioxide
NOx	Oxides of nitrogen (NO and NO_2)
Pax	passengers
PHE	Public Health England
$PM_{2.5}$ PM_{10}	Airborne particulate matter passing a sampling inlet with a 50% efficiency cut off at 2.5µm or 10µm aerodynamic diameter and which transmits particles of below this size
PSDH	Programme for the Sustainable Development of Heathrow
R&BBC	Reigate and Banstead Borough Council
SCR	Selective catalytic reduction
WHO	World Health Organisation
$\mu g/m^3$	micrograms per cubic metre

1 Introduction

Ove Arup and Partners Ltd (Arup) has been commissioned by Gatwick Airport Limited to carry out an air quality study of the proposed use of a two runway airport with an operational throughput of 95 mppa. Previous modelling studies carried out by Ricardo-AEA and presented to the Airports Commission (AC) as part of Gatwick's Updated Scheme Design submission (May 2014) had examined various options including a throughput of 87 mppa. This report builds on these previous modelling studies to examine the impact at the proposed 95mppa case. In addition, some further mitigation measures have been incorporated into the revised modelling as follows:

- Reduction in the use of Auxiliary Power Units (APUs) as most stands are assumed to be fitted with Fixed Electrical Ground Power (FEGP);
- Use of single engine taxiing; and
- Use of hybrid engine vehicles where possible for Ground Support Equipment (GSE).

This assessment largely follows the methodology previous adopted by Ricardo-AEA to maintain consistency in approach; however, where Arup consider a revised approach would be more suitable, changes have been made. These are detailed within this report.

2 Air quality policy and regulations

2.1 European air quality management

In 1996 the European Commission published the Air Quality Framework Directive on ambient air quality assessment and management (96/62/EC)[1]. This Directive defined the policy framework for 12 air pollutants including NO_2 known to have harmful effects on human health and the environment. Limit values (*pollutant concentrations not to be exceeded by a certain date*) for each specified pollutant were set through a series of Daughter Directives, including Directive 1999/30/EC (the 1st Daughter Directive)[2] which sets limit values for nitrogen dioxide (NO_2) and particulate matter (amongst other pollutants) in ambient air.

In May 2008 the Directive 2008/50/EC[3] on ambient air quality and cleaner air for Europe came into force. This Directive consolidates the above (apart from the 4th Daughter Directive) and makes provision for extended compliance deadlines for NO_2 and PM_{10}. The Directive has been transposed into national legislation in England by the Air Quality Standards Regulations 2010[4]. The Secretary of State (SoS) for the Environment has the duty of ensuring the air quality limit values are complied with.

2.2 Environment Act 1995

Part IV of the Environment Act 1995[5] places a duty on the SoS for the Environment to develop, implement and maintain an air quality strategy with the aim of reducing atmospheric emissions and improving air quality. The national air quality strategy (NAQS) for England, Scotland, Wales and Northern Ireland[6] provides the framework for ensuring that air quality limit values are complied with based on a combination of international, national and local measures to reduce emissions and improve air quality. This includes the statutory duty, also under Part IV of the Environment Act 1995, for local authorities to undergo a process of local air quality management and declare Air Quality Management Areas (AQMAs) where necessary.

2.3 Air quality objectives and limit values

The air quality limit values set by the European legislation and transposed into national law (UK objectives) are based on recommended guideline values from the World Health Organisation (WHO). Some pollutants have standards expressed as annual average concentrations due to the chronic way in which they affect health (i.e. effects occur after a prolonged period of exposure to elevated concentrations) and others have standards expressed as 24-hour, 1-hour or 15-

---

[1] Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management

[2] Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air

[3] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe

[4] The Air Quality Standards Regulations 2010, SI 2010/1001

[5] Environment Act 1995, Chapter 25, Part IV Air Quality

[6] The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, Volume 1, July 2007

minute average concentrations due to the acute way in which they affect health (i.e. after a relatively short period of exposure). Some pollutants have standards expressed in terms of both long-term and short-term concentrations. Table 1 sets out the air quality standards for the pollutants relevant to this study (NO_2, PM_{10} and $PM_{2.5}$).

Table 1 Air quality standards for NO_2, PM_{10} and $PM_{2.5}$

Pollutant	Averaging period	Air quality standard
Nitrogen dioxide (NO_2)	Annual mean	40µg/m^3
	1-hour mean	200µg/m^3 [1]
Particulate matter (PM_{10})	Annual mean	40µg/m^3
	24-hour mean	50µg/m^3 [2]
Particulate matter ($PM_{2.5}$)	Annual mean	25µg/m^3 [3]

[1] *not to be exceeded more than 18 times a year (99.8th percentile)*
[2] *not to be exceeded more than 35 times a year (90.4th percentile)*
[3] *to be complied with by 2015*

3 Current air quality issues around Gatwick

The air quality around Gatwick is influenced mainly by the surrounding road network with its road traffic emissions, as is generally the case for most locations in the UK. The airport operations, the M23 and the A23, as well as the towns of Horley to the north and Crawley to the south, are the major sources of air pollutants in the local area. Large variations in pollutant concentrations are observed, for instance, with higher concentrations being observed near to major roads. This reflects the localised influences of these sources. The land to the west of Gatwick is largely rural and there are few sources of air pollutants.

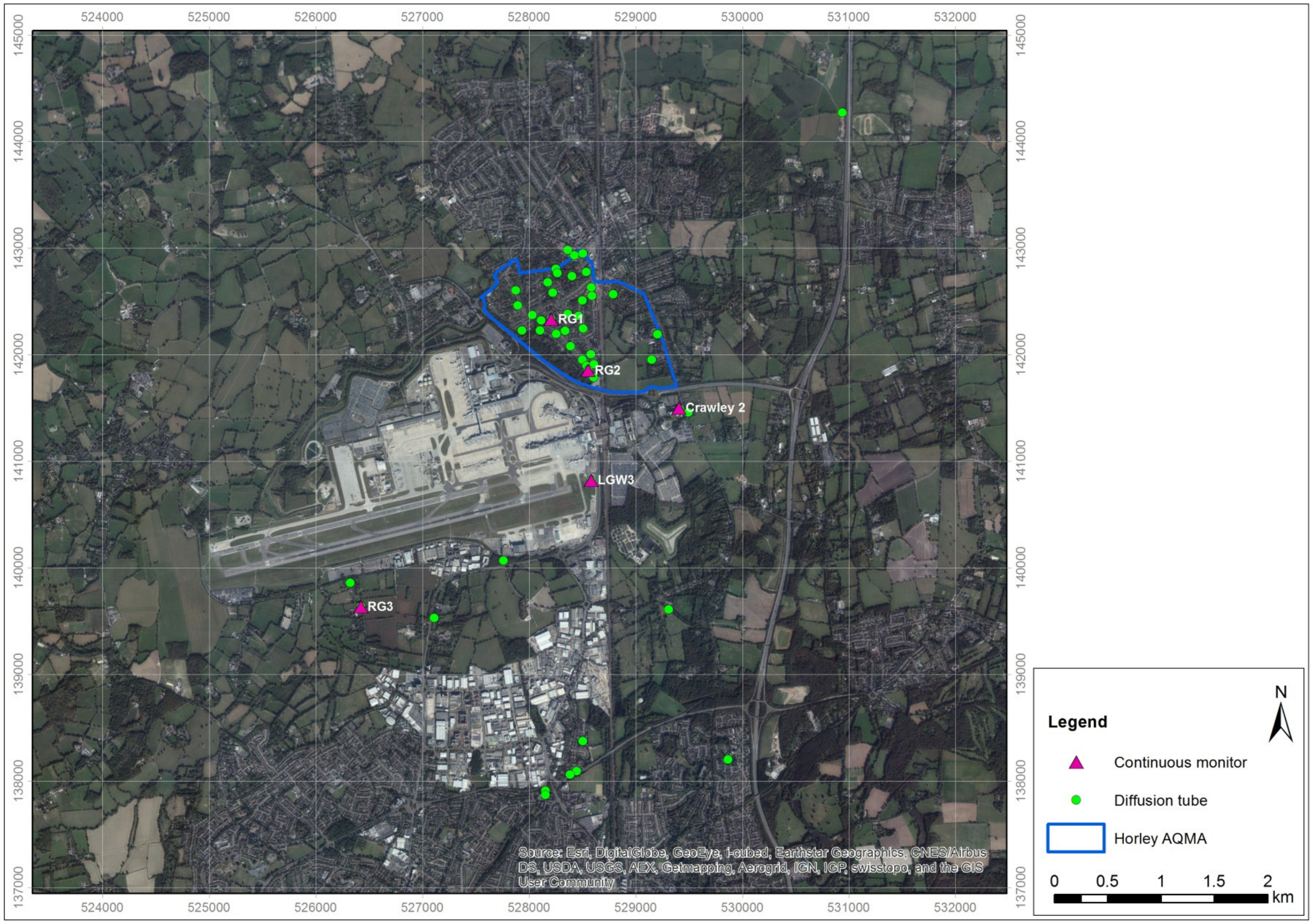
A substantial amount of useful data exists in the area on local concentrations of NO_2 in particular. Gatwick and the two local authorities with the most direct interest in local air quality contribute to the operation of monitoring stations on or near to the airport. The principal continuous monitoring stations are shown in Figure 1, along with the diffusion tube sites in the area. The continuous monitoring stations are operated by either the local authority or Gatwick, although Gatwick makes a financial contribution to the operation of all of them. They have been established for several years and provide a good basis for describing current concentrations of NO_2 and trends in concentrations. In addition to these automatic monitoring stations that provide hourly average concentration data, there is a dense network of diffusion tubes providing additional information on annual average concentrations of NO_2, especially in Horley.

The area to the north of the airport perimeter, across the A23, was declared an Air Quality Management Area (AQMA) by Reigate and Banstead Borough Council (R&BBC) for NO_2 in 2002. This has been the focus of attention in respect of the airport and its effect on local air quality in recent years. The precise spatial extent of the AQMA is shown in Figure 1.

The residents in the southern part of the AQMA are the closest to the current airport and therefore most exposed to its emissions, in combination with non-airport emissions from the local road network. For these reasons, the NO_2 concentrations in this area have been taken previously as the main indicator of the airport's impact on local air quality.

To the south of the airport, there have been no AQMAs declared by Crawley Borough Council, although a location adjacent to the A2011 in the northern part of Crawley (Tinsley Close) has been the subject of a formal Detailed Assessment process in order to determine the need for an AQMA. This indicates there was a potential risk of the NO_2 concentrations exceeding the air quality objective.

Figure 1 Location of automatic monitoring sites and Horley AQMA



The measurements of local NO_2 concentrations indicate that they are currently below the limit values for both the annual average and the short term peak concentrations. The values for the annual average concentrations of NO_2 are presented in Table 2 for the most recent years at the automatic monitoring locations shown in Figure 1. The concentrations from the passive monitoring locations are presented in Table 17 (Appendix A).

Table 2 Annual average NO_2 concentrations measured around Gatwick

Location	Year					
	2008	2009	2010	2011	2012	2013
RG1 Horley	22	23	21	29	25	27
RG2 Horley South	28	–	–	31	31	33
RG3 Poles Lane	19	23	18	21	19	19
CA2 Gatwick East	30	29	38*	28*	28	–
LGW3 Airport	35	34	37	32	33	–
** A problem with the analyser was reported that year – measurements taken from the co-located diffusion tubes instead.*						

At no location where public exposure occurs does the available monitoring evidence from recent years suggest that annual average NO_2 concentrations are consistently in excess of $40\mu g/m^3$. This remains true even on the airport perimeter. Concentrations in the Horley AQMA are currently well below the air quality objective.

NO_2 concentrations in 2030 and beyond are expected to be substantially lower than at present. The progressive introduction into the vehicle fleet of vehicles conforming to the Euro 6/VI emission standard (and better) will sharply reduce NOx emissions in future years, according to the projections of national emissions published by Defra[7]. It is these national initiatives that are the main reason why compliance with air quality standards will be achieved.

Using these projections, the highest background concentration of NO_2 in the Horley AQMA is predicted by Defra to be $17\mu g/m^3$ in 2030[8]. To the south of the airport, the background NO_2 concentration in the Tinsley Green and A2011 area is predicted to be around $22\mu g/m^3$. Concentrations alongside the major roads will be higher than these background concentrations, but are still expected to be well below $40\mu g/m^3$.

For PM_{10} and $PM_{2.5}$, the downward trend in concentrations is expected to be less pronounced over the period 2015 to 2030 than will be the case for NO_2 concentrations. Defra estimates the background concentration of PM_{10} in Horley in 2014 to be $15.1\mu g/m^3$, as compared with a projected estimate of $13.9\mu g/m^3$ for 2030[8]. The actual PM_{10} concentration at Michael Crescent in Horley (RG1) has been measured by R&BBC as $18\text{-}19\mu g/m^3$ in recent years.

$PM_{2.5}$ concentrations are typically around 60% of PM_{10} concentrations and the Defra estimate for the current annual average background concentration in the Horley area is 10-11 $\mu g/m^3$. The estimate for 2030 is only slightly lower at 9-$10\mu g/m^3$.

---

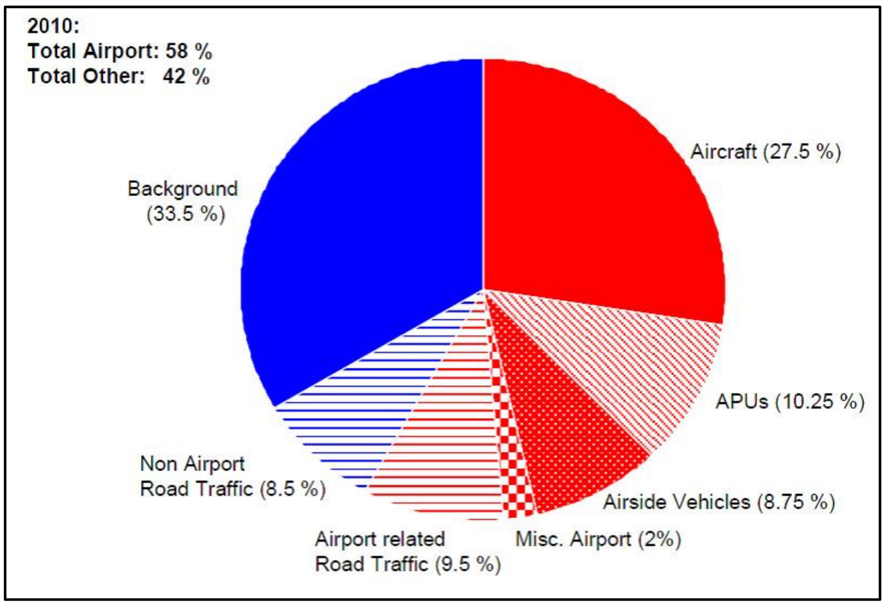
[7] Defra, Emission Factors Toolkit for Vehicle Emissions, Available from: http://laqm.defra.gov.uk/review-and-assessment/tools/emissions.html#eft [Accessed: March 2014]

[8] Defra, Background Maps, Available from: http://laqm.defra.gov.uk/maps/maps2010.html#2010BackgroundMaps [Accessed: March 2014]

PM_{10} and $PM_{2.5}$ concentrations are more difficult to reduce through national and local policies than NO_2, partly because of the large range of source types. Concentrations of both size fractions are well below the relevant limit values at all locations around Gatwick airport and there is no indication that this will change.

The impact that the airport's operations have on local air quality has been the subject of detailed investigation by both Gatwick and the two local authorities, with a particular focus on NO_2 and compliance with the national air quality objective. In addition to the routine monitoring referred to above, dispersion modelling has been carried out to quantify the airport's contribution to annual average NO_2 concentrations at key locations. Modelling by R&BBC has produced an estimate of the relative contribution made by the airport and its various source types to NO_2 concentrations at The Crescent, the most southerly residential location in the Horley AQMA. This is shown in Figure 2.

Figure 2 NOx contribution by source type for a receptor in The Crescent, Horley



At this location, very close to the airport perimeter, sources related to the airport's operations are estimated by the modelling to contribute a majority of the NO_x concentrations. This situation is likely to continue in the future, as the non-airport contribution decreases with lower road transport emissions. This decrease will be balanced, to some extent, as the airport reduces contributions from APUs and airside vehicles.

Careful analysis of the monitoring data at the RG1 and RG2 sites was undertaken using the OpenAir software to create bivariate plots of NO_2 concentration with variables such as wind direction, time of day and wind speed. This analysis did not reveal an airport signal at these locations within the AQMA. Instead, a stronger signal from road traffic was discernible and from a more northerly direction. This may reflect the fact that the airport's current emissions have an impact that is confined to locations very close to the airport's perimeter.

4 Predicted impacts of the proposed second runway (R2)

This section presents the assessment of predicted local air quality impacts from the operation of the proposed second runway at Gatwick without end around taxiways (EATs). A comparison of the assessment results with an alternative 'with EATs' option is presented in Appendix B of this report. Emissions from some ground sources have been calculated using worst case estimates; however it is expected that by the time of the R2 operation, emissions will be greatly reduced by the use of mitigation measures. Therefore, Appendix C describes these measures and presents the results of the assessment when taking them into account.

4.1 Methodology

Operational air quality impacts from the scheme arise principally as a result of increased aircraft traffic, as well as road traffic changes on the local road network. The effects of this increase in aircraft and road traffic have been assessed using the ADMS-Airport (version 3.2.4) atmospheric dispersion model. Annual mean concentrations of NOx, NO_2, PM_{10} and $PM_{2.5}$ have been estimated for comparison with the relevant air quality standards as mentioned in section 2. It has been assumed that short-term concentrations (hourly/daily means) can be derived using the empirical relationships identified in Defra's TG09 guidance[9]. The following sections detail the inputs and processes used in this assessment.

Assessment scenarios

The assessment scenarios are summarised as follows:

- 2040 Base Case scenario – the future scenario of the airport's operation without the scheme;
- 2040 operational scenario – the future scenario of the airport's operation with the scheme in 2040; and
- 2050 operational scenario – the future scenario of the airport's operation with the scheme in 2050.

The two operational scenarios refer to different predicted levels of passengers (in mppa) and their traffic movements in 2040 and 2050 respectively without EATs as shown in Table 3.

Table 3 Passenger capacity and aircraft movements in the assessment scenarios

Scenario	Passengers (mppa)	Aircraft movements
2040 Base Case	45.77	293,588
2040 Operation	83.09	496,214
2050 Operation	95.23	559,231

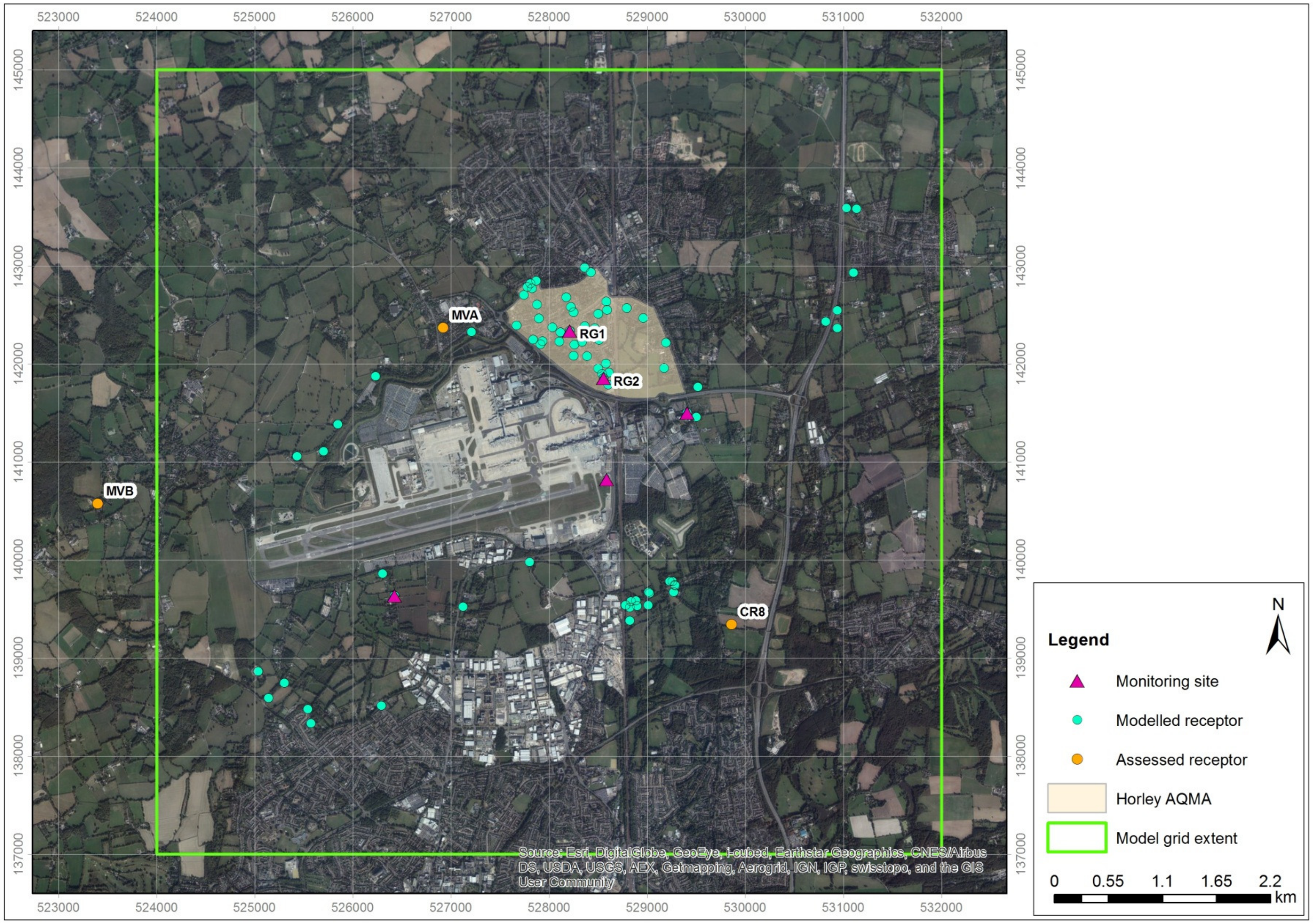
[9] Defra (2009) Local Air Quality Management Technical Guidance (TG09), London: Defra

Sensitive receptors

Pollutant concentrations have been forecast at selected locations around the airport, representing public exposure. Concentrations have also been forecast in a 8km by 8km grid centred around the airport, with intervals of 100m and a height of 1.5m, in order to generate contour plots in the study area (Figure 3). Intelligent gridding was also used in the model to calculate pollutant concentrations close to the sources.

Representative receptors around Gatwick have also been selected to present the model results in section 4.2. As shown in Figure 3, receptor CR8 is located to the south-east of the airport, where the proposed North East Sector residential development will be located as per Crawley's Local Plan. Receptors MVB and MVA are located to the north-west and to the north of the airport respectively.

Figure 3 Modelled receptors, monitoring sites and extent of grid



Emissions inventory

An inventory of annual emissions was built for the following pollution sources:

- Aircraft main engines in the landing and take-off (LTO) phases, both at ground level and at height;
- Aircraft Auxilliary Power Units (APUs);
- Ground Support Equipment (GSE), namely vehicles within the airport site which are associated with the aircraft turn-around and the runway maintenance;
- Other airport sources, including car parks, airport heating plant and fire training ground;
- Road vehicles on the local and strategic road network around the airport.

The modelled pollution sources for the 2040 base case and the 2040 and 2050 operational scenarios are shown in Figure 9 and Figure 10 respectively (Appendix A).

Aircraft emissions and APUs

Emissions for the aircrafts have been calculated using fleet data provided by Gatwick, consisting of annual forecasts of aircraft movements broken down by type (Table 4). Diurnal profiles for these forecasts were also derived based on passenger data. In order to define the engine types fitted in these aircrafts, the methodology that was developed for the PSDH (Programme for the Sustainable Development of Heathrow) project was followed.

Operations data for 2010 were used to derive the split between the different engine types from the aircraft. For the future scenarios, this split was used in conjunction with the age profile of the global aircraft fleet and a fleet rollover model, to define the proportion of future fleet likely to be using existing engine types. Future engine variants were also applied, taking into account reduced NOx emissions due to improved combustion systems and unchanged fuel efficiency. For future aircraft types, estimates of their emissions were derived using values scaled from existing representative engines. A further discussion on future engine emissions is provided in Appendix C.

Emissions from the different movement modes on the ground during the landing and take-off phases were based on ground-radar data from 2010 and 2005/06. This includes take-off roll, taxiing, hold and landing roll. Take-off thrust levels were also taken into account, using emission factors from the International Civil Aviation Organization (ICAO)[10]. Further corrections were used to take account of ambient conditions, forward-speed effects and engine spool-up, following the PSDH methodology. It was assumed that when the aircraft is idling, 7% thrust of the engine is used, 30% during the approach mode and 85% for take off and initial climb. All the different modes modelled in the airport are presented in Figure 4.

Emissions from APUs were also calculated based on the running time of the unit, the fuel consumption and relevant emission factors. Data for these were taken

[10] EASA (2012) ICAO Engine Emissions Databank, Issue 18A, Available from: http://easa.europa.eu/environment/edb/aircraft-engine-emissions.php [Accessed: September 2012]

from the Managing Director's Instructions for 2011 at Gatwick. This sets allowances for the use of APUs at stands, as well as at situations when the aircraft is towed, at ambient temperature beyond the specified range and at temporary exemptions. During normal operation and within an ambient temperature range of -5^{o}C to 25^{o}C, all aircraft should not exceed 10min APUs running time on arrival, while before departure the times are limited to 15min for narrow body and 50min for wide body aircraft. The APU running times have therefore assumed maximum use in accordance with the Instructions, i.e. 10 mins on arrival and 15 mins and 50 min on departure for narrow and wide body respectively.

The assumptions that APUs will be in widespread use for future scenarios is unrealistic, in that Fixed Electrical Ground Power is a more likely alternative for aircraft at piers, as is already the case at Gatwick for new piers. Therefore, emissions used in the modelling represent a worst case scenario.

Figure 4 Modelled airport sources and aircraft modes

Table 4 Predicted movements and for different aircraft types in the future assessment scenarios

Aircraft model	Description	2040 Base Case	2040 Operation	2050 Operation
AT7	ATR-72	1,420	2,344	0
DH4	Bombardier Q400	542	896	0
E75	Embraer 175	414	683	0
E95	Embraer 195	609	1,005	0
319ceo	A319 current engine option	2,773	4,578	0
320ceo	A320 current engine option	2,522	4,164	0
321ceo	A321 current engine option	763	1,260	0
737NGs	Boeing 737 current generation	1,336	2,206	0
E-Jet	Embraer E-Jets E2 series, C-series, MRJ or similar, same size category as E-175	10,346	17,079	9,790
E-Jet	Embraer E-Jets E2 series, C-series, MRJ or similar, same size category as E-195	15,221	25,127	14,404
319neo	A319 new engine option	51,994	85,833	32,801
320neo	A320 new engine option	47,291	78,069	29,834
321neo	A321 new engine option	14,315	23,632	9,031
737MAX	Boeing 737 new generation	25,052	41,356	15,804
Future TP	Clean sheet turboprop to replace AT7 & DH4 (entry into service 2025)	5,888	9,720	14,286
Future RJ small	Clean sheet regional jet of similar capacity to E75	0	0	9,790
Future RJ large	Clean sheet regional jet of similar capacity to E95	0	0	14,404
Future SA2	Clean sheet single aisle jet of similar capacity to A319	20,115	33,206	114,207
Future SA3	Clean sheet single aisle jet of similar capacity to A320	18,547	30,618	105,307
Future SA4	Clean sheet single aisle jet of similar capacity to A321	7,555	12,472	42,897
332	A330-200	0	0	0
333	A330-300	0	0	0
744	747-400	0	0	0
772	777-200	0	0	0
773	777-300	0	0	0
380	A380	2,821	5,145	2,062
350-8	A350-800	1,863	3,397	1,362
350-9	A350-900	9,377	17,099	6,854
350-10	A350-1000	3,035	5,534	2,219

Aircraft model	Description	2040 Base Case	2040 Operation	2050 Operation
77X	777X (planned development of the Boeing 777)	8,868	16,171	6,482
787-10	787-1000	7,255	13,230	5,303
787-8	787-800	9,273	16,911	6,779
787-9	787-900	7,671	13,988	5,607
Future TA1	Clean sheet twin aisle jet of similar capacity to A350-800	3,445	6,282	22,664
Future TA2	Clean sheet twin aisle jet of similar capacity to A350-900	7,311	13,332	48,099
Future TA3	Clean sheet twin aisle jet of similar capacity to A350-1000	5,025	9,162	33,056
Future LA	Clean sheet very large jet of similar capacity to A380	940	1,715	6,187
	TOTAL	*293,588*	*496,214*	*559,231*

Ground Support Equipment

Emissions for all the vehicles and plant within the airport site have been calculated for 2010. Vehicle emissions were calculated using emission factors from COPERT 4, assuming an airside speed of 20mph. Plant emissions were calculated using the European Environment Agency's inventory[11].

For the future assessment years, the emissions were scaled up from the 2010 inventory using the ratio of passenger numbers and accounting for future vehicle fleet and tighter emissions controls. It is more likely, however, that future GSE vehicles will be electric, making their emissions zero. Thus the modelling undertaken represents a worst case scenario.

Car parks, car rental pounds and taxis

Emissions from existing and proposed car parks, as well as car rental pounds, were calculated using the number of vehicles, travelling time in/out of the car parks and distance travelled. Emission factors were taken from the 2010 NAEI database for all vehicle types, also accounting for cold starts. Emissions from idling and queuing taxis were also calculated using a similar methodology.

Airport heating plant and fire training ground

Gatwick currently operates natural gas-fired boilers in both the North and South terminals to accommodate the heating demand. Annual emissions from these boilers were derived using information on fuel energy input and emission factors, based on stack emission measurements on site. For the future assessment years, emissions from boilers in the New Terminal were also calculated. In reality, the future emissions are likely to be considerably lower for space heating requirements, as the opportunity exists for a new and much more efficient energy centre to replace the existing gas fired boilers and there are further initiatives to reduce energy demand within the R2 Masterplan.

Road traffic

Dispersion modelling of road traffic emissions was undertaken using the ADMS-Roads (version 3.2.4) software. Traffic data for the road network surrounding the airport was provided for each assessment scenario in the form of daily flows, average speeds and junctions delays, broken down by types of vehicles (cars, LGVs, HGVs, buses) and categorised as airport or non-airport related (Table 5). Emission rates for all the road sources in this network were calculated using the UK Defra Emissions Factor Toolkit (EFT) (version 6.0)[12] which incorporates COPERT 4 (v10) emission factors for NOx and particulate matter. Emissions were calculated separately for each vehicle class and then added together for each road link.

Delays at junctions were also provided along with the traffic data. However, the resulting queues were not significantly long. Therefore, as a worst case, speeds were reduced to 20kph close to junctions following the Defra TG09 guidance[9]. Cold start vehicle emissions and diurnal profiles were also included in the models following the methodology of the previous assessment.

---

[11] EEA (2009) EMEP/EEA Air Pollutant Emission Inventory Guidebook 2009, Technical Report 9/2009

[12] Defra, Emissions Factor Toolkit v6.0, Available from: http://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html

Emissions from the strategic road network further away from the airport remained as in the previous assessment and were calculated using emission factors from the 2010 NAEI database[13].

Table 5 Breakdown of vehicle types in the traffic data

ID	Class	Description
1	Air pax cars	Cars (including minicabs and taxis). Air pax travelling between airport zones (forecourt, MSCP, GAL long stay) and external zones. Excludes air pax to off-airport zones (hotels, non-GAL parking, etc).
3	Airport related LV	All light vehicles (cars and LGVs) related to the airport operation, which are not included in class 1 and 11. This includes contractors, maintenance, deliveries, staff drop off etc, but also air pax related, eg. service trips of taxis and minicabs.
4	Airport related OGV1	OGV1 with origin or destination on the airport.
5	Airport related OGV2	OGV2 with origin or destination on the airport.
6	Minibuses	All minibuses.
7	Buses / coaches	Midibuses, standard buses and coaches.
8	Background LV	Through traffic light vehicles (cars and LGVs).
9	Background OGV1	Through traffic.
10	Background OGV2	Through traffic.
11	Staff cars	Employee car trips to/from staff car parks only.
OGV1 relates to rigid heavy goods vehicles and OGV2 relates to articulated heavy goods vehicles.		

Model setup

Meteorological data

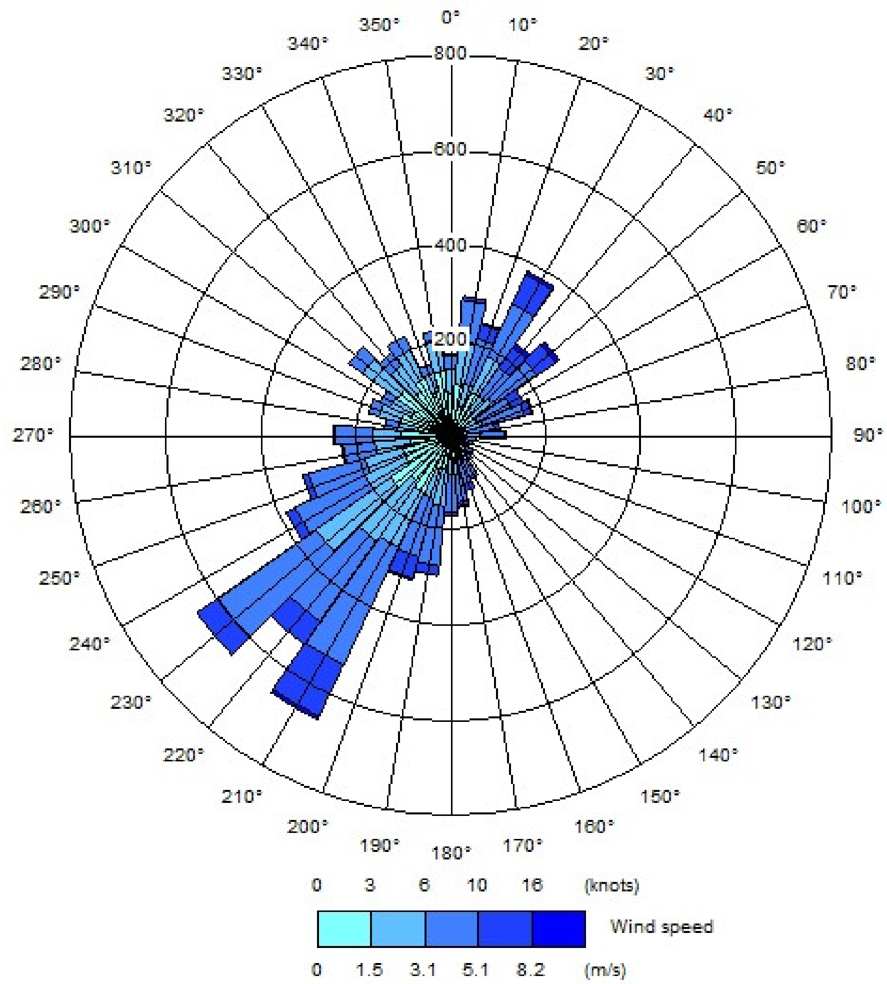
Hourly sequential observation data for 2005/06 was used in the assessment from the meteorological station at Charlwood, which is located immediately northwest of Gatwick Airport. Prevailing winds for the area are predominantly south-westerly (Figure 5). This met year was used in the initial assessment of the airport in 2005-06 and the model verification. Therefore, it has been kept the same to ensure consistency with previous assessments.

Most dispersion models do not use meteorological data if they relate to calm wind conditions, as dispersion of air pollutants is more difficult to calculate in these circumstances. ADMS treats calm wind conditions by setting the minimum wind speed to 0.75m/s. Defra's TG09 guidance[9] recommends that the meteorological data file is tested within a dispersion model and the relevant output log file checked to confirm the number of missing and calm hour that cannot be used by the dispersion model. This is important when considering predictions of high percentiles and the number of exceedances. The guidance recommends that meteorological data should only be used if the percentage of usable hours is greater than 75% and preferably 90%.

The 2005/06 meteorological data from Charlwood include 8,585 lines of usable hourly data, which corresponds to 98% of the year and 1,122 calm hours which correspond to 13% of the year. Both of these parameters are above the 75% threshold and the data is therefore adequate for the dispersion modelling.

[13] NAEI (2012) Emissions Maps 2010, Available from: http://naei.defra.gov.uk/mapping/mapping_2010.php?f_poll=all

Figure 5 Windrose for 2005-06 from Charlwood meteorological station



Other model parameters

The extent of mechanical turbulence (and hence, mixing) in the atmosphere is affected by the roughness of the surface/ground over which the air is passing. Typical surface roughness values range from 1.5m (for cities, forests and industrial areas) to 0.0001m (for water or sandy deserts). In this assessment, the general land use in the local study area can be described as agricultural with a corresponding surface roughness of 0.2m.

Another model parameter is the Monin-Obukhov length, which describes the stability of the atmosphere. Typical values range from 2m to 20m for rural areas. In urban areas though, where traffic and buildings cause the generation of more heat, these values are higher. For this model, a minimum length of 20m was used.

Model verification

Model verification refers to the comparison of modelled pollutant concentrations with measured concentrations at the same points to determine the performance of the model. Should the model results for NO_2 be largely within ±25% of the measured values and there is no systematic over or under-prediction of concentrations, then no adjustment is necessary according to Defra's TG09 guidance[9]. If this is not the case, then the modelled values are adjusted based on the observed relationship between modelling and measured NOx concentrations to provide a better agreement.

A detailed modelling evaluation study was undertaken in the 2005/6 assessment of the airport[14] and a re-evaluation was undertaken in the 2010 assessment[15]. Both studies showed that the model was performing well close to the airport and so no adjustment was applied to the modelled concentrations.

Results processing

NOx to NO_2 conversion

The model predicts NOx concentrations which comprise principally nitric oxide (NO) and primary NO_2. The emitted NO reacts with oxidants in the air (mainly ozone) to form more NO_2, known as secondary NO_2. Since only NO_2 has been associated with effects on human health, the air quality standards for the protection of human health are based on NO_2 rather than NOx or NO. Thus, a suitable NOx to NO_2 conversion needs to be applied to the modelled NOx concentrations.

The method taken for converting NOx to NO_2 in this assessment follows the approach described by Clapp and Jenkin[16,17], which takes account of the proportion of primary NO_2 in the balance between NO and NO_2 as a function of distance from major sources. Primary NO_2 fractions for the aircraft sources were taken from the PSDH methodology, while for road vehicles these were taken from the 2010 NAEI database[13]. A value for the regional background oxidant was taken as 33.5ppb in 2008 and was projected by +0.1ppb/yr for future years.

Background concentrations

Background concentrations refer to the existing levels of pollution in the atmosphere, produced by a variety of sources, such as roads and industrial processes. Emissions from these sources, which have not been explicitly included in the model, were taken from the National Atmospheric Emissions Inventory (NAEI) and the London Atmospheric Emissions Inventory (LAEI). For the future assessment years, emissions were calculated using the national projections[18]. A

[14] Underwood, Walker and Peirce (2008) Gatwick Emission Inventory 2005/6, AEAT/ENV/R/2395
[15] Peace and Walker (2012) Gatwick Airport emissions inventory and air quality modelling for 2010, Ricardo-AEA/R/3347
[16] Clapp and Jenkin (2001) Analysis of the relationship between ambient levels of O_3, NO_2 and NO as a function of NOx in the UK, Atmospheric Environment 35, 6391-6405
[17] Jenkin (2004) Analysis of sources and portioning of oxidant in the UK – Part 1: the NOx-dependence of annual mean concentrations of nitrogen dioxide and ozone
[18] Misra et al (2012) UK Emission Projections of Air Quality Pollutants to 2030, AEA/ENV/R/3337

rural contribution term was also added to the model concentrations, which was derived from three rural monitoring sites. Background $PM_{2.5}$ concentrations were assumed as 64% of background PM_{10} concentrations.

4.2 Results

NOx emissions and concentrations

Table 6 presents the estimated annual emission rates of NOx for each pollution source. It can be observed that aircraft movements make the highest contribution to emissions by a considerable margin. The second biggest source in NOx emissions is the non-airport road traffic, but this is an order of magnitude less.

Figure 6 shows these emissions graphically for each assessment scenario. It can be observed that total 2040 base case NOx emissions are expected to decrease compared with 2010. This is mainly due to the decrease in road-related emissions from the introduction of cleaner vehicles and tighter emissions controls. It can also be observed that aircraft NOx emissions are predicted to increase with the operation of the second runway in 2040, while non-airport road emissions are expected to decrease further into the future.

However, if these emissions are normalised by the passenger numbers in each assessment year (Table 7), it can be observed that both aircraft and non-airport road NOx emissions are less than the anticipated increase in passenger numbers compared to 2010. More specifically, aircraft NOx emissions per passenger in 2040 are almost 24% lower than in 2010, while non-airport road NOx emissions per passenger for the same year are estimated to be almost 80% lower than in 2010. This is a result of improved emission controls on road vehicles and aircraft engines with lower NOx emissions, as well as the introduction of larger aircraft.

Table 6 Predicted NOx emission rates without EATs

Source		NOx emission rate (tonnes/year)			
		2010	**2040 Base Case**	**2040 Operation**	**2050 Operation**
Airport	Aircraft (elevated)	806.75	963.94	1,616.27	1,721.02
	Aircraft (ground)	471.24	531.68	959.96	1,051.95
	GSE	118.18	21.34	38.31	43.87
	Road network	141.55	43.94	61.50	65.70
	Car parks	6.89	4.09	6.63	7.25
	Stationary sources	24.66	24.66	46.34	46.34
Non-airport	Road network	271.05	148.04	141.24	131.41

Figure 6 NOx emission rates (tonnes/year) per source for each assessment scenario

Table 7 Normalised NOx emissions by passenger numbers

Metric	2010	2040 Base Case	2040 Operation	2050 Operation
Aircraft				
NOx emissions (tonnes/year)	1,277.99	1,495.62	2,576.24	2,772.97
Pax (mppa)	31.38	45.77	83.09	95.23
Ratio (g/pax)	40.7	32.7	31.0	29.1
Non-airport road traffic				
NOx emissions (tonnes/year)	271.05	148.04	141.24	131.41
Pax (mppa)	31.38	45.77	83.09	95.23
Ratio (g/pax)	8.6	3.2	1.7	1.4

Figure 11 to Figure 13 in Appendix A show the predicted NOx concentrations as contour plots for each of the assessment scenarios without EATs. Table 8 and Figure 7 show the modelled NOx concentrations broken down by sources at the monitoring sites within the Horley AQMA (RG1 and RG2), as well as at locations representing population exposure around the airport, as mentioned in section 4.1 (Figure 3). The other monitoring sites in the area (LGW3 and Crawley 2) can be discarded, since in future operational scenarios they fall within the airport's perimeter.

It can be observed that concentrations of NOx within parts of the Horley AQMA are expected to have a small increase, up to a maximum of 0.7μg/m^3 in 2040, relative to the base case. At the receptor locations north-west and north of the airport (MVB and MVA), the increase in NOx concentrations is predicted to be approximately 1µg/m^3. At the location CR8 south-east of the airport, it is predicted that NOx concentrations will increase by 1.3µg/m^3 in 2040, but remain below 30µg/m^3 at all assessment scenarios. It can also be observed that, at this location, the road traffic emissions contribute the same magnitude of NOx concentrations as the aircraft and APUs sources, while the other airport operations have a very small contribution to NOx concentrations.

Table 8 Predicted NOx concentrations at selected locations

Location	NOx concentrations (µg/m^3)				
	Aircraft and APUs	**Airport operations**	**Road network**	**Background concentrations**	**Total**
RG1 Horley *(within Horley AQMA)*					
2040 Base Case	7.75	2.98	3.62	19.72	34.1
2040 Operation	8.95	3.40	2.73		34.8
2050 Operation	9.49	3.57	2.83		35.6
RG2 Horley South *(within Horley AQMA)*					
2040 Base Case	12.65	2.59	7.64	18.73	41.6
2040 Operation	13.66	3.37	4.43		40.2
2050 Operation	14.49	3.65	4.63		41.5
CR8 *(south-east of the airport)*					
2040 Base Case	1.94	0.41	3.00	19.64	25.0
2040 Operation	3.03	0.75	2.84		26.3
2050 Operation	3.24	0.78	2.81		26.5
MVB *(north-west of the airport)*					
2040 Base Case	0.69	0.06	0.11	16.60	17.5
2040 Operation	0.76	0.09	0.10		17.5
2050 Operation	0.82	0.09	0.10		17.6
MVA *(north of the airport)*					
2040 Base Case	3.25	0.50	0.68	18.01	22.5
2040 Operation	4.39	0.70	0.43		23.6
2050 Operation	4.70	0.77	0.44		24.0

Figure 7 Predicted contributions to NOx concentrations around the airport

NO_2 concentrations

Figure 14 to Figure 16 in Appendix A show the predicted NO_2 concentrations as contour plots for each of the assessment scenarios. Table 9 shows the predicted NO_2 concentrations at selected locations around the airport. It can be observed that concentrations are expected to be well below the air quality objective and EU limit value at all locations for the future base case and operational scenarios.

The Horley AQMA and the south-east of the airport are expected to experience small changes in NO_2 concentrations in 2040 of up to a maximum of 1.4µg/m^3. To the north-west of the airport, NO_2 concentrations are predicted to increase by 1.1µg/m^3 in 2040 at worst. At all locations, however, NO_2 concentrations are predicted to be well below the air quality objective value in both future operation scenarios. Therefore, it is predicted that only negligible impacts from NO_2 concentrations would occur around the airport in 2040.

Table 9 Predicted NO_2 concentrations at selected locations

Location	2040 Base Case	2040 Operation	2050 Operation
RG1 Horley	24.2	25.6	26.7
RG2 Horley South	28.1	28.8	30.2
CR8	19.2	20.4	21.1
MVB	14.2	14.4	14.8
MVA	17.5	18.6	19.4

PM emissions and concentrations (PM_{10} and $PM_{2.5}$)

Emissions

Table 10 and Table 11 present the estimated emission rates for PM_{10} and $PM_{2.5}$ respectively, broken down by pollution source type. It can be observed that the highest contributions come from the road network and aircraft on the ground. The increased contribution from aircraft ground emissions in future years compared with the 2040 base case is mainly due to an increase in emissions from brake and tyre wear. Emissions from the road network are estimated to be reduced in future years compared with the 2040 base case, mainly owing to improved emission controls in future vehicle fleets.

Table 10 Predicted PM_{10} emission rates without EATs

Source		PM_{10} emission rate (tonnes/year)			
		2010	2040 Base Case	2040 Operation	2050 Operation
Airport	Aircraft (elevated)	3.75	4.02	6.71	7.08
	Aircraft (ground)	11.08	13.37	23.44	28.03
	GSE	7.78	3.62	6.49	7.47

Source		PM_{10} emission rate (tonnes/year)			
		2010	2040 Base Case	2040 Operation	2050 Operation
	Road network	14.60	12.45	10.01	14.61
	Stationary sources	0.39	0.39	0.72	0.72
Non-airport	Road network	29.76	30.33	29.99	31.11

Table 11 Predicted $PM_{2.5}$ emission rates without EATs

Source		$PM_{2.5}$ emission rate (tonnes/year)			
		2010	2040 Base Case	2040 Operation	2050 Operation
Airport	Aircraft (elevated)	3.75	4.02	6.71	7.08
	Aircraft (ground)	9.11	9.94	17.57	21.01
	GSE	6.36	1.95	3.50	4.03
	Road network	9.03	6.69	5.64	9.91
	Stationary sources	0.39	0.39	0.72	0.72
Non-airport	Road network	19.04	16.49	16.22	16.83

PM_{10} concentrations

Figure 17 to Figure 19 in Appendix A show the predicted concentrations of PM_{10} as contour plots for each of the assessment scenarios. Table 12 presents the predicted airport and non-airport PM_{10} concentrations around the airport. It can be observed that concentrations are expected to be well below the air quality standard at all locations and that the highest contribution is from non-airport sources, i.e. the road network and background. The change in concentrations is imperceptible in 2040 and 2050. Therefore, all sites are expected to experience impacts that are considered to be negligible.

Table 12 Predicted PM_{10} concentrations at selected locations

Location	PM_{10} concentrations ($\mu g/m^3$)				
	Aircraft & APUs	Airport operations	Road network	Background	Total
RG1 Horley *(within Horley AQMA)*					
2040 Base Case	0.25	0.20	0.45	17.41	18.3
2040 Operation	0.31	0.25	0.50		18.5
2050 Operation	0.38	0.28	0.53		18.6
RG2 Horley South *(within Horley AQMA)*					
2040 Base Case	0.43	0.30	0.89	17.24	18.9
2040 Operation	0.47	0.36	0.74		18.8
2050 Operation	0.57	0.41	0.79		19.0
CR8 *(south-east of the airport)*					
2040 Base Case	0.07	0.03	0.48	17.78	18.4
2040 Operation	0.12	0.06	0.53		17.0

Location	PM_{10} concentrations (µg/m³)				
	Aircraft & APUs	Airport operations	Road network	Background	Total
2050 Operation	0.14	0.06	0.55		18.5
***MVB** (north-west of the airport)*					
2040 Base Case	0.02	0.01	0.10	16.94	17.1
2040 Operation	0.02	0.01	0.02		17.0
2050 Operation	0.03	0.01	0.02		17.0
***MVA** (north of the airport)*					
2040 Base Case	0.09	0.06	0.02	17.13	17.3
2040 Operation	0.6	0.08	0.10		17.5
2050 Operation	0.19	0.10	0.10		17.5

$PM_{2.5}$ concentrations

Figure 20 to Figure 22 in Appendix A show the contours of $PM_{2.5}$ concentrations in the study area for the assessment scenarios. Table 13 presents the predicted airport and non-airport $PM_{2.5}$ concentrations around the airport. Similar to the PM_{10} results, the highest contributions are from the non-airport sources, i.e. the background and the road network, and concentrations are expected to be well below the air quality standard at all locations.

Table 13 Predicted $PM_{2.5}$ concentrations at selected locations

Location	$PM_{2.5}$ concentrations (µg/m³)				
	Aircraft & APUs	Airport operations	Road network	Background	Total
RG1 Horley					
2040 Base Case	0.20	0.12	0.25	11.16	11.7
2040 Operation	0.24	0.15	0.27		11.8
2050 Operation	0.30	0.17	0.29		11.9
RG2 Horley South					
2040 Base Case	0.34	0.17	0.51	11.03	12.1
2040 Operation	0.37	0.21	0.42		12.0
2050 Operation	0.46	0.23	0.45		12.2
***CR8** (south-east of the airport)*					
2040 Base Case	0.05	0.02	0.27	11.23	11.6
2040 Operation	0.08	0.03	0.29		11.6
2050 Operation	0.10	0.04	0.30		11.7
***MVB** (north-west of the airport)*					
2040 Base Case	0.01	0.003	0.01	10.82	10.8
2040 Operation	0.02	0.01	0.01		10.8
2050 Operation	0.02	0.01	0.01		10.9
***MVA** (north of the airport)*					
2040 Base Case	0.07	0.03	0.05	10.95	11.1
2040 Operation	0.12	0.05	0.05		11.2
2050 Operation	0.14	0.05	0.06		11.2

5 Assessment of air quality impacts during construction

Construction activities can impact on air quality directly by emissions from activities such as demolition, earth moving, handling of dusty materials and dust emissions from movement of construction vehicles. Air quality emissions from these activities are largely associated with dust and particulate matter although operation of construction machinery and vehicles also gives rise to gaseous pollutants such as NOx. A second source of air quality impacts is from traffic, either from construction related vehicles travelling to and from the site or from changes in emissions caused by congestion, diversions, delays and road closures that result from construction activities.

5.1 Construction dust

Dust and particulate matter emissions from construction activities can generally be readily controlled by careful planning and the use of mitigation measures. The IAQM has produced guidance[19] for the assessment and mitigation of dust emissions and notes that "*it is anticipated that with the implementation of effective site-specific mitigation measures the environmental effect will not be significant in most cases*". This is because there are numerous mitigation measures that can be applied that successfully reduce dust emissions and these would be applied during the construction activities at Gatwick.

Dust impacts from construction are confined to relatively short distances from the construction activity; the IAQM guidance suggests that only receptors within 350m of the boundary of a construction are likely to be impacted by dust. As most of the construction activities at Gatwick are in areas distant from any significant numbers of sensitive receptors it can be expected that impacts from construction dust would not be significant, particularly if the mitigation measures proposed below are applied. The measures that would be applied at Gatwick are detailed in Table 14.

Table 14 Mitigation measures assumed to be applied at all construction sites

Activity	Mitigation
Site planning	Machinery, fuel and chemical storage and dust generating activities should not be located close to boundaries and sensitive receptors if at all possible. Erect effective barriers around dusty activities or the site boundary.
Haul roads	Use consolidated surfaces on haul roads near to residential areas. Use agreed wet cleaning methods or mechanical road sweepers on all roads during periods of dry weather. Clean road edges and pavements using agreed wet cleaning methods.
Vehicles	All vehicles should switch off engines - no idling. Clean or wash all vehicles effectively before they leave a site if there is a risk of affecting nearby sensitive receptors. All loads entering and leaving site to be covered. All vehicles under the control of GAL to comply with Euro VI emission standards or better.

[19] IAQM (2014) Guidance on the assessment of dust from demolition and construction

Activity	Mitigation
Site entrances/exits	Wash or clean all vehicles effectively before leaving the site if it is close to sensitive receptors. Ideally there should be a paved area between the wheel wash and before the public road.
Excavation and earthworks	All dusty activities should be damped down, especially during dry weather. Temporarily cover earthworks if possible. Minimise drop heights to control the fall of materials.
Stockpiles	Make sure that stockpiles exist for the shortest possible time. Where stockpiles are required for longer periods, ensure these are covered or re-vegetated.
Grinding, cutting, sawing	All equipment should use water suppressant or suitable local exhaust ventilation systems, where located close to sensitive receptors.
Chutes and skips	Securely cover skips. Minimise drop heights to control the fall of materials. Regularly damp down surfaces with water.
Off road vehicles and plant	All non-road mobile machinery (NRMM) should use fuel equivalent to ultra-low sulphur diesel (ULSD), especially where a bunkered fuel supply is available. No vehicles or plant will be left idling unnecessarily. NRMM (vehicles and plant) should be well maintained. Should any emissions of dark smoke occur (except during start up) then the relevant machinery should be stopped immediately and any problem rectified before being used. Engines and exhaust systems should be regularly serviced according to manufacturer's recommendations and maintained to meet statutory limits/opacity tests. All vehicles should hold current MOT certificates where required. Vehicle exhausts should be directed away from the ground and positioned so they are not directed at site entrances. Locate plant away from the boundaries close to residential areas

5.2 Construction-related traffic impacts

There are two main sources of potential impacts on air quality during the construction period on the local road network. Firstly emissions from vehicles directly associated with the construction activities travelling to and from the site and secondly, changes in emissions from other vehicles on the network where they need to be diverted or they are delayed owing to increased congestion.

For the vehicles directly associated with the construction activities, their impacts on the local population would be carefully controlled by the implementation of two main measures:

1. Requiring the use of vehicles that comply with Euro VI emission standards or better. The emission controls fitted to such vehicles represent the best available at present and reduce NOx emissions to a level lower than that of current diesel cars. This represents a reduction in NOx emissions of over 90% compared with the current average HDV in the UK fleet.
2. Use of construction vehicle management to fix routes to access and leave the site so that impacts on major residential areas is minimised.

The management plans would also include the timing of journeys to minimise the use of construction vehicles during more congested periods where emissions from vehicles tend to be at their highest.

The proposal for the second runway at Gatwick includes realignment of the A23 and works at the junction of the M23 spur. However, no major works are required on the alignment of the M23 and therefore disruption will be minimised. The realignment of the A23 moves the road through a relatively sparsely populated area and the new line of the new permanent road can be built largely without disruption to the existing A23. It can therefore be anticipated that required road works can be completed without resulting in long periods of congestion. This compares favourably with the situation at Heathrow where major works are required on the motorway network and the A4 in an area that is already amongst the most heavily trafficked in the UK and where such works will be required for an extended period of several years.

No significant volumes of spoil would be removed from the airport site during construction of the new runway and the new infrastructure. All the excavated earth would be used elsewhere on the site. It is possible that aggregates could be imported by rail if a new siding was created for this purpose. These features of the construction programme would reduce HDV movements relative to any similar projects of this scale.

The use of HDVs complying with the Euro VI controls would reduce the direct impacts of emissions from construction traffic to low levels. The Euro VI controls represent a step change in emissions controls for NOx. The technology used includes selective catalytic reduction (SCR) and is highly effective in reducing NOx emissions. It is anticipated that these controls would reduce NOx emission by some 95% compared with the current vehicle fleet and the nature of the testing required to demonstrate compliance with the standard includes testing in “on the road” conditions. This means that the Euro VI controls are more likely to be effective than previous Euro standards and hence there is greater confidence that substantial reductions in emissions will be achieved.

Taking all these controls together it can be anticipated that the second runway at Gatwick can be constructed without risk of breaching the EU air quality limit values and UK air quality objectives.

6 National Assessment

6.1 National Emissions

The 2001 National Emissions Ceiling Directive[20] set binding limits on Member States for the national emissions of four pollutants (NOx, sulphur dioxide, ammonia and non-volatile organic compounds), to be achieved by 2010 and not to be exceeded thereafter. The UK met this limit, with national emissions reported as 95% of the ceiling value of 1,167 ktonnes in 2010. Twelve other Member States did not comply with their emission ceilings for NOx. The European Commission has proposed a revision to the Directive that would require the UK to reduce its NOx and $PM_{2.5}$ emissions by 73% and 47%, respectively, for years beyond 2030, relative to a base year of 2005. (This implies targets of 483 ktonnes for NOx and 49 ktonnes for $PM_{2.5}$). This proposal has yet to be adopted.

Member States are also signatories to the Gothenburg Protocol, which was revised in 2012 and has set reduction targets for national emissions of the four pollutants, along with $PM_{2.5}$, for 2020 and beyond. The UK has agreed to reduce its NOx emissions relative to 2005 by 55%, giving a target of 716 ktonnes. Similarly, the UK's $PM_{2.5}$ emissions will be reduced by 30% to 57 ktonnes.

Current projections made by Defra indicate that the UK will meet these Gothenburg Protocol targets for national emissions of both NOx and $PM_{2.5}$[21]. In particular, emissions of NOx are expected to decline as a consequence of continued reductions from the road transport sector and the decarbonisation of the electricity generating industry, which will mean the closure of power stations fuelled by coal and natural gas. The estimate for national emissions of NOx in 2030 is 589 ktonnes, although this is subject to assumptions made on factors such as economic growth, fuel prices and transport activity.

The pollutant emitted in the greatest quantity by the proposed scheme is NOx, chiefly from the aircraft movements. By 2040, it is estimated that the airport would be emitting 2,729 tonnes annually, relative to 1,590 tonnes in a single runway (R1) base case scenario. This implies an approximate increase of around 1 ktonne of NOx. The airport's contribution to the national total is a small proportion of the total and the estimated increase of 1 ktonne of NOx can be accommodated in the context of the Gothenburg Protocol and its likely amendments for future decades. There are unlikely to be significant differences in total emissions with a third runway at Heathrow, although they are more likely to affect the more densely populated areas of London.

6.2 Human health

This increase in NOx emissions has two pathways for health effects. Firstly, it will cause an increase in NO_2 concentrations around the airport and secondly it will lead to the formation of secondary particulate matter at a regional level. This latter pathway is addressed in the damage costs provided by Defra and HM Treasury for use in estimating the economic impact of air pollution. The figure for

[20] Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants, Official Journal of the European Communities L309, pp 22-30

[21] AEA (2012) UK Emission Projections of Air Quality Pollutants to 2030

NOx is £955 per tonne as a central estimate (at 2010 prices)[22]. Hence in this case, the annual damage cost associated with NOx emissions from the expanded airport is approximately £1M. This impact takes into account the additional effects on morbidity and mortality that are associated with the direct effects on health of NO_2 and the health effects of the secondary particulate matter, which contribute to additional mortality. It is assumed in the damage cost for NOx that the health impact per tonne is 0.082 years of life lost and only 0.002 additional hospital admissions. (The damage cost does not take into account the health impacts of excess tropospheric ozone.)

On this basis, and for the additional NOx emissions in 2040 only, the associated loss of life years over 100 years from 2040 onwards would be just over 90 for the whole of the exposed population, which is much of England. This is a very approximate number, since the Green Book methodology assumes a 'pulse' change occurring at a point in time, whereas the change in airport emissions would be more gradual over a period of time. It should also be noted that this health impact is likely to be broadly similar if the additional NOx emissions were instead at Heathrow, not Gatwick.

The damage costs suggested by the Green Book are, of necessity, based on some assumptions regarding the emissions' location and the resulting public exposure to the pollutant. The damage cost for NO_2 is accounting for health effects, which in monetary terms is dominated by the value assigned to the loss of life years from long term exposure to $PM_{2.5}$. Since this is attributable to the assumed secondary particulate matter resulting from the NOx emission, this will be accounting for health effects on a regional or national basis and far away from the airport. The population exposure is therefore based on the likely distribution of people on a national basis and can be taken as reasonably accurate in this case.

For particulate matter, there are some contrasting characteristics to NO_2 that influence the health impacts. The principal health impact in monetary terms is again mortality, but the impact that $PM_{2.5}$ has is much greater per unit mass of pollutant and it is direct. Thus, whilst there is also a regional effect that cannot be discounted, a significant proportion of the effect on mortality will occur within several kilometres of the airport. The increased severity of the impact is reflected in the Green Book damage cost, which is expressed for PM_{10} for road transport by National Transport Model areas. For Gatwick it is most appropriate to take the value as the 'Transport Average', because Gatwick has a mixture of urban and rural areas around it. This value has a central estimate of £48,517 per tonne at 2010 prices (a small element is included for building soiling). This is mostly based on a value of years of life lost over 100 years of approximately 2.44 per tonne, with a very small value attributable to additional hospital admissions (0.04).

For the year 2040, the emissions inventory used for the dispersion modelling has a PM_{10} emission for the airport of 33.8 tonnes in the case of the single runway future base case and 47.4 tonnes with the second runway, i.e. a difference of 13.5 tonnes. Thus, the central estimate for the damage cost is approximately £660,000 for this year's emissions, using the value of £48,517 given above. It would be higher if the value used was for the 'Outer Conurbation' or 'Outer London' category, but lower if the 'Rural' category value was selected. For Heathrow, it would be more appropriate to take the value for 'Outer London', as this would

[22] HM Treasury (2013) Valuing impacts on air quality: Supplementary Green Book guidance

capture the higher population exposure for this airport. (This damage cost is £148,949 per tonne).

In summary, the health impacts resulting from the additional emissions to atmosphere arising from R2 are likely to be small and not significant in public health terms, because of the relatively low public exposure around the airport and the very small changes to the local concentrations of the key pollutants.

6.3 Ecosystems

The additional 1 ktonne of NOx released annually by the second runway proposal (from 2040 onwards) will have other environmental and economic consequences beyond those for human health. On a national scale, the NOx will add to deposition of nitrogen compounds, which has positive and negative effects.

Some ecosystems are sensitive to additional nutrients or acidification. By 2020, it is anticipated that the area of sensitive habitats across the UK where the critical load for nitrogen is exceeded will be 48% (the equivalent value for 2012 is 58%)[23]. This is still a substantial fraction and demonstrates how sensitive many habitats are and how recovery to a pre-industrial state is difficult to achieve.

Acidification effects from nitrogen compounds have historically been lower than for sulphur compounds. With the sharp reduction in sulphur emissions in recent decades (94% from 1970 to 2010), the relative importance of nitrogen has risen in this regard. Emissions of NOx contribute hydrogen ions through the formation of nitric acid (HNO_3) and its subsequent wet deposition, chiefly during rainfall at long distances from the source. Acidification affects not just the health of the vegetation in the habitats where deposition occurs, but also the water catchment and watercourses.

The net effect of the long range transport of nitrogen compounds and their deposition is a complex aggregation of positive and negative effects. The deposition of nutrient nitrogen and acidity on habitats that are sensitive will have negative effects on the plant species diversity in those habitats, with consequent effects on the animals dependent on those plants. There are other more subtle effects, such as the effect on microbial activity in the soils, which may have implications for nutrient cycling, carbon sequestration and nitrous oxide (N_2O) release. Excess nitrogen leached from soils will add to nitrate levels in surface water and groundwater, which is thought to have adverse effects on human health.

In contrast to certain natural environments, nitrogen deposition on agricultural land and managed forests is a benefit, in that it represents a fertiliser and a boost to production.

The valuation of these effects is still in its infancy, relative to the human health effects of air pollution. The ‘ecosystems services’ concept can be applied here and an early example can be found in the work of Jones et al[24], who examined the consequences for ecosystem services of N deposition decline in the UK from 1987 to 2005. The authors concluded that the adverse effects of nitrogen deposition on

---

[23] RoTAP (2012) Review of Transboundary air pollution: Acidification, Eutrophication, Ground level Ozone and Heavy Metals in the UK. Contract Report to the Department for Environment, Food and Rural affairs. Centre for Ecology and Hydrology

[24] Jones L *et al* (2014) A review and application of the evidence for the impacts of nitrogen on ecosystems services, *Ecosystems Services* **7**, 76-88

sensitive ecosystems, as expressed in appreciation in biodiversity, considerably outweigh the benefits found elsewhere. Their conclusion is that a net benefit of £65million (net equivalent annual value) accrued from the annual decline of 2.5kgN/ha averaged nationally in the 18 year period they considered. (National emissions of NOx declined at a rate of 67 ktonnes per annum over this period).

The implication of this is that the 1 ktonne of additional NOx in 2040 and every year after will have some adverse effect that has a monetary value that cannot be easily identified, but is less than £1M (net equivalent annual value) if scaled with the national emission and deposition rate. On a national scale, this incremental NOx emission will be less than 0.2% of the UK's total emissions in 2020, if the Gothenburg Protocol target is met. The national total may well be less than this in 2030 and 2040, but the contribution from the scheme is still likely to be less than 1% of this total and the area of habitat in the UK exceeding the critical load for nitrogen and acid deposition will have declined further from the 2020 figure.

6.4 Population exposure

The impact on local air quality of an airport with the aircraft movements and passenger numbers associated with the R2 proposal would be approximately the same regardless of its location, as measured simply by the change in concentrations of the key pollutants. As Table 6 and Table 10 of this report clearly show, a large proportion of the emissions of NOx and particulate matter are attributable to the aircraft and these are, for the most part, outside the direct control of the airport.

In contrast, the effects of such changes in pollutant concentrations on human health are not independent of airport location and most obviously depend on the numbers of people exposed to the additional concentrations. Dispersion modelling and air quality monitoring at many airports have both consistently shown that the impacts on air quality are greatest on the airport itself and decline quite rapidly with distance. In terms of public exposure, this means that the largest effects on health would be at locations near the airport perimeter where people spend long periods of time, e.g. residential areas.

The most obvious implication for local air quality near the airport is the change in NO_2 concentrations. In this case, the modelling shows that some parts of Horley may experience an increase of approximately $1\mu g/m^3$, purely as a consequence of the R2 proposal. An increase of this magnitude is confined to a relatively small number of dwellings, however, and most people living within 1km of Gatwick would experience lower increases in NO_2 concentrations. Current thinking on the health effects of NO_2 is that exposure to this pollutant is associated with respiratory symptoms and there is, as yet, insufficient evidence to relate long-term exposure with mortality. This position reflects the current advice of the Committee on the Medical Effects of Air Pollution (COMEAP), for example, in terms of quantifying effects, although this may change in the future. COMEAP provides an estimate of the effect of short term changes in NO_2 concentrations with respiratory hospital admissions and it is likely that any health effects would occur in this form or as other symptoms requiring lesser interventions. Given the slight increases in concentrations and the numbers of people exposed near the airport this would imply effects of a very small magnitude that would be insignificant in the context of background rates for such health outcomes.

The evidence for mortality being associated with long term exposure to fine particles is much stronger and COMEAP has provided some clear advice on how this may be quantified. In the case of an airport, the changes in concentrations of $PM_{2.5}$ are much lower in magnitude than for NO_2, but the fact that such changes are associated with mortality effects makes them arguably more significant in health terms for the local population. For a large population, even a very small change in long term concentration would be associated with a substantial health effect, as measured by loss of life years across that population. As the radius of interest increases from the source, the number of people living within this radius increases significantly and, in densely populated areas, this can readily translate into hundreds of thousands of people.

The numbers of dwellings around the airport within the modelling domain has been quantified and the outcome is expressed below in Table 15, categorised by the change in $PM_{2.5}$ concentrations attributable to the R2 proposal. The population within the modelling domain used here is approximately 69,000. (The ONS estimate of 2.3 persons per household has been used to derive this number.)

Table 15 Distribution of change in $PM_{2.5}$ concentrations by number of dwellings

Change in $PM_{2.5}$ concentration ($\mu g/m^3$)	Number of dwellings	Number of people
-0.2 – -0.1	1	2.3
-0.1 – 0.0	1,248	2,870
0.0 – 0.1	25,598	58,875
0.1 – 0.2	3,040	6,992
0.2 – 0.3	153	352
0.3 – 0.4	29	67
0.5 – 1.0	41	94
> 1.0	45	104

The extensive work carried out by COMEAP on the quantification of mortality effects from long term exposure to $PM_{2.5}$ indicates that, across a population, there is a loss of life years amounting to 20 days per person[25] for a permanent increase in exposure of $1\mu g/m^3$. Strictly speaking, this applies to a birth cohort for the year in which the change occurs, over a period going forward of 106 years. For an actual population alive at that point, the position is complicated by the survival times applicable to that population. A useful comparison can be made with the local mortality burdens recently calculated by Public Health England (PHE), from which the following data in Table 16 have been extracted.

[25] Public Health England (2014)Estimating Local Mortality Burdens associated with Particulate Air Pollution Report number PHE-CRCE-010

Table 16 Results for the burden of mortality in 2010 associated with $PM_{2.5}$ (extracted from the 2014 PHE report)

LA area	Population (25+)	Mean anthropogenic $PM_{2.5}$ ($\mu g\ m^{-3}$)	Attributable fraction of deaths (%)	Number of deaths (age 25+)	Associated life years lost
Reigate & Banstead	97,500	9.9	5.6	69	596
Crawley	72,000	9.7	5.5	41	497
Tandridge	58,700	9.5	5.4	41	416
Mole Valley	60,700	9.6	5.4	44	446
Mid Sussex	93,200	8.8	5.0	63	549
Horsham	93,200	8.7	4.9	57	553
Hounslow	66,500	12.7	7.1	99	1167
Slough	84,700	12.1	6.8	51	714
Hillingdon	172,400	11.6	6.5	118	1335
Spelthorne	66,500	11.1	6.3	50	538

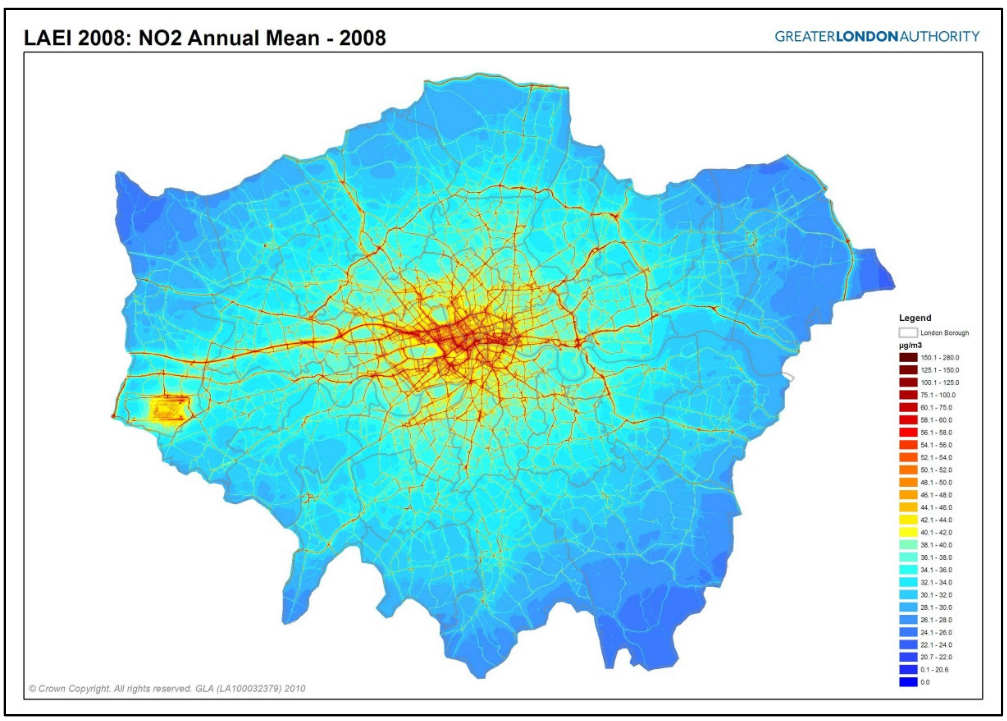
The population weighted mean change in $PM_{2.5}$ concentration in this case is clearly less than $0.1\mu g/m^3$ for the population of 69,000. Comparing with the PHE estimates presented above, it is reasonable to assume therefore that the burden on mortality for this population of the $PM_{2.5}$ exposure resulting from the R2 proposal is less than 5 years – given that current exposures of approximately $10\mu g/m^3$ are calculated to be associated with a ‘life years lost’ value of approximately 500 years.

7 The overall air quality case for Gatwick

The Commission's overall objective for air quality is "to improve air quality consistent with EU standards and local planning policy requirements", although the Appraisal Framework then considers other aspects at a regional or national level. This objective should relate to the location of the next runway, rather than concentrate on the specific impacts of the new runway. It is not possible to construct and operate a new runway without subsequent changes in air quality and clearly its operation would result in increases in air pollution levels compared with the base case situation. Therefore, a comparative assessment with other shortlisted options is required to appraise the scheme fully against the Commission's objective.

Gatwick is located in a considerably more favourable air quality environment than the two other shortlisted options, which are both at Heathrow. Not only are the concentrations of the key pollutants lower and universally in compliance with air quality objectives, but the surrounding population density is lower than that of west London and therefore exposure to air pollutants is lower. Heathrow's current size as a two runway airport, with a location near to several major motorways and the London conurbation result in air quality objectives being under pressure in the west of London. A very significant impact is clearly discernible from its operations, as shown in Figure 8.

Figure 8 Modelled NO_2 concentrations in London 2008



As is also apparent from Figure 8, pollutant concentrations near to many of the major roads used to access Heathrow are also elevated and considerably above the NO_2 objective of $40 \mu g/m^3$. The air quality impacts of traffic associated with Heathrow therefore occur in an area that is already substantially polluted and where compliance with air quality objectives is difficult to achieve at present. The impact of traffic using an expanded airport at Heathrow will delay compliance with UK objectives and EU limit values. Current policy is under development but the current draft National Networks National Policy Statement details that the Secretary of State should refuse consent where the air quality impacts of the scheme will substantially affect the ability of a non-compliant area to achieve compliance within the timescales as reported to the European Commission. This advice suggests that a refusal of permission should be automatic if this is the case.

The wider air quality impacts of Heathrow across West London may appear to not be significant, as there are already high concentrations of pollutants and the increased levels of traffic are only small percentage increases, but their impact spreads over a wide and diffuse area.

In contrast, the air quality in the area around Gatwick is close to, or already achieves, compliance with air quality objectives and further development at the airport will not result in a delay to compliance being achieved within the zone. The modelling carried out of the second runway's impact at Gatwick shows that it will be readily compliant with air quality objectives and limit values at sensitive receptors. The direct impacts of the airport operation are largely in relatively unpopulated areas and the transport access routes are through less populated areas.

The protection of local air quality should also not be considered solely in terms of the compliance with objectives and limit values. The Commission's Appraisal Framework also discusses the schemes' contributions to exposure for the population at a national scale. Some pollutants such as particulate matter have no lower threshold below which health effects are not observed and hence the reduction of population exposure to particulate matter, even where concentrations are compliant with air quality standards, has a beneficial outcome on health. To reduce the exposure of the UK population to air pollutants requires that the new runway be located in an area where the inevitable emissions from its operations would affect fewer people and in areas where the air quality is not already under pressure.

The impact of an airport on air quality is largest in its immediate locality, but the impact also extends regionally through dispersion of the primary pollutants and also through the airport's contribution to the formation of secondary pollutants, such as sulphate and nitrate particles. In terms of impacts on health, the most important pollutant on a per tonne basis is particulate matter and while the largest contribution of an airport's operations to particulate matter concentrations is at, or near, the airport perimeter, the impact in terms of population exposure is always more distant, because more people are affected as the area of impact increases.

A study of the current and future impact on health of $PM_{2.5}$ emissions from UK airports has been undertaken and published by Yim et al[26]. In this study, the authors provide an estimate of mortality effects arising from UK airports in 2005 and 2030. They also consider the implications of expanding Heathrow airport relative to the case of a Thames estuary airport. The study shows that in the scenario of constrained growth, i.e. unexpanded, Heathrow's emissions in 2030 would result in approximately 110 early deaths in the UK, an increase of 120% relative to the 2005 estimate of approximately 50 early deaths. Of this total in 2030, 67 would be within 32 km of Heathrow, or 83 if the airport were allowed to expand. These calculations are made on the basis that 70% of the airport's impact

[26] Yim S H L, Stettler M E J and Barrett S R H (2013) Air quality and public health impacts of UK airports, Part II: Impacts and Policy assessment, *Atmospheric Environment* **67**, 184-192

on mortality effects occur within 32 km (or 20 miles) of the airport, as indicated by the modelling results of the study.

Thus, although the total effect on health is regional and national, a majority of the effect occurs relatively close to the airport, emphasising the importance of local population densities in the magnitude of the mortality effect.

As a result of the differences in population affected by emissions from the airport and its operation, the overall health impacts from atmospheric emissions will be expected to be lower at Gatwick than for Heathrow and consequently the economic costs from health impacts will also be lower at Gatwick. The current methodology suggested by the Appraisal Framework will not identify these differences precisely as it is based on mass emissions of pollutants and their damage costs, and not changes in exposure.

Consideration also needs to be given to the air quality impacts of the construction period. Whilst there are very effective mitigation measures to reduce the air quality impacts from the actual construction activities, experience with the assessment of other major transport infrastructure schemes, such as HS2, shows that some of the largest air quality impacts of the proposal would arise from the emissions of construction traffic and from the consequential effects of road works, diversions and closures that may arise during the construction period. This is especially important in a period when pollutant levels and emissions will not have been sufficiently reduced as a result of the impact of national initiatives to improve air quality through the introduction of cleaner vehicles. During the construction period, background concentrations of pollutants will be higher than during operation of the airport in later years and consequently there are more likely to be breaches of air quality standards. At this stage, a detailed assessment of these impacts has not been undertaken; the likely scale of impacts, however, can be assessed by a qualitative examination of the proposals.

Both shortlisted options at Heathrow involve major reconfiguration of the motorway network. The option to build the runway to the northwest requires a "major reconfiguration" of the M4/M25 junction and large changes to the M25. The Heathrow Hub option details three options for changes to the road network; all require substantial changes to the M25 and to junctions in the area. Further construction work is also required in association with the reservoirs in the area. Such changes to the motorway network would be required early in the construction process to facilitate the remaining construction activities. Prolonged construction activities on this section of the motorway network, one of the busiest in the country, will inevitably lead to disruption to traffic flows for some years. Given that construction activities will take place on the M4, the M25 and the A4, the potential area of the network disrupted will inevitably be considerable. Emissions of pollutants from vehicles increase substantially when traffic flows are congested and therefore the air quality impacts during the construction period will be considerable. Experience from the HS2 project suggests that construction traffic can result in changes in local air pollutant concentrations. It could be expected that similar scale of changes could occur for works involving major motorways near to Heathrow. Given the nature of the works required it could be expected that these impacts could occur over a period of several years during a period when reductions in pollutant concentrations as a result of cleaner vehicle technologies will not have had their full effect. Changes to the motorway network and, for the Heathrow Hub option changes to the reservoirs, will result in considerable traffic generation in their own right which will exacerbate the air quality issues in the area and most importantly could prolong the period before the UK complies with its obligations to meet the EU limit values for NO_2.

In contrast, the works for Gatwick are more modest and require improvement of only one motorway junction and diversion of the A23, which can be largely undertaken without disruption to the existing road network. The area around Gatwick is predicted to achieve air quality objectives more quickly than Heathrow and consequently any disruption can be more easily accommodated.

8 Conclusions

The second runway proposals for Gatwick will result in additional emissions to atmosphere, notably of NOx, PM_{10} and $PM_{2.5}$. These can be quantified for future years, relative to the case of a future single runway, i.e. the base case. For example, in 2040, the additional NOx emissions from the airport would be approximately 1 ktonne. For $PM_{2.5}$, the amount is 11 tonnes in this year.

These additional emissions would have very little impact on local air quality, as measured by concentrations of these pollutants beyond the airport perimeter where people live. Detailed dispersion modelling shows that the annual average concentrations of NO_2, PM_{10} and $PM_{2.5}$ would be well within EU limit values and that the second runway proposals pose no problems for local air quality management. The exposure of the local population to pollutants attributable to the scheme is very small. This is partly because much of the immediate land use surrounding Gatwick is non-residential.

Part of the reason for the low additional exposure of people to the additional pollution lies in the inherent design of the scheme, which has much of the additional development and activity in the centre of the airport and therefore increasing the separation between the point of emission and the local population.

In monetary terms, use of HM Treasury's damage cost for PM_{10} emissions gives a value of approximately £660,000 in 2040, almost all of which is attributable to the mortality effects of the $PM_{2.5}$ fraction. This estimate is subject to some uncertainty, chiefly related to the actual exposure experienced locally to the airport. The effect on human health of the $PM_{2.5}$ emitted will be experienced mostly within 15km of the airport and therefore dependent on the numbers of people exposed to the additional concentrations. The effects associated with NOx emissions, on the other hand, are almost all likely to occur far away from the airport, on a regional and national level. These derive from the health effects of the secondary particulate matter formed and the effects on sensitive ecosystems from eutrophication and acidification.

Relative to these additional emissions occurring at Heathrow, the effects are largely neutral with regard to NOx, since they would be felt at places far removed from the source. For PM_{10} and $PM_{2.5}$, the effects on human health would be local and at Gatwick are likely to be smaller, as fewer people are exposed within 15km of the airport.

Emissions will also be associated with the construction phase of the proposals, which takes place over a 19-year period. Impacts on air quality will be very slight, however, since the activities will occur at locations well away from residential areas. Just as importantly, the scheme can be implemented without substantial and disruptive changes to the local transport network, minimising the potential for road traffic congestion to occur.

Appendix A

Tables and Figures

Table 17 Diffusion tube sites around Gatwick airport

Site	OS coordinates	Location type[1]	2008	2009	2010	2011	2012
Birch Lea	528201, 138377	UB	24.0	23.0	30.0	22.0	25.0
Headley Close	529864, 138204	UB	25.0	24.0	32.0	22.0	23.0
Lynhurst Cottage	527110, 139530	UB	25.0	25.0	37.0	24.0	26.0
Charlwood Nursery	526320, 139860	UB	22.0	18.0	26.0	17.0	19.0
Rowley Cottage	527760, 140070	UB	23.0	22.0	31.0	20.0	21.0
Balcombe Road	529490, 141460	UB	26.0	25.0	33.0	25.0	26.0
Steers Lane	529307, 139611	RD	21.0	20.0	27.0	–	–
Gatwick airport[2]	529411, 141493	UB	30.0	27.0	38.0	28.0	27.0
10 Tinsley Close	528445, 138094	UB	35.0	37.0	**51.0**	**40.0**	38.0
6 Tinsley Close	528385, 138064	UB	–	–	–	35.0	33.0
Woodfield Lodge, Hazelwick roundabout	528153, 137912	UB	**48.0**	**48.0**	**69.0**	**55.0**	**51.0**
Woodfield Lodge, Northgate Avenue	528153, 137871	UB	39.0	39.0	**55.0**	**41.0**	39.0
Riverside	528103, 142228	Other	26.9	26.9	27.0	22.0	28.0
Horley Police Station	528424, 142934	KB	32.7	30.1	32.6	26.0	32.0
Public car park off Massetts Road	528362, 142983	Intermediate	25.9	24.0	28.3	21.0	28.0
Michael Crescent	528208, 142337	BG	25.2	25.1	26.3	22.0	27.0
Wolverton Gardens	527873, 142606	RD	29.6	27.0	29.0	24.0	26.0
Wolverton Gardens	527892, 142463	RD	28.8	27.3	30.2	23.0	29.0
Cheyne Walk	528030, 142373	RD	32.6	28.8	34.7	28.0	33.0
Crescent Way	528112, 142321	RD	32.3	26.9	29.6	23.0	29.0
Crescent Way	528254, 142196	RD	31.0	27.6	31.5	25.0	29.0
The Crescent	528386, 142080	RD	30.9	29.7	30.7	27.0	29.0
The Crescent	528499, 141953	RD	31.5	27.5	29.8	25.0	33.0
The Crescent	528538, 141897	RD	31.9	31.2	31.7	26.0	33.0
The Crescent	528602, 141789	Other	35.1	32.2	30.8	27.0	32.0
The Crescent	528607, 141910	RD	36.3	34.6	32.4	27.0	32.0
The Crescent	525578, 142006	KB	31.8	29.7	26.7	25.0	29.0
The Drive	528589, 142552	UB	30.2	28.4	30.2	23.0	29.0
The Drive	528581, 142635	UB	30.8	30.7	32.4	26.0	30.0

Site	OS coordinates	Location type[1]	2008	2009	2010	2011	2012
Fairfield Avenue	528499, 142512	UB	28.6	27.0	29.0	23.0	26.0
Fairfield Avenue	528492, 142366	UB	27.1	28.4	29.7	25.0	–
Fairfield Avenue	528505, 142246	UB	29.4	27.9	29.6	23.0	28.0
Upfield	528335, 142224	UB	29.2	27.8	29.3	26.0	29.0
Upfield	528360, 142384	UB	29.2	29.1	27.7	23.0	30.0
Upfield	528220, 142583	UB	28.2	26.6	28.6	21.0	26.0
Upfield	528172, 142679	UB	29.8	26.3	28.7	22.0	26.0
Meadowcroft Close	529149, 141953	UB	30.7	24.6	28.5	23.0	25.0
Roundabout, The Coronet	529203, 142192	UB	26.2	24.1	26.9	23.0	27.0
Staffords Place	528789, 142570	UB	25.8	24.9	26.6	20.0	27.0
The Crescent	528553, 141857	RD	33.3	30.7	31.5	28.0	33.0
16-17 Woodroyd Gardens	527931, 142231	Other	32.6	28.7	32.8	26.0	32.0
Poles Lane pumping station	526421, 139639	Other	20.0	18.5	22.5	17.0	19.0
Hathersham Farm	530937, 144272	Other	26.0	27.1	33.5	23.0	27.0
83-85 Victoria Road	528502, 142952	RD	–	**42.4**	–	–	–
1 Russell’s Crescent	528250, 142806	RD	–	35.9	–	–	–
Laurel Cottage, 6 Russell’s Crescent	528163, 142766	RD	–	33.4	–	–	–
15 Russell’s Crescent	528402, 142737	RD	–	27.1	–	–	–
32 Russell’s Crescent	528533, 142779	RD	–	29.8	–	–	–

[1] UB: urban background, RD: roadside, KB: kerbside, BG: background

[2] co-location with Crawley 2 continuous monitor

Sources: Crawley Borough Council (2013) 2013 Air Quality Progress Report

Reigate and Banstead Borough Council (2011) Progress Report (2011) on Air Quality within the Borough of Reigate and Banstead

Figure 9 Modelled pollution sources in the 2040 base case scenario

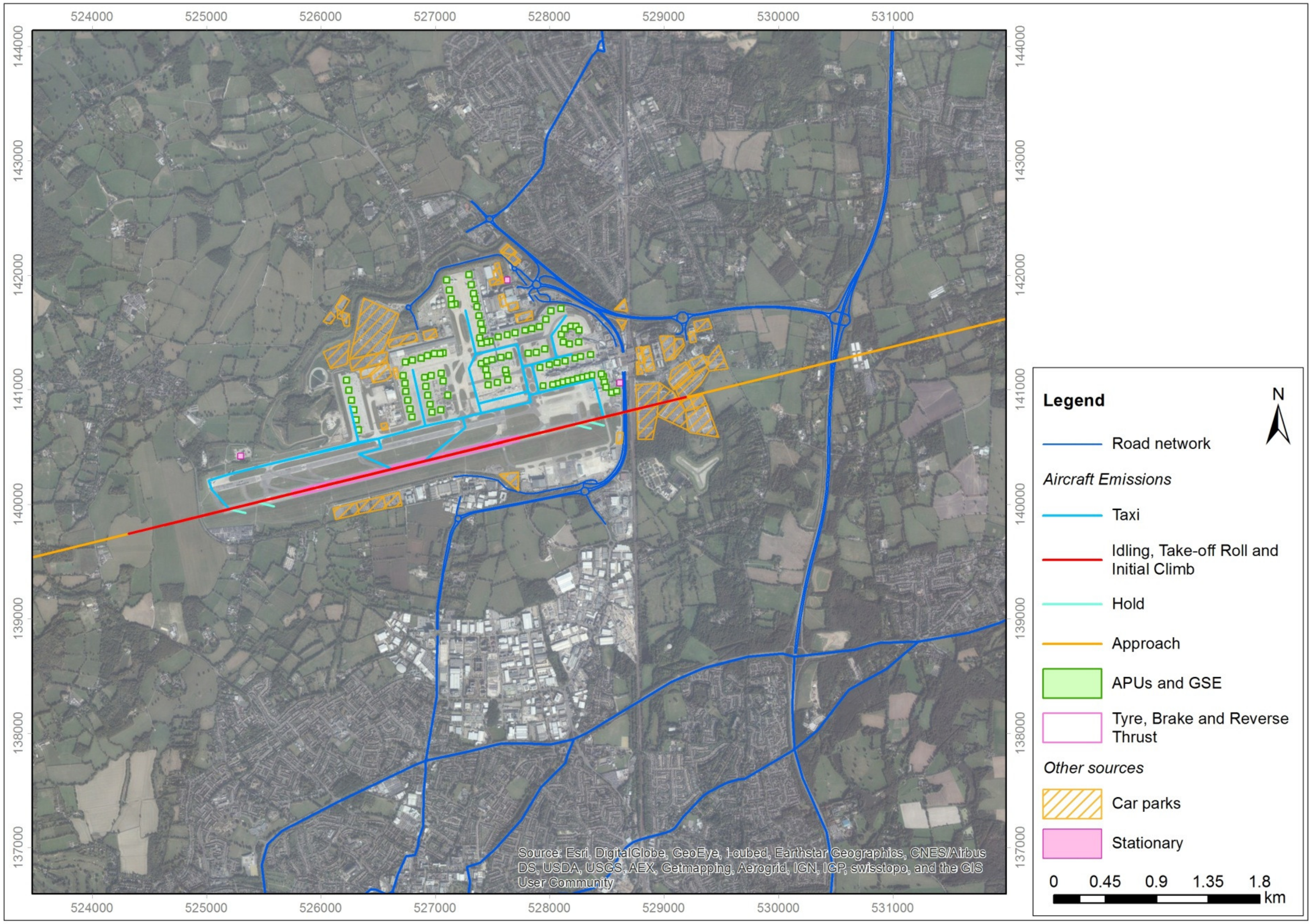


Figure 10 Modelled pollution sources in the 2040 and 2050 operational scenarios

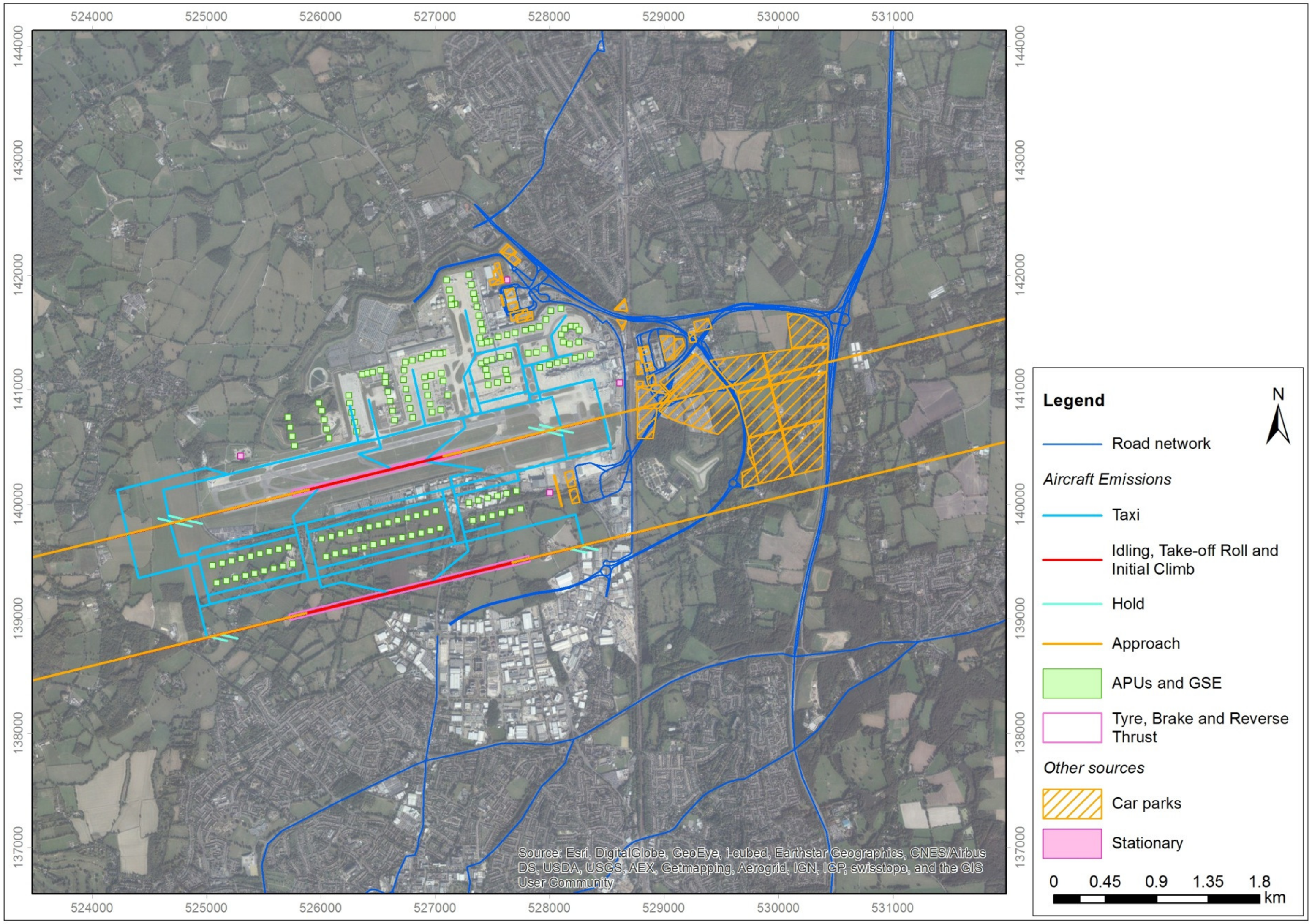


Figure 11 Predicted NOx concentrations in the 2040 base case scenario

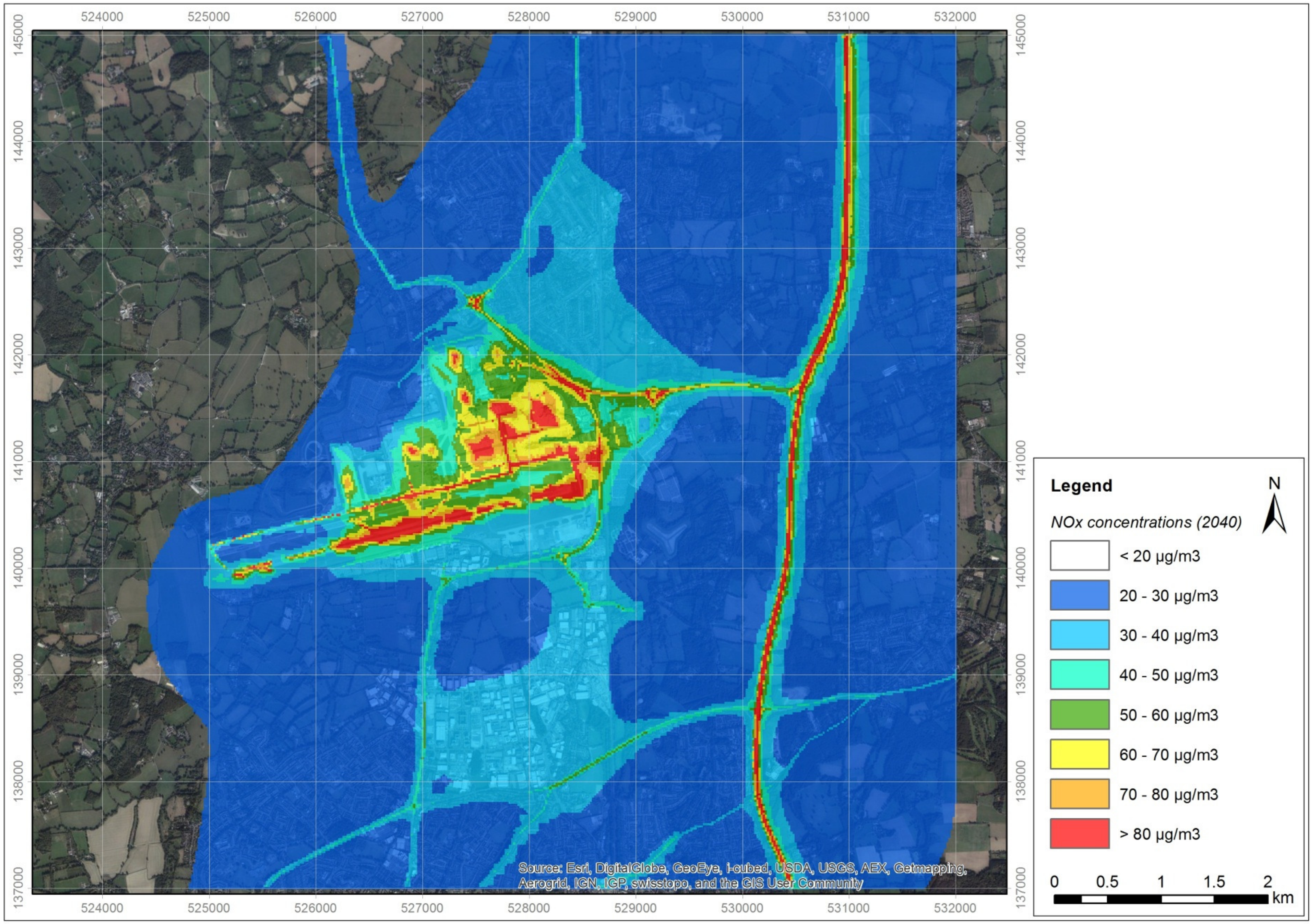


Figure 12 Predicted NOx concentrations in the 2040 operational scenario without EATs

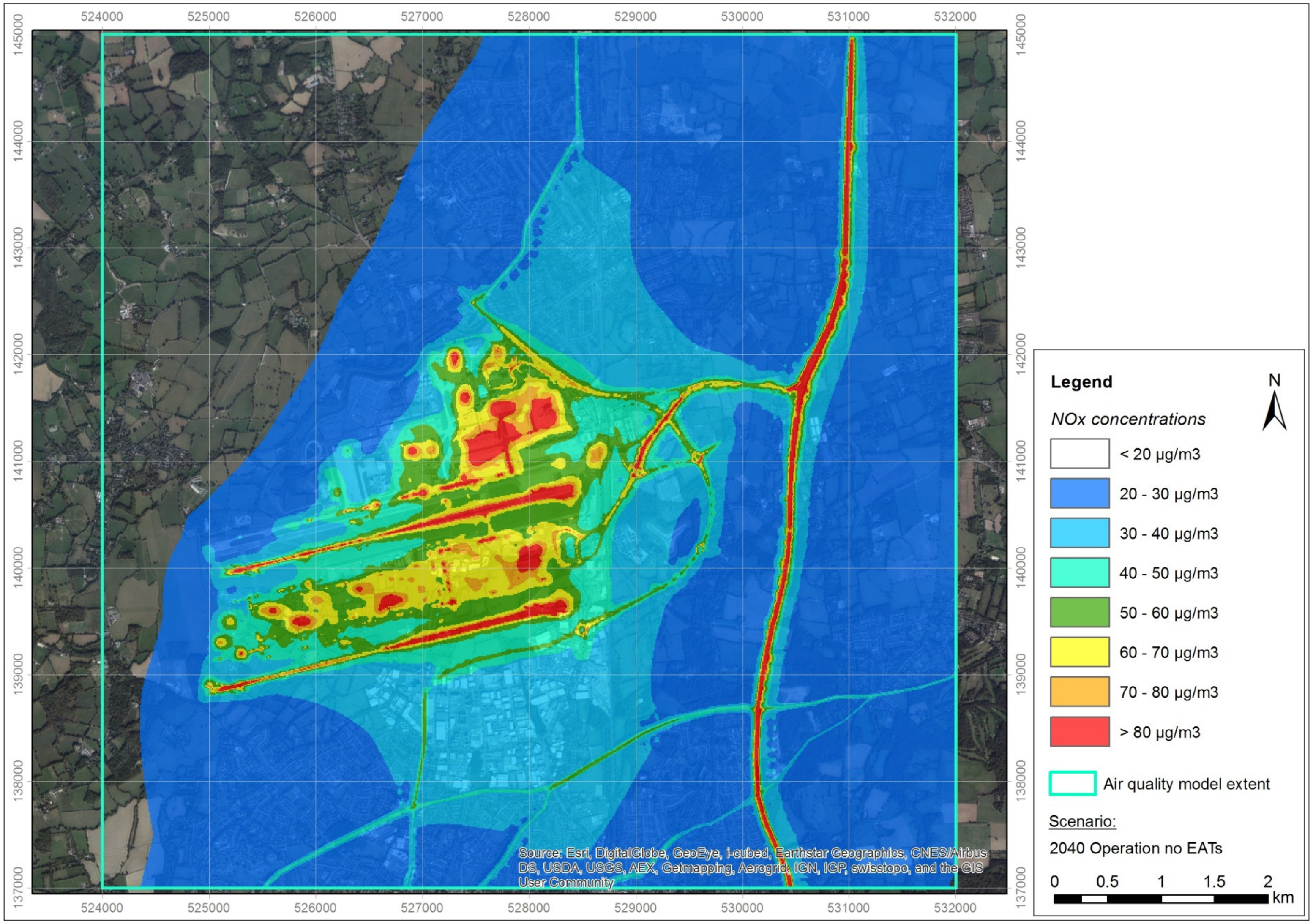


Figure 13 Predicted NOx concentrations in the 2050 operational scenario without EATs

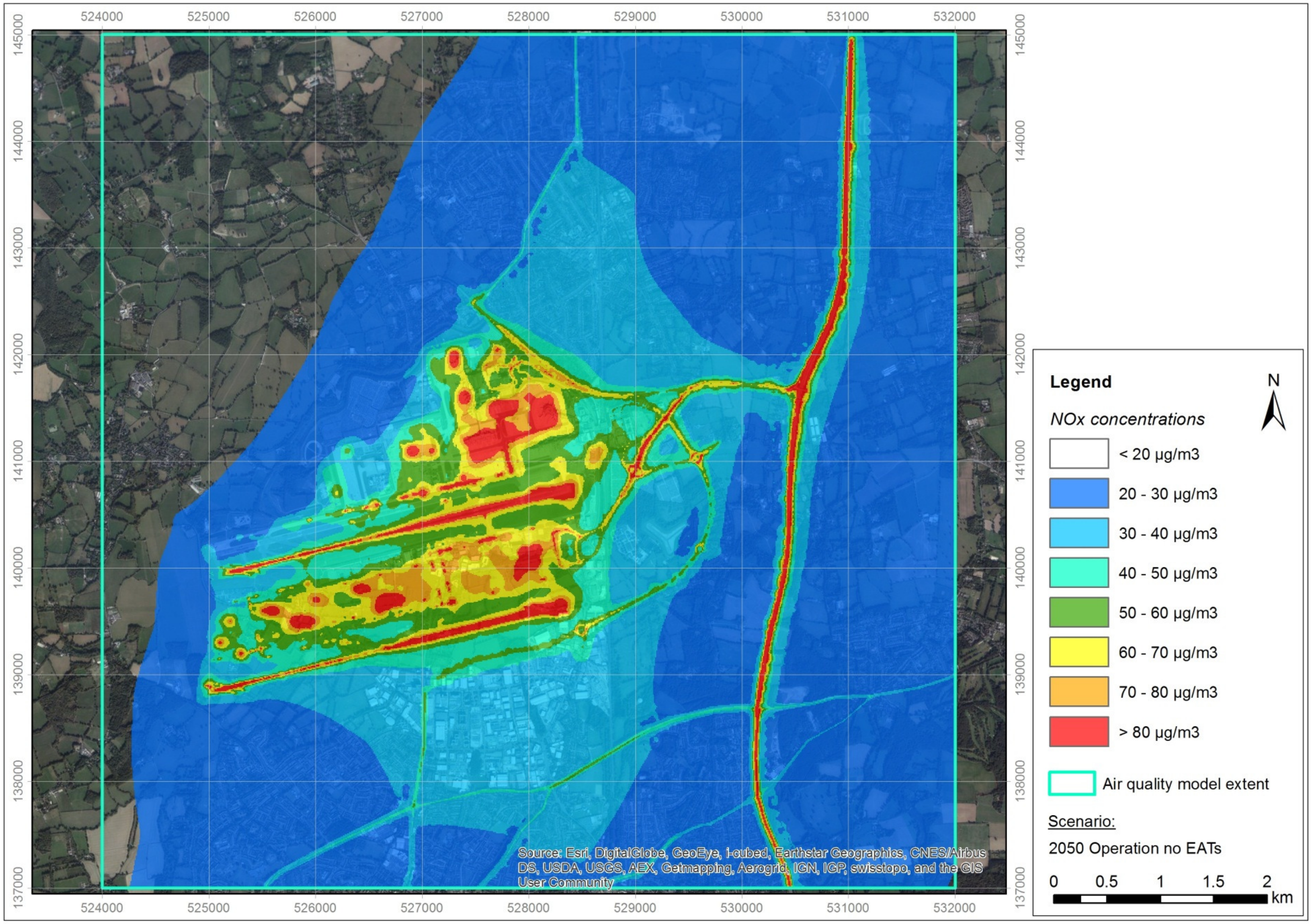


Figure 14 Predicted NO_2 concentrations in the 2040 base case scenario

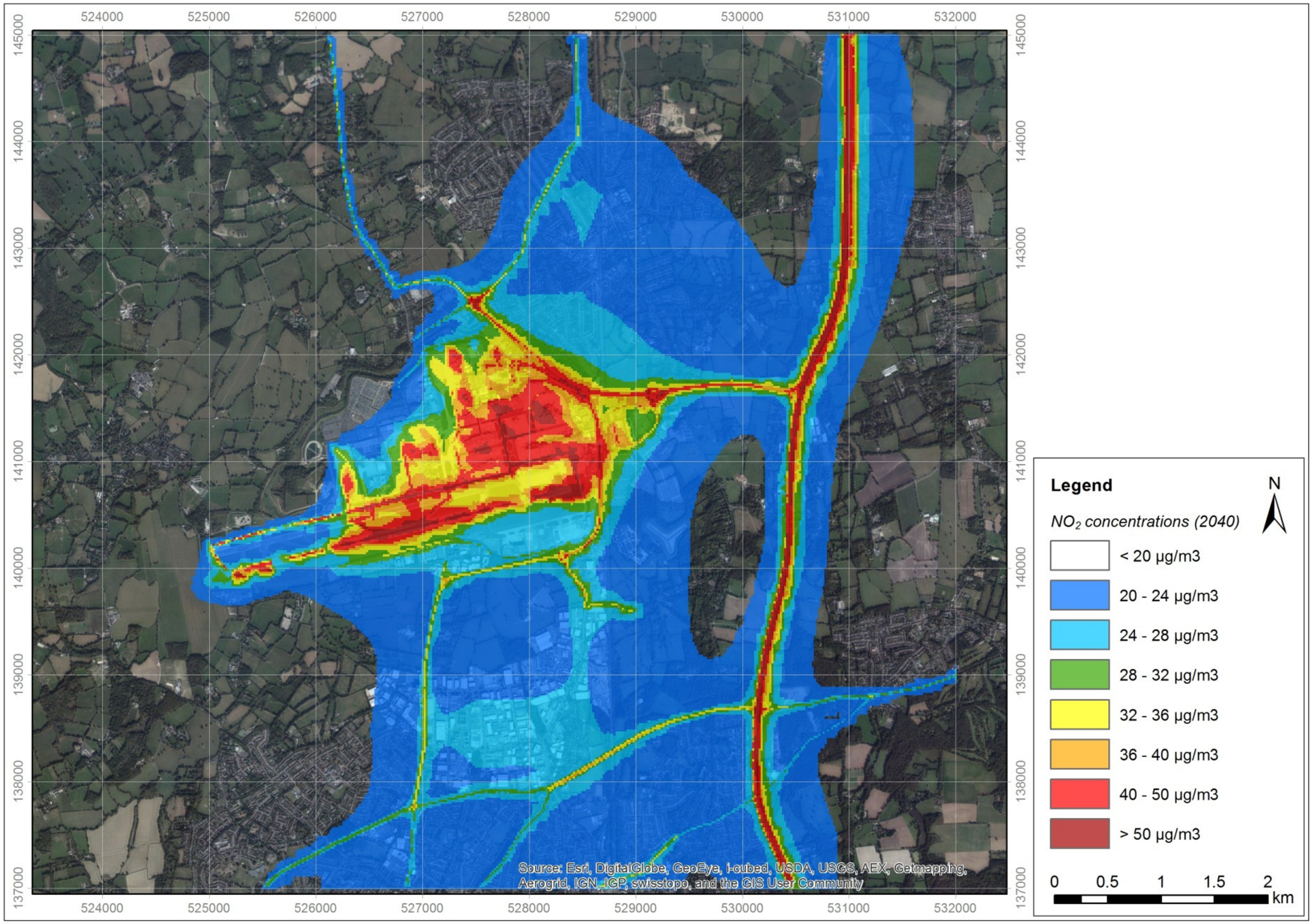


Figure 15 Predicted NO_2 concentrations in the 2040 operational scenario without EATs

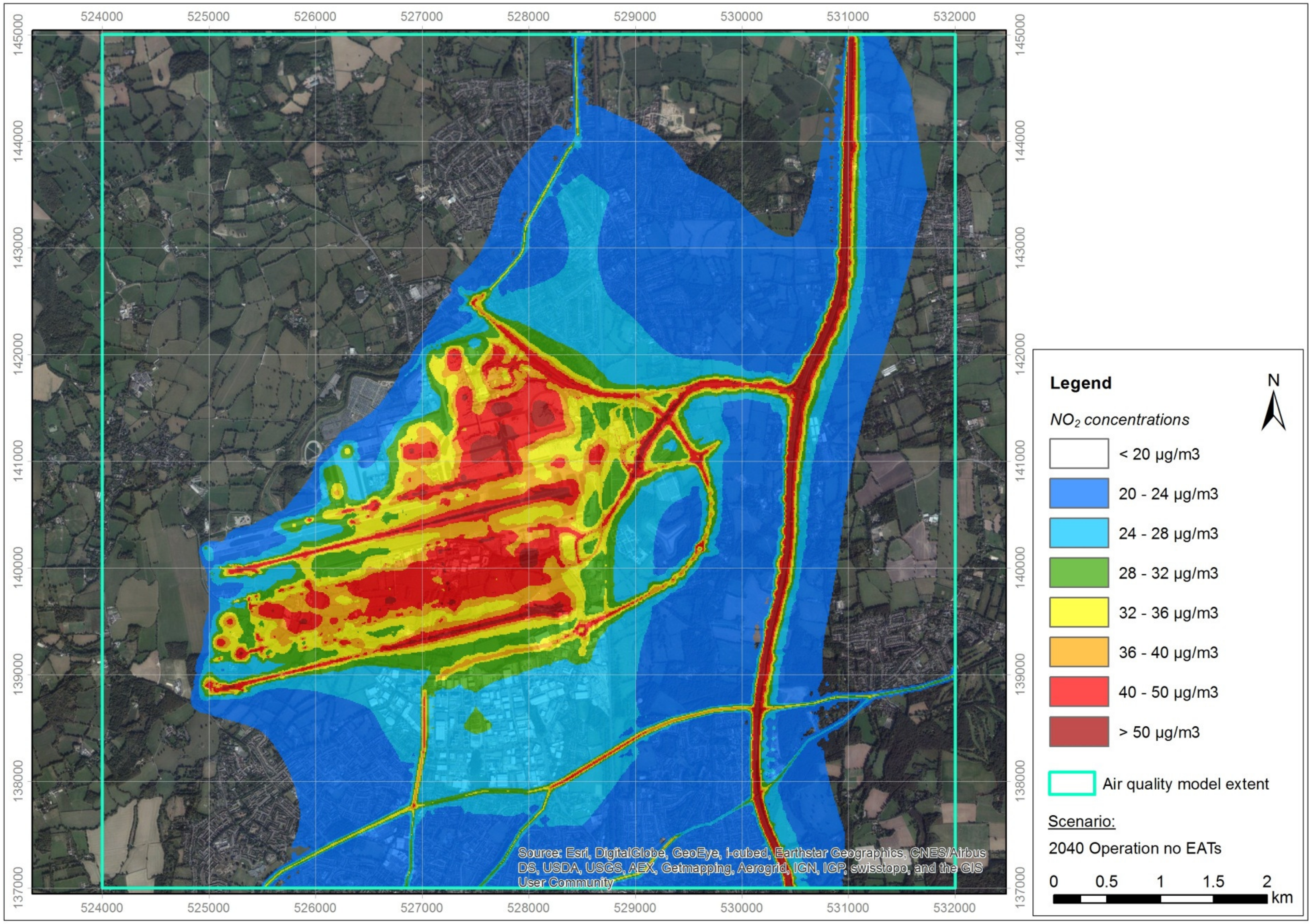


Figure 16 Predicted NO_2 concentrations in the 2050 operational scenario without EATs

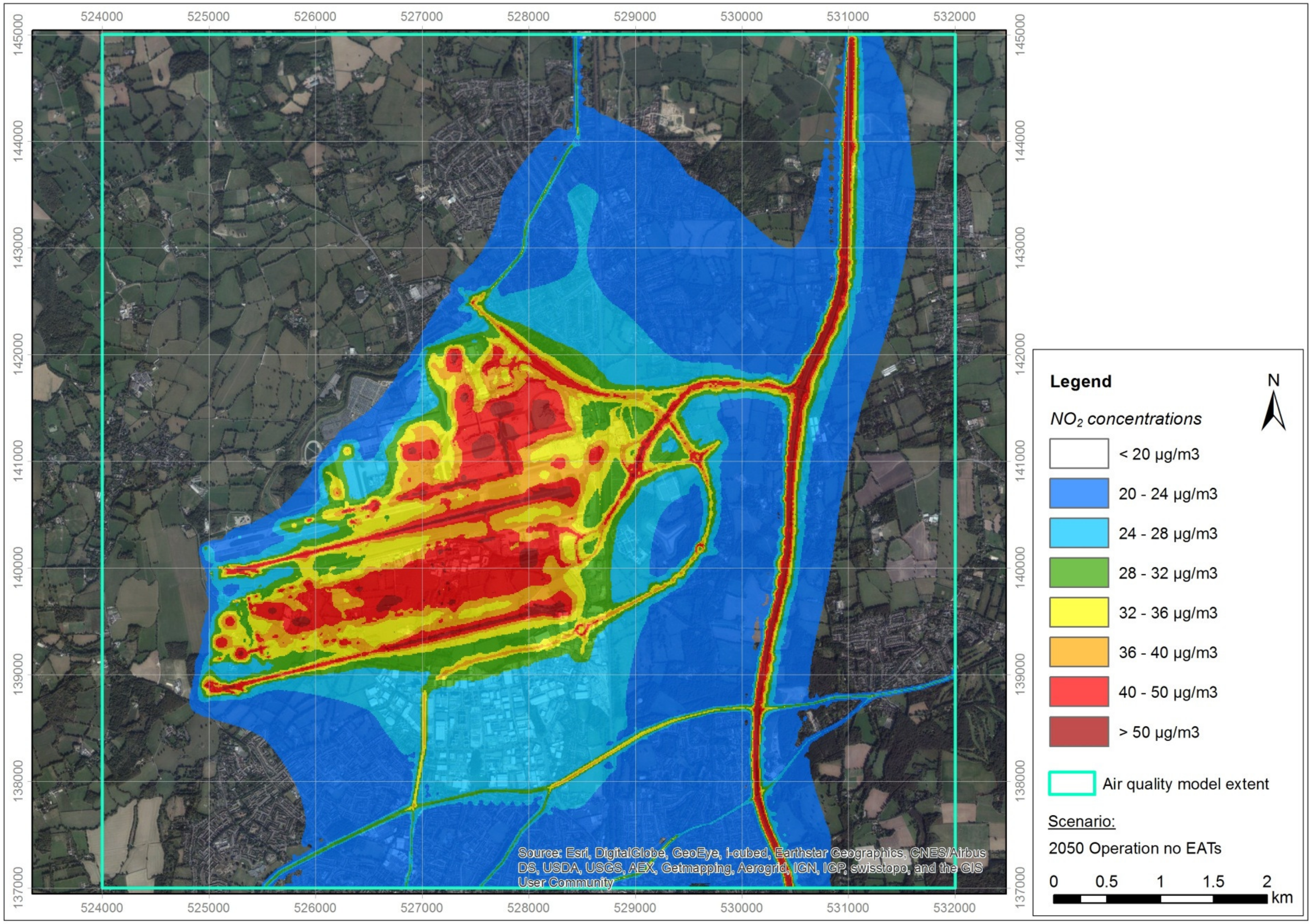


Figure 17 Predicted PM_{10} concentrations in the 2040 base case scenario

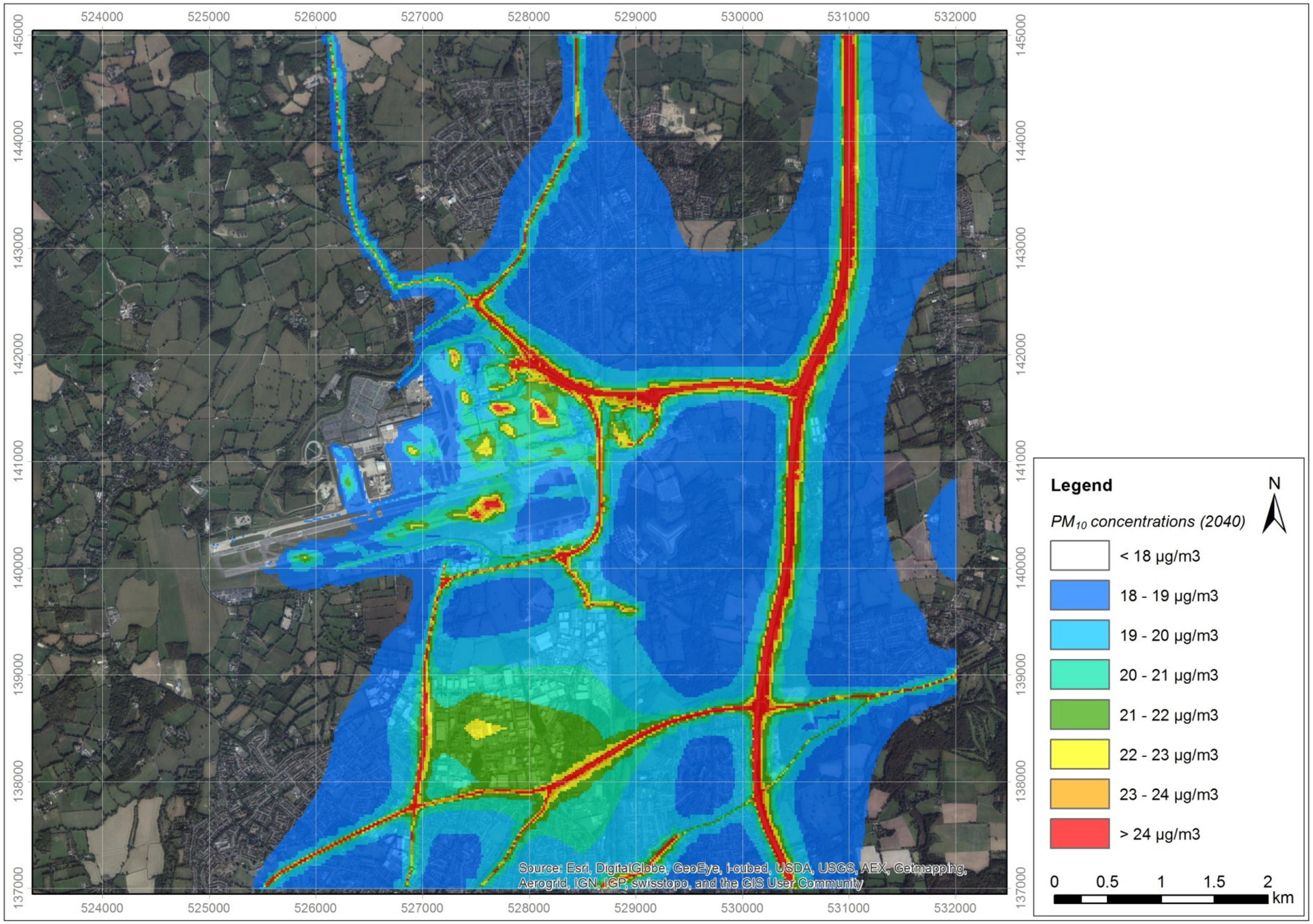


Figure 18 Predicted PM_{10} concentrations in the 2040 operational scenario without EATs

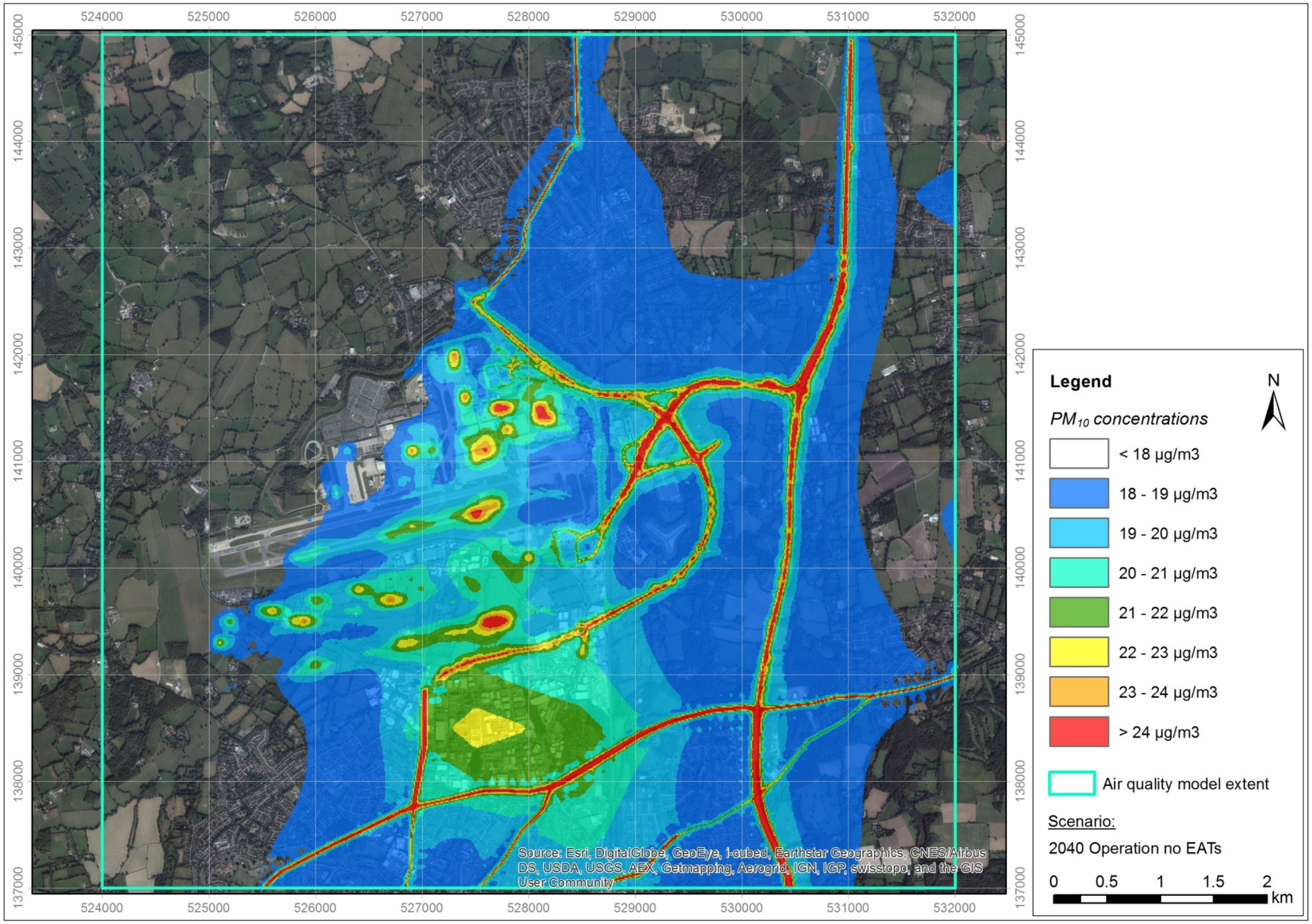


Figure 19 Predicted PM_{10} concentrations in the 2050 operational scenario without EATs

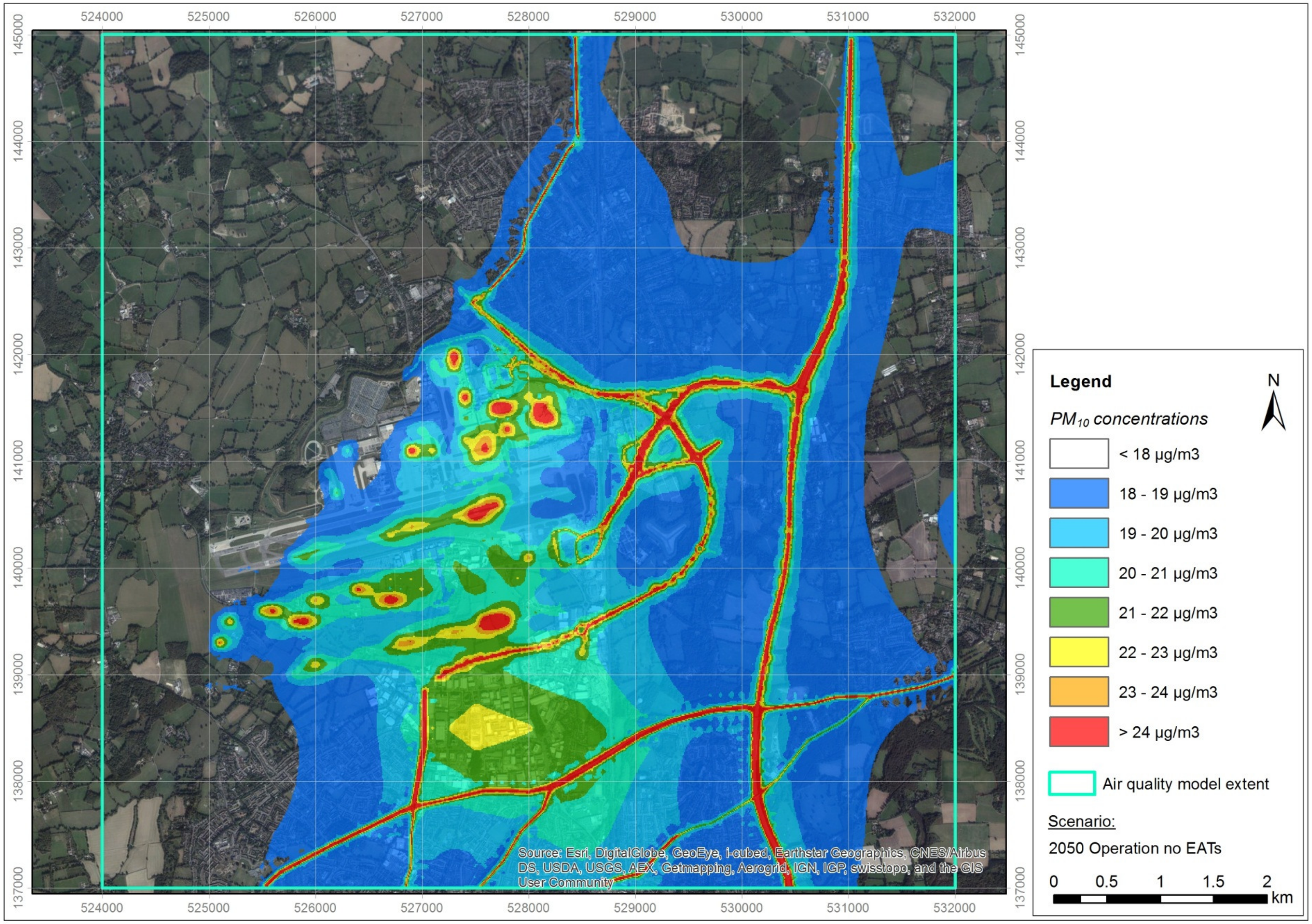


Figure 20 Predicted $PM_{2.5}$ concentrations in the 2040 base case scenario

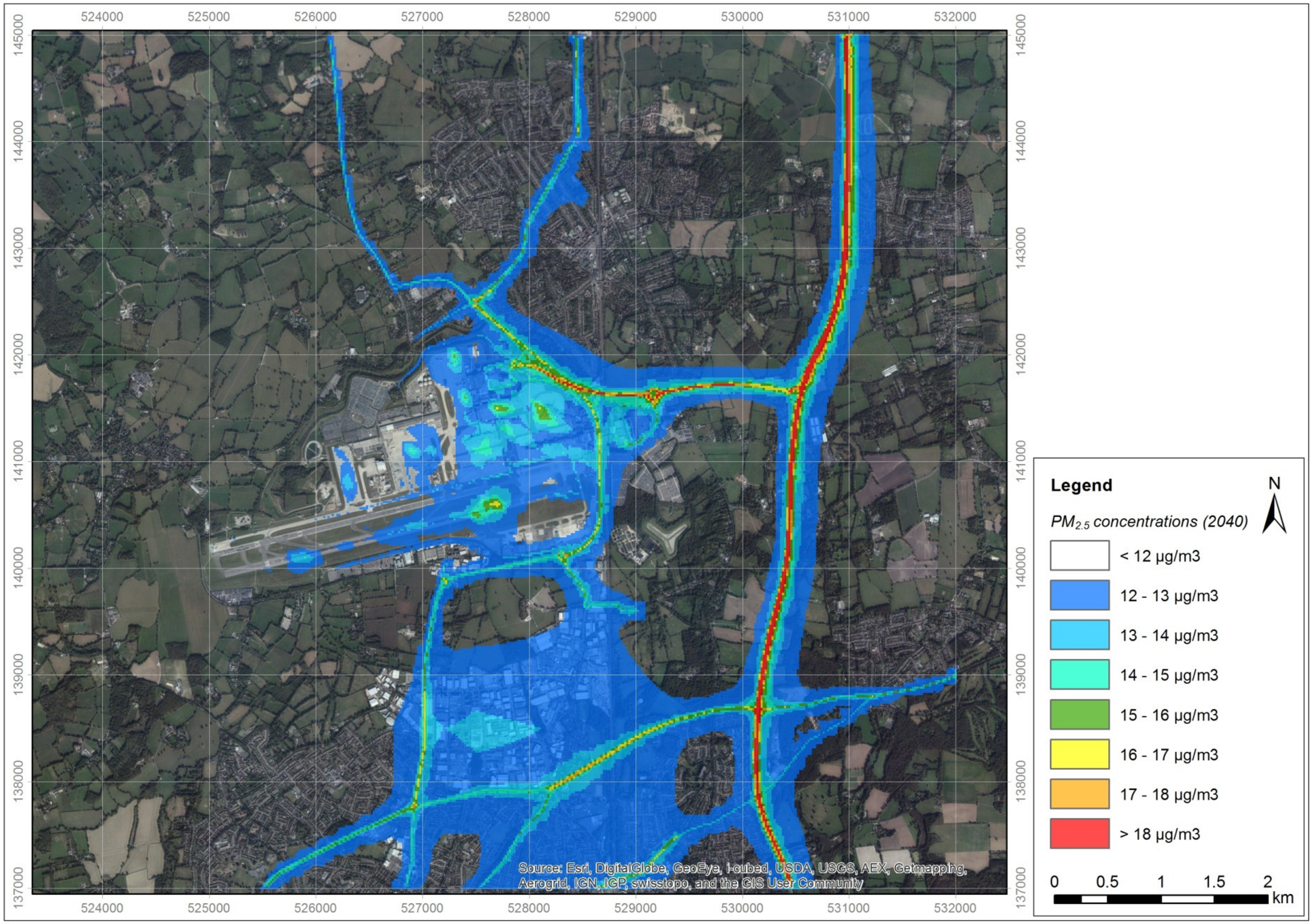


Figure 21 Predicted $PM_{2.5}$ concentrations in the 2040 operational scenario without EATs

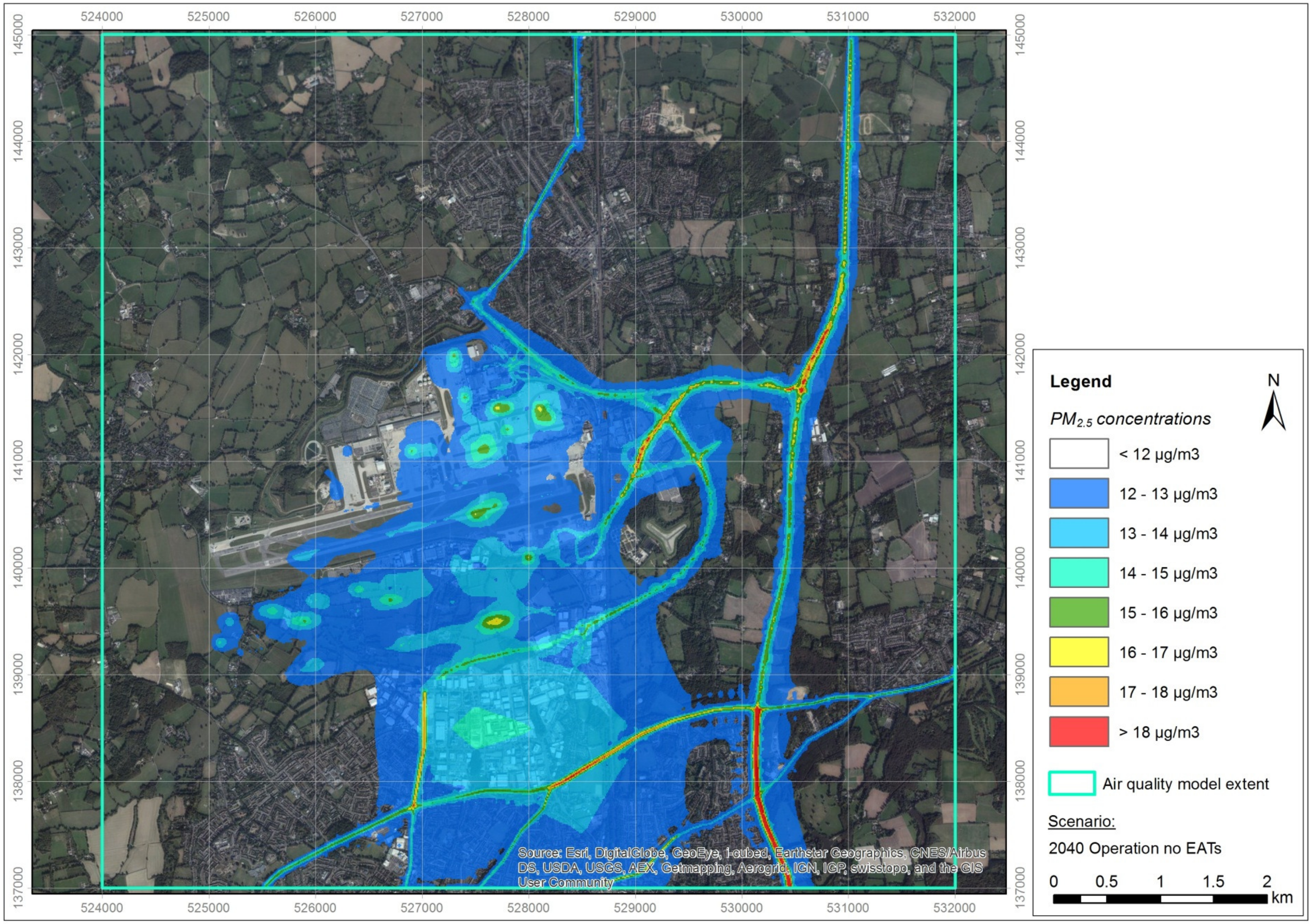
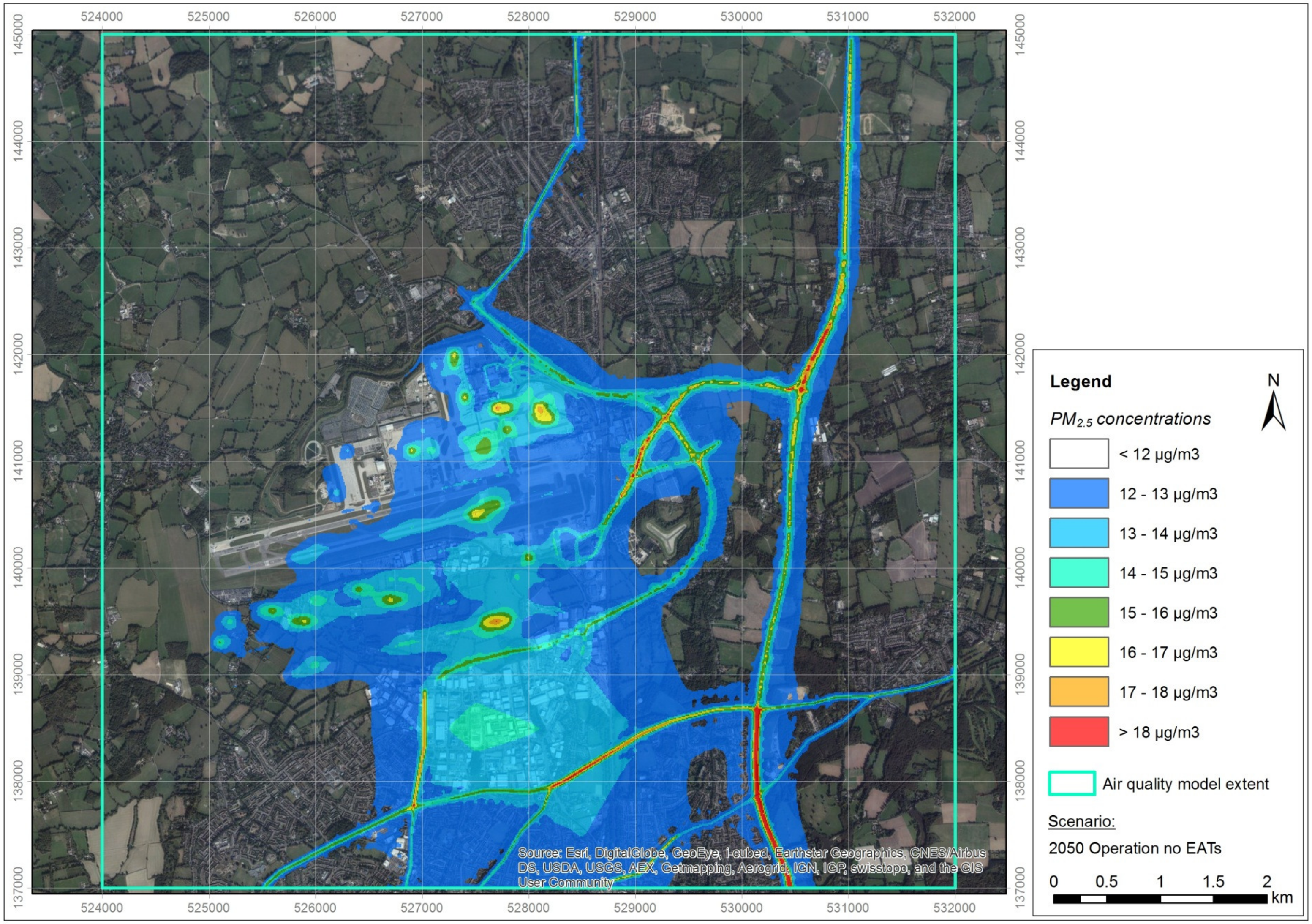


Figure 22 Predicted $PM_{2.5}$ concentrations in the 2050 operational scenario without EATs



Appendix B

Assessment results with EATs

This section presents the predicted air quality impacts for an alternative option of Gatwick with end around taxiways (EATs), along with a comparison of these results with those presented in the main report (without EATs). Figure 23 to Figure 30 show the predicted NOx, NO_2, PM_{10} and $PM_{2.5}$ concentrations as contour plots for 2040 and 2050 with EATs.

NOx emissions and concentrations

Table 18 presents the estimated annual emission rates of NOx for each pollution source and a comparison with and without EATs. It can be observed that the only difference is the aircraft NOx emissions at ground level (presented in **bold**), which would increase by approximately 50 tonnes with the EATs option.

Table 18 Comparison of NOx emission rates (tonnes/year) with and without EATs

Source		2040 Operation		2050 Operation	
		without EATs	with EATs	without EATs	with EATs
Airport	Aircraft (elevated)	1,616.27	1,616.27	1,721.02	1,721.02
	Aircraft (ground)	959.96	**1,008.36**	1,051.95	**1,101.51**
	GSE	38.31	38.31	43.87	43.87
	Road network	61.50	61.50	65.70	65.70
	Car parks	6.63	6.63	7.25	7.25
	Stationary sources	46.34	46.34	46.34	46.34
Non-airport	Road network	141.24	141.24	131.41	131.41

Table 19 presents the comparison of the predicted total NOx concentrations at the selected assessment sites with and without EATs. It can be observed that concentrations of NOx would increase by a maximum of only 0.2μg/m^3 in 2040 and 0.7μg/m^3 in 2050 in the Horley AQMA with EATs. This is expected, since the EATs for the existing runway at Gatwick would be located close to the AQMA, but the changes are negligible.

Table 19 Comparison of total NOx concentrations (μg/m^3) with and without EATs

Location	2040 Operation		2050 Operation	
	without EATs	with EATs	without EATs	with EATs
RG1 Horley	34.8	35.0	35.6	36.0
RG2 Horley South	40.2	40.2	41.5	42.2
CR8	26.3	26.2	26.5	26.7
MVB	17.6	17.6	17.6	17.7
MVA	23.6	23.8	24.0	24.2

NO_2 concentrations

Table 20 presents the comparison of the predicted total NO_2 concentrations at selected locations around the airport with and without EATs. It can be observed that NO_2 concentrations would increase by a maximum of only 0.1µg/m^3 in 2040 and 0.5µg/m^3 in 2050 in the Horley AQMA, but would still remain well below the air quality objective and EU limit value.

Table 20 Predicted NO_2 concentrations at selected locations

Location	2040 Operation		2050 Operation	
	without EATs	with EATs	without EATs	with EATs
RG1 Horley	25.6	25.7	26.7	27.0
RG2 Horley South	28.8	28.9	30.2	30.7
CR8	20.4	20.4	21.1	21.2
MVB	14.4	14.4	14.8	14.8
MVA	18.6	18.8	19.4	19.5

PM emissions and concentrations (PM_{10} and $PM_{2.5}$)

Table 18 and Table 22 present the estimated annual emission rates of PM_{10} and $PM_{2.5}$ respectively, for each pollution source and a comparison with and without EATs. It can be observed that similar to the NOx emission rates, the only difference is the aircraft emissions at ground level (presented in **bold**). These would increase by approximately 0.7 tonnes with the EATs option for both PM_{10} and $PM_{2.5}$.

In terms of the total PM_{10} and $PM_{2.5}$ concentrations with EATs, these are expected to remain the same as those in the without EATs option presented in the main report.

Table 21 Comparison of PM_{10} emission rates (tonnes/year) with and without EATs

Source		2040 Operation		2050 Operation	
		without EATs	with EATs	without EATs	with EATs
Airport	Aircraft (elevated)	7.71	7.71	7.08	7.08
	Aircraft (ground)	23.44	**24.13**	28.03	**28.77**
	GSE	6.49	6.49	7.47	7.47
	Road network	10.01	10.01	14.61	14.61
	Stationary sources	0.72	0.72	0.72	0.72
Non-airport	Road network	29.99	29.99	31.11	31.11

Table 22 Comparison of $PM_{2.5}$ emission rates (tonnes/year) with and without EATs

Source		2040 Operation		2050 Operation	
		without EATs	**with EATs**	**without EATs**	**with EATs**
Airport	Aircraft (elevated)	6.71	6.71	7.08	7.08
	Aircraft (ground)	17.57	**18.27**	21.01	**21.76**
	GSE	3.50	3.50	4.03	4.03
	Road network	5.64	5.64	9.91	9.91
	Stationary sources	0.72	0.72	0.72	0.72
Non-airport	Road network	16.22	16.22	16.83	16.83

Summary

From the results presented here it can be observed that the alternative option for Gatwick with EATs is predicted to result in very small changes to the air quality assessment results. NOx emission rates from aircrafts at ground level would increase by approximately 50 tonnes with EATs, while total NO_2 concentrations in the Horley AQMA would increase by a maximum of 0.5µg/m^3 in 2050 but still remain well below the air quality objective and EU limit value. Predicted increases in concentrations elsewhere are lower. In relation to PM emissions, these would increase by approximately 0.7 tonnes for both PM_{10} and $PM_{2.5}$ from the aircraft at ground level, while predicted concentrations would remain the same with and without the EATs.

Figure 23 Predicted NOx concentrations in the 2040 operational scenario with EATs

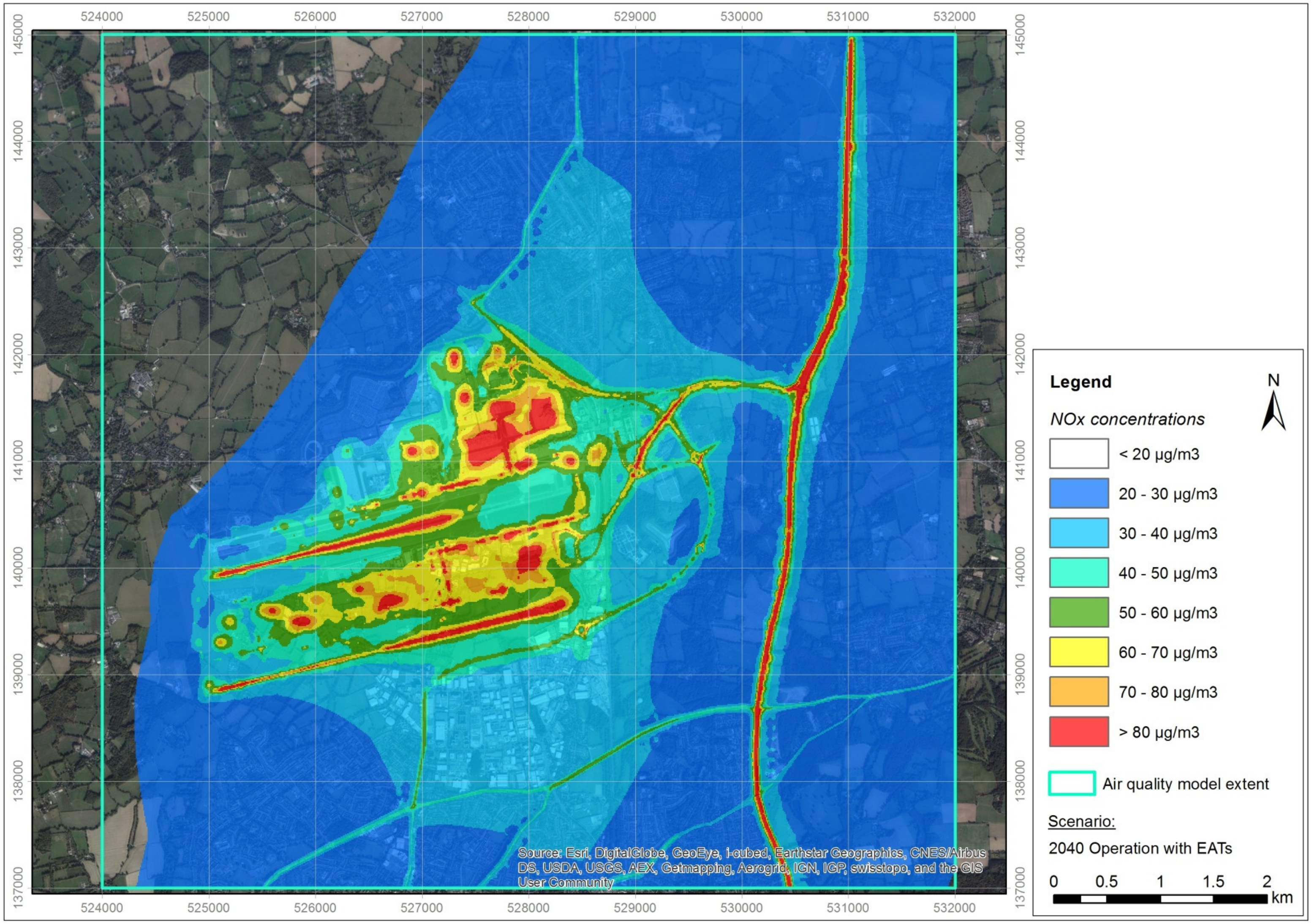


Figure 24 Predicted NO_2 concentrations in the 2040 operational scenario with EATs

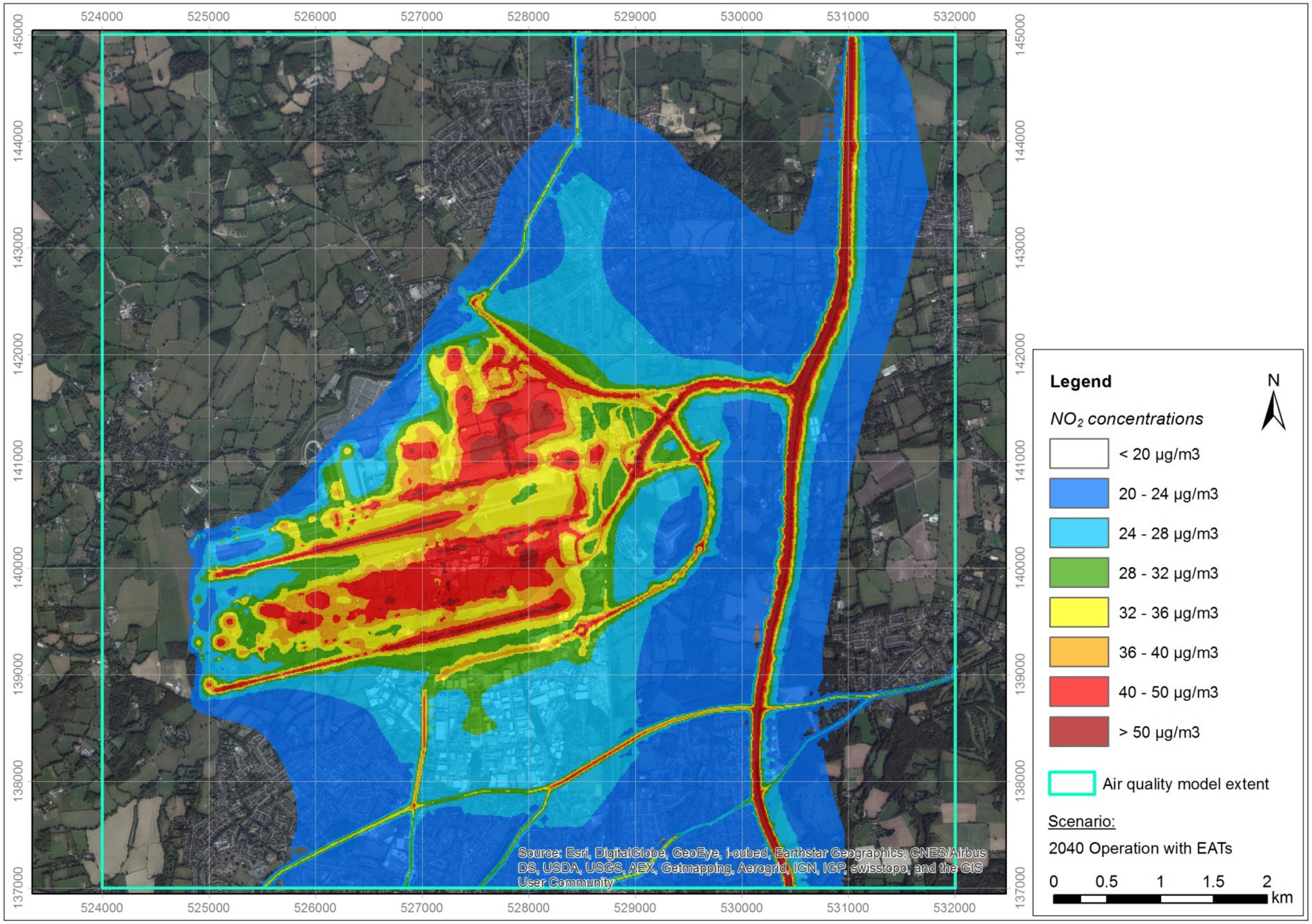


Figure 25 Predicted PM_{10} concentrations in the 2040 operational scenario with EATs

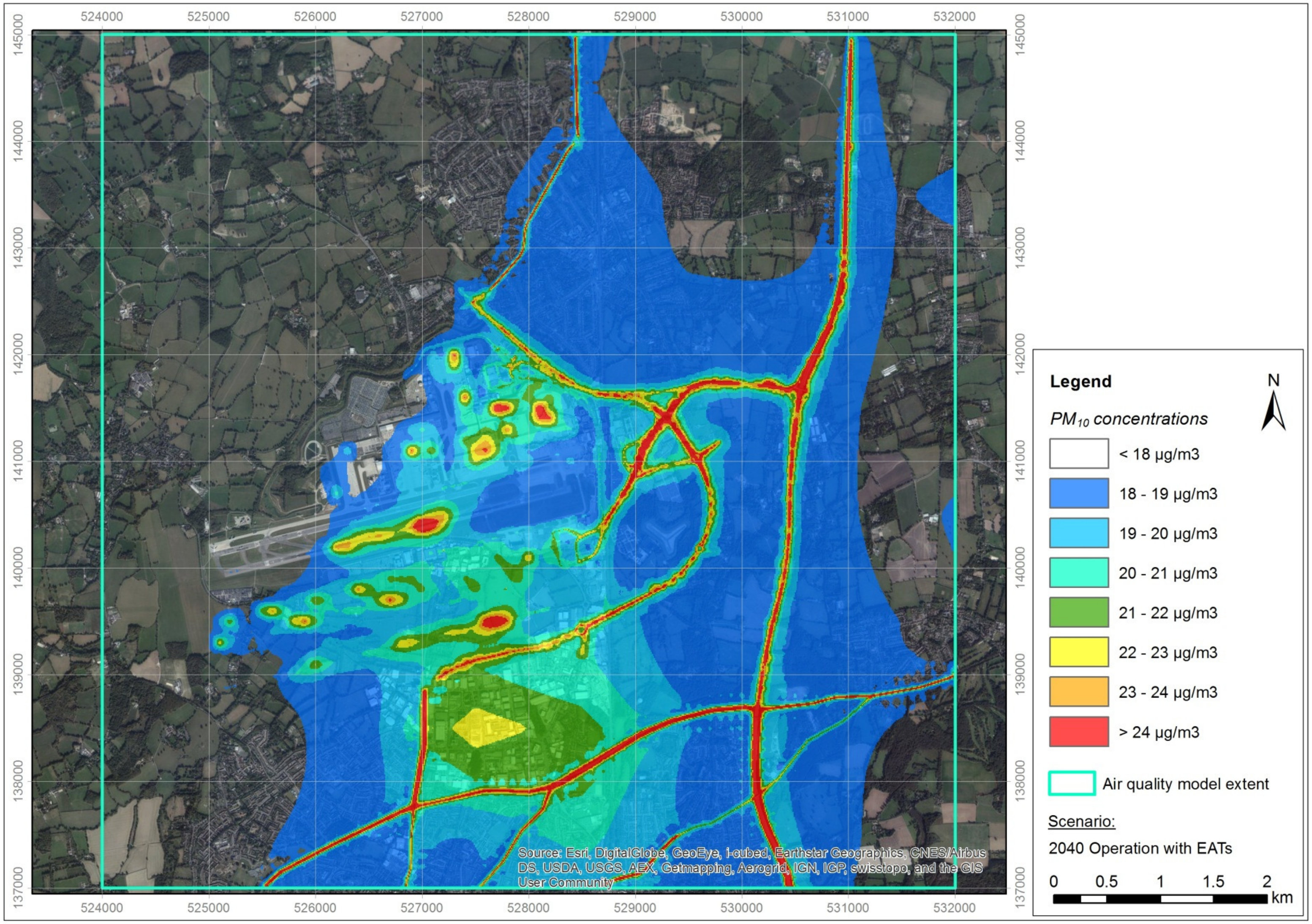


Figure 26 Predicted PM2.5 concentrations in the 2040 operational scenario with EATs

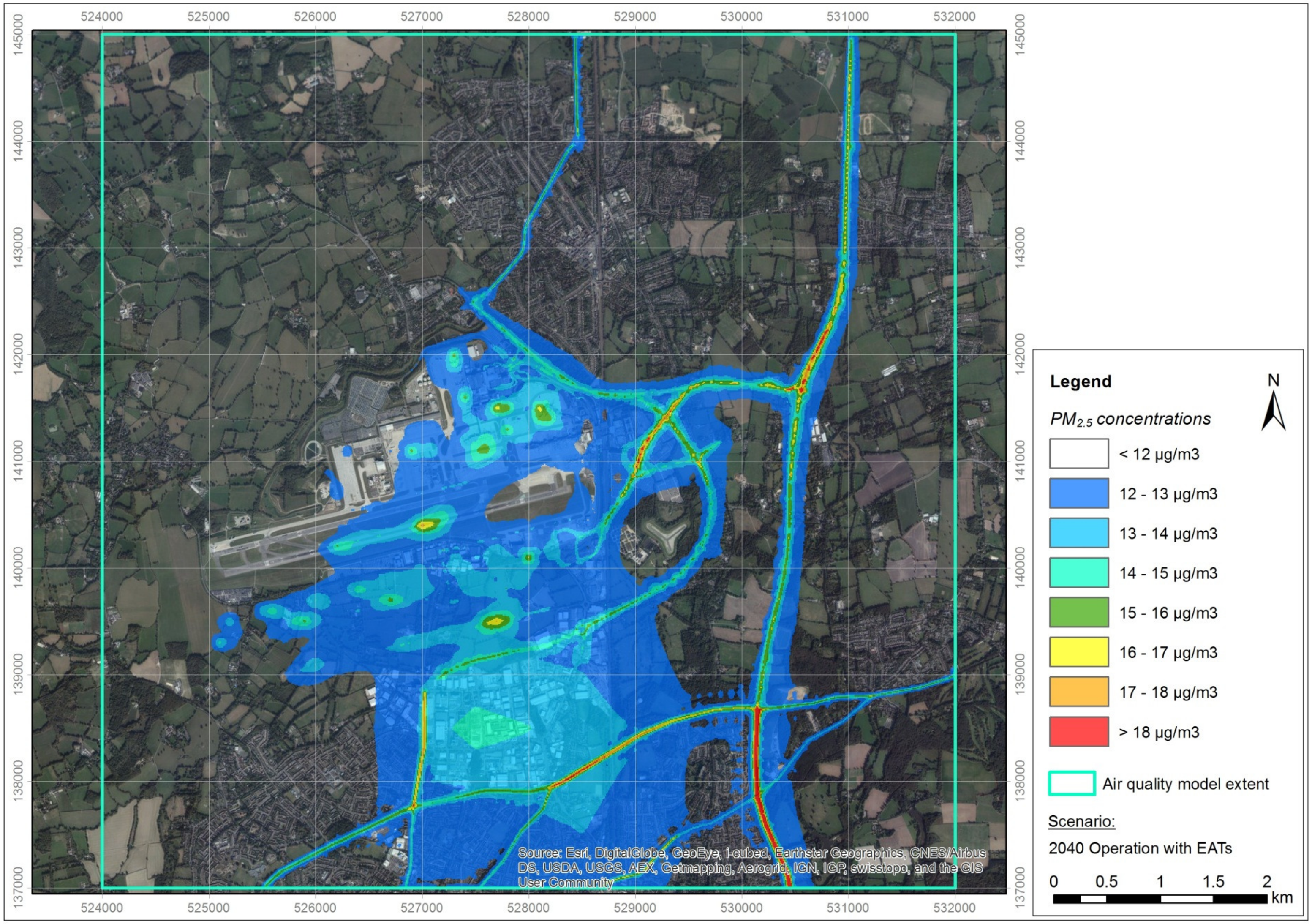


Figure 27 Predicted NOx concentrations for the 2050 operational scenario with EATs

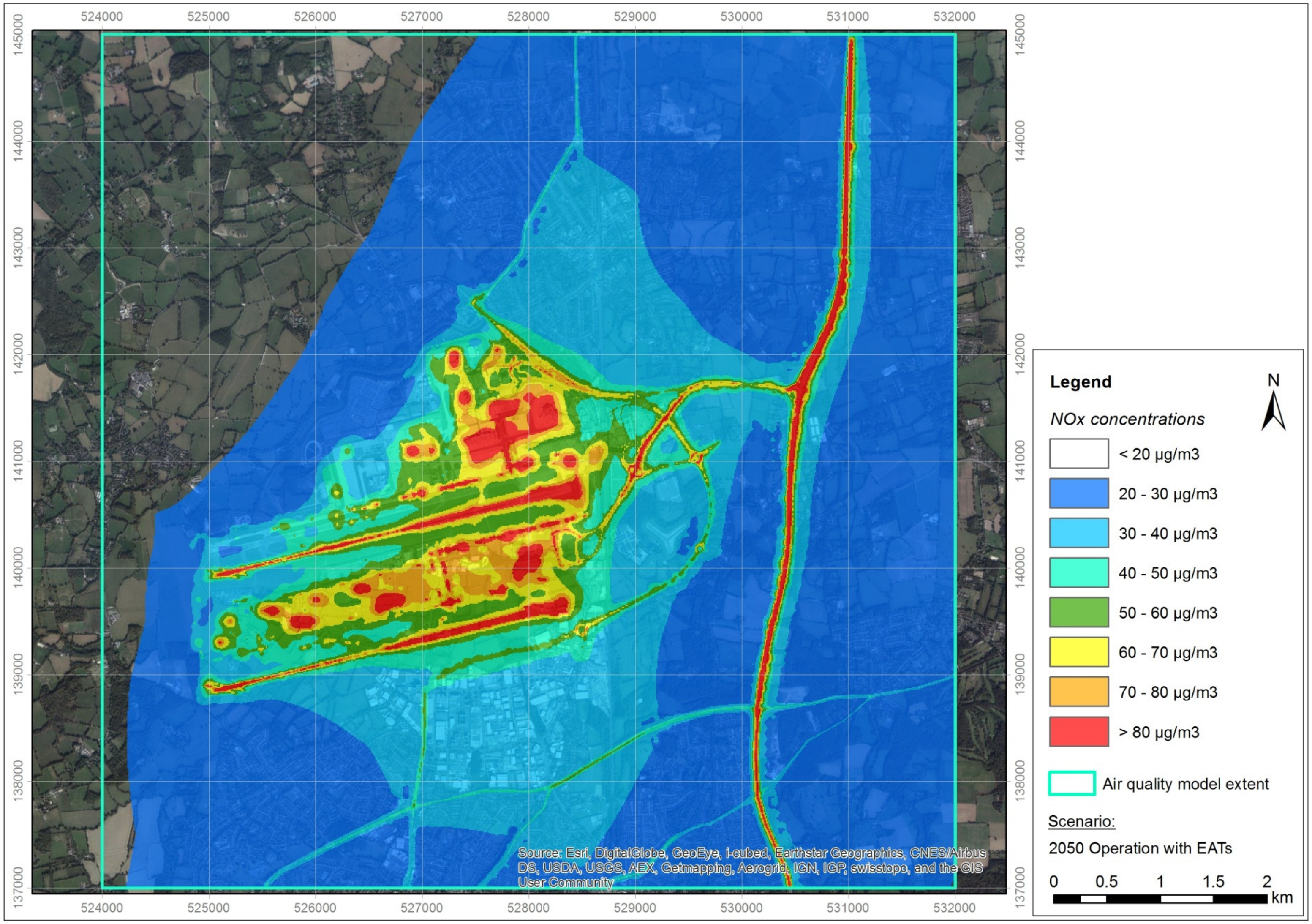


Figure 28 Predicted NO_2 concentrations for the 2050 operational scenario with EATs

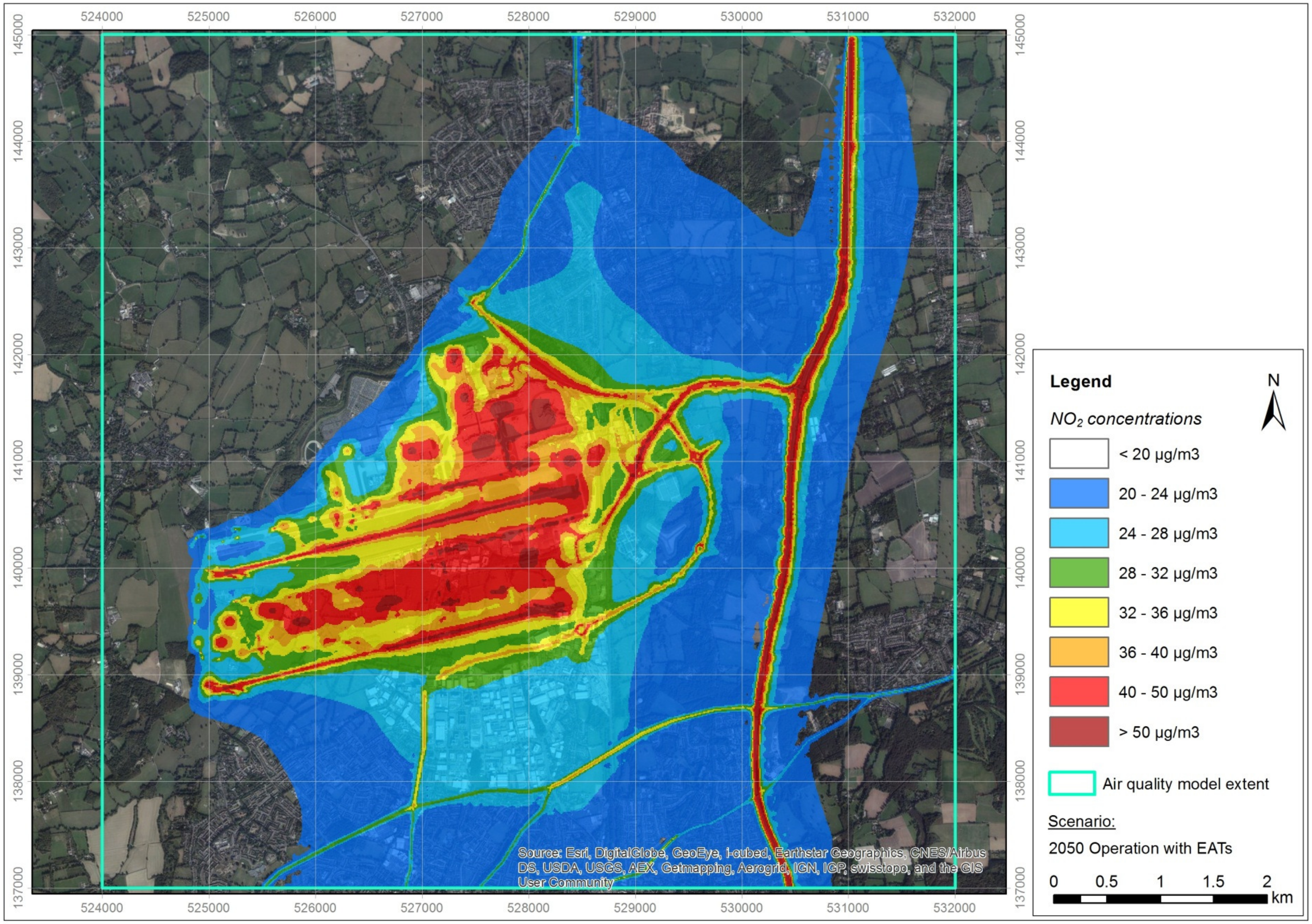


Figure 29 Predicted PM_{10} concentrations for the 2050 operational scenario with EATs

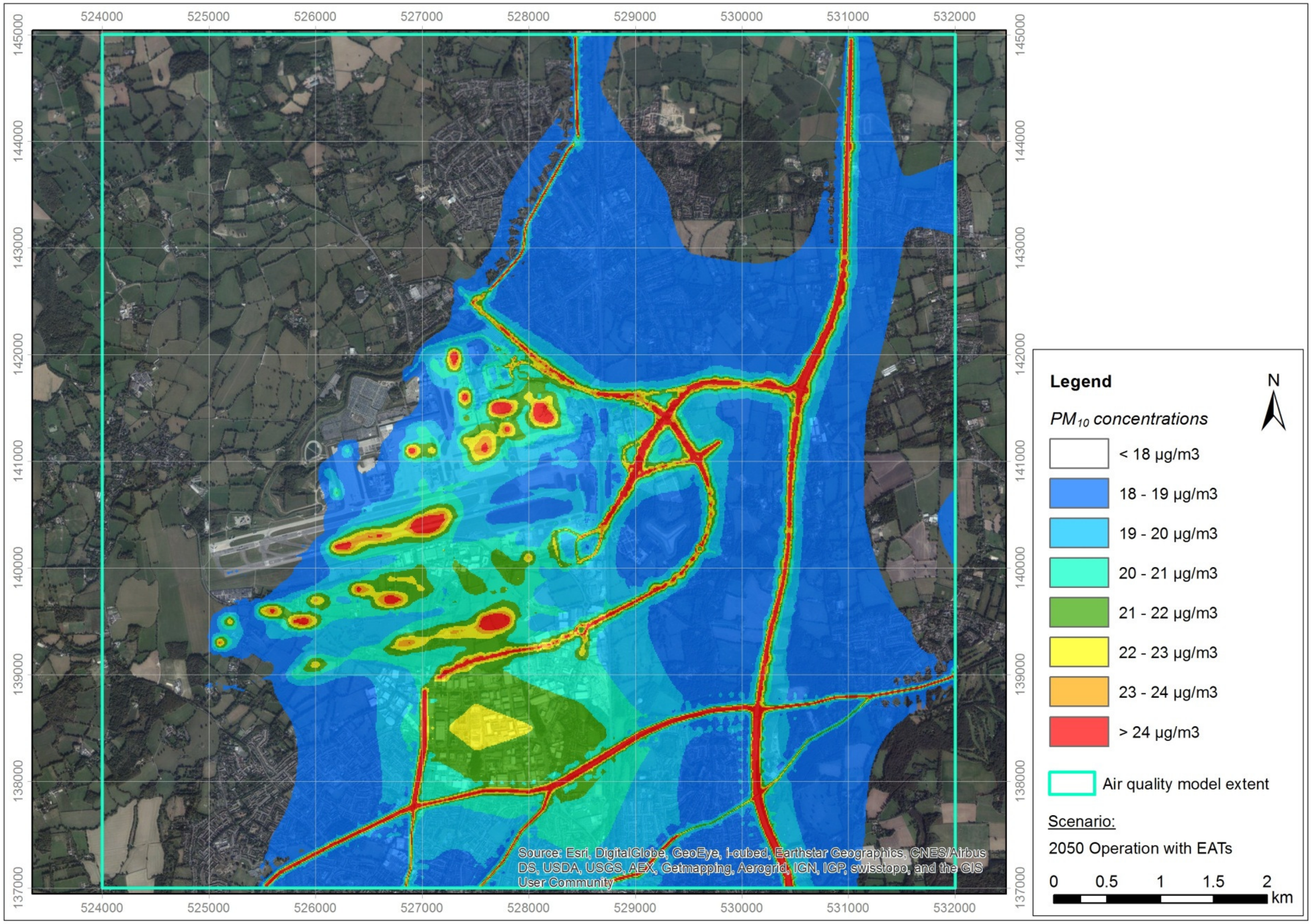
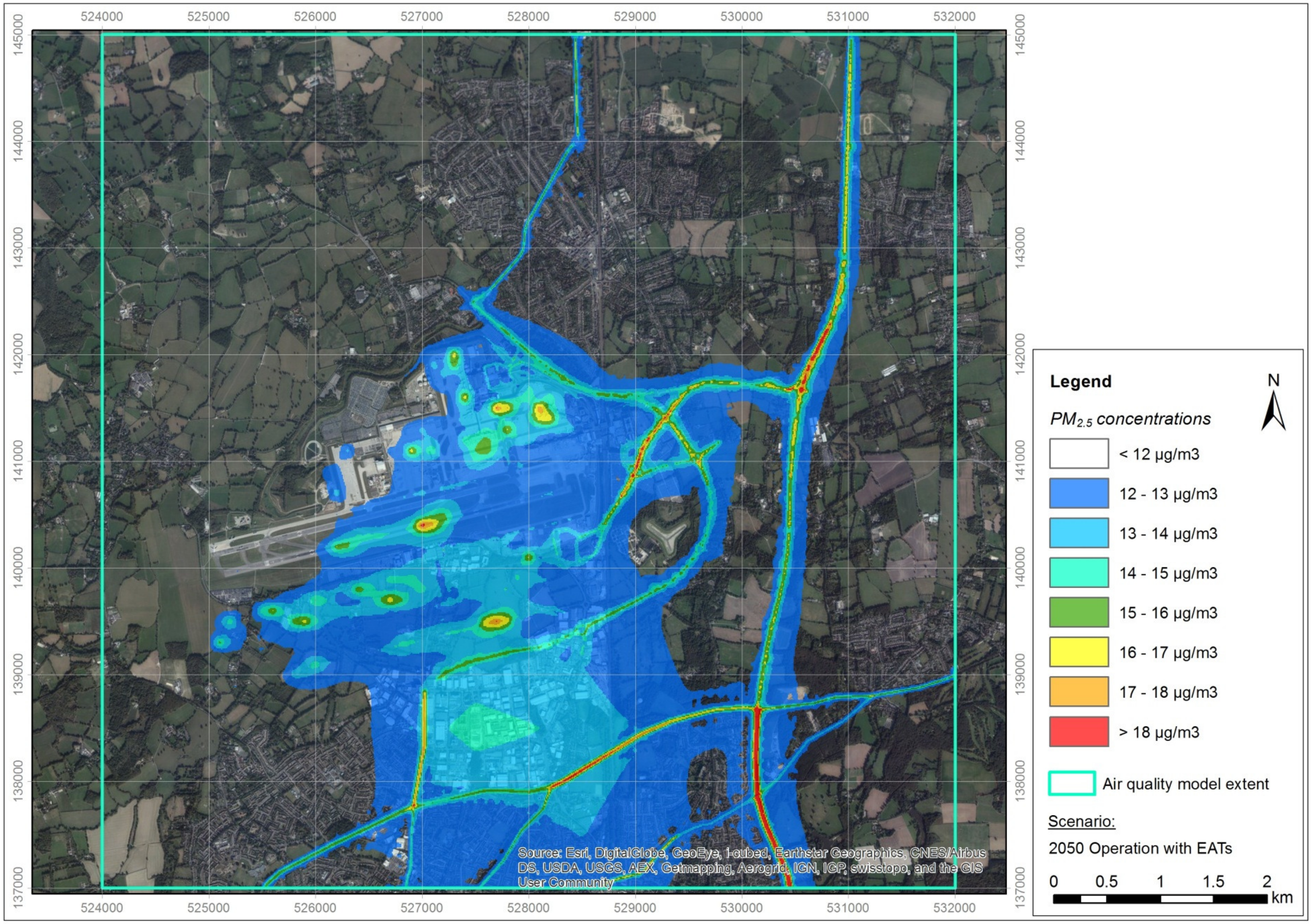


Figure 30 Predicted $PM_{2.5}$ concentrations for the 2050 operational scenario with EATs



Appendix C

Mitigation scenarios

As mentioned in section 4.1, some of the modelling assumptions in the current assessment are considered to be worst case estimates and do not represent Gatwick's commitments or aspirations for future operations; these relate to the use of auxiliary power units (APUs), taxiing emissions and ground support equipment (GSE). This appendix presents an assessment of pollutant concentrations with the incorporation of mitigation measures for these sources, as well as a discussion on future aircraft engines. The results are presented for the two monitoring sites (RG1, RG2) and the three assessment receptors (CR8, MVA, MVB) for comparison with the main report.

Methodology

The use of APUs in the current model is a considerable overestimation and based on Gatwick's 2011 MDI allowances for running times. Recent compliance surveys at the airport showed that almost 90% of the stands are fitted with FEGP. This is estimated to increase to 95% by 2040 since Gatwick has committed that all new stands in the future will be fitted with FEGP. However, there will still be cases when APUs will be required to run, such as when ambient temperatures are outside the normal conditions (currently between -5^{o}C to 25^{o}C) and prior to towing the aircraft on/off the stand. From recent observations and Gatwick's experience, it was estimated that aircraft are likely to use APUs only 25% of the time when on ground. Therefore, the mitigation scenario allows for this reduced use of APUs for the two future operation scenarios of the airport although this assumption can still be considered to be conservative given the increased adoption of FEPG and management practices designed to avoid the use of APUs in the future.

In relation to taxiing, the current model assumes that each aircraft is using both engines at a 7% thrust. Discussions with airlines and recent research have shown that single engine taxiing is feasible and that this results in NOx emissions being reduced by 10 – 30%. As a conservative approach, the mitigation scenario is based on aircraft using a single engine when taxiing in and out, but on a 10% thrust setting, which reduces the emissions by almost 15%.

Gatwick is also committed to look into electrification and/or hybrid vehicles for ground support. The current modelling assumption do not take into account these measures and potential improvements in emissions. Therefore, the mitigation scenario is based on the assumption of these measures been taken forward and as a conservative approach, uses a reduction of emissions by 10%.

Results

NOx emissions and concentrations

Table 23 presents the estimated annual emission rates of NOx for each pollution source and a comparison with and without mitigation without EATs. As expected, the only difference is the aircraft NOx emissions at ground level and GSE (presented in **bold**), which would by approximately 167 tonnes in total with the mitigation measures in 2040. For direct comparison, the APUs and taxiing emissions are also presented (in *italics*).

Table 23 Comparison of NOx emission rates (tonnes/year) with and without mitigation (without EATs)

Source		2040 Operation		2050 Operation	
		no mitigation	with mitigation	no mitigation	with mitigation
Airport	Aircraft (elevated)	1,616.27	1,616.27	1,721.02	1,721.02
	Aircraft (ground)	959.96	**796.18**	1,051.95	**878.88**
	APUs	*155.10*	*86.68*	*164.58*	*88.85*
	Taxiing	*316.38*	*268.92*	*330.88*	*281.25*
	GSE	38.31	**34.48**	43.87	**39.48**
	Road network	61.50	61.50	65.70	65.70
	Car parks	6.63	6.63	7.25	7.25
	Stationary sources	46.34	46.34	46.34	46.34
Non-airport	Road network	141.24	141.24	131.41	131.41

Table 24 presents the comparison of the predicted total NOx concentrations at the selected assessment sites with and without mitigation. It can be observed that concentrations of NOx would decrease by a maximum of 5.6µg/m^3 in 2040 and 5.9µg/m^3 in 2050 in the Horley AQMA with mitigation measures. The decrease in NOx concentrations at the other locations is predicted to be smaller.

Table 24 Comparison of total NOx concentrations (µg/m^3) with and without mitigation (without EATs)

Location	2040 Operation		2050 Operation	
	no mitigation	with mitigation	no mitigation	with mitigation
RG1 Horley	34.8	31.3	35.6	31.9
RG2 Horley South	40.2	34.6	41.5	35.6
CR8	26.3	25.5	26.5	25.7
MVB	17.6	17.4	17.6	17.4
MVA	23.6	22.1	24.0	22.4

NO_2 concentrations

Table 25 presents the comparison of the predicted total NO_2 concentrations at selected locations around the airport with and without mitigation without EATs. It can be observed that NO_2 concentrations would reduce by a maximum of approximately 3µg/m^3 in the Horley AQMA.

Table 25 Predicted NO_2 concentrations at selected locations with and without mitigation (without EATs)

Location	2040 Operation		2050 Operation	
	no mitigation	with mitigation	no mitigation	with mitigation
RG1 Horley	25.6	23.5	26.7	24.5
RG2 Horley South	28.8	25.6	30.2	26.9
CR8	20.4	19.9	21.1	20.6
MVB	14.4	14.3	14.8	14.7
MVA	18.6	17.6	19.4	18.3

PM emissions and concentrations (PM_{10} and $PM_{2.5}$)

Table 26 and Table 27 present the estimated annual emission rates of PM_{10} and $PM_{2.5}$ respectively, for each pollution source and a comparison with and without mitigation without EATs. It can be observed that similar to the NOx emission rates, the only difference is the aircraft emissions at ground level and GSE (presented in **bold**). These would decrease by almost 5 tonnes in total with the mitigation measures in 2040. For direct comparison, the APUs and taxiing emissions are also presented (in *italics*).

In terms of the total PM_{10} and $PM_{2.5}$ concentrations with mitigation measures, these are expected to reduce by a maximum of 0.2µg/m^3 in the Horley AQMA.

Table 26 Comparison of PM_{10} emission rates (tonnes/year) with and without EATs

Source		2040 Operation		2050 Operation	
		no mitigation	with mitigation	no mitigation	with mitigation
Airport	Aircraft (elevated)	7.71	7.71	7.08	7.08
	Aircraft (ground)	23.44	**19.23**	28.03	**22.63**
	APUs	*4.68*	*1.17*	*6.20*	*1.55*
	Taxiing	*4.64*	*3.94*	*5.02*	*4.26*
	GSE	6.49	**5.84**	7.47	**6.72**
	Road network	10.01	10.01	14.61	14.61
	Stationary sources	0.72	0.72	0.72	0.72
Non-airport	Road network	29.99	29.99	31.11	31.11

Table 27 Comparison of $PM_{2.5}$ emission rates (tonnes/year) with and without EATs

Source		2040 Operation		2050 Operation	
		no mitigation	with mitigation	no mitigation	with mitigation
Airport	Aircraft (elevated)	6.71	6.71	7.08	7.08

Source		2040 Operation		2050 Operation	
		no mitigation	with mitigation	no mitigation	with mitigation
	Aircraft (ground)	17.57	**13.37**	21.01	**15.61**
	GSE	3.50	**3.15**	4.03	**3.62**
	Road network	5.64	5.64	9.91	9.91
	Stationary sources	0.72	0.72	0.72	0.72
Non-airport	Road network	16.22	16.22	16.83	16.83

Summary

From the results presented here it can be observed that the application of mitigation measures for APUs, taxiing and GSE is predicted to result in overall reductions in emission rates and pollutant concentrations. NOx emission rates from aircrafts at ground level and GSE would reduce by approximately 167 tonnes, while total NO_2 concentrations in the Horley AQMA would reduce by a maximum of 3µg/m^3 in 2040. In relation to PM emissions, these would reduce by approximately 5 tonnes for both PM_{10} and $PM_{2.5}$ from the aircraft at ground level and GSE, while predicted concentrations would reduce by a maximum of 0.2µg/m^3 in the Horley AQMA.

Discussion on future aircraft engines

The emissions of pollutants, especially NOx, from engines currently in service are very precisely given by the ICAO emissions databank. Some of these engines will be in service for some time yet and so their emissions data can be used as a reliable estimate for part of the fleet in future years. Aircraft are active in the fleet for an average of 25 -30 years, with some aircraft still in use after 40 – 50 years[27]. On this basis, an aircraft entering service in 2015 has an even chance of still being operational in 2040 if historical data and trends continue to apply[28].

For new aircraft entering the fleet in future years, there are no precise estimates of the relevant emission factors. There is, however, a defined policy framework for reducing the NOx emissions in the LTO cycle. The emission certification of engines is governed by ICAO, through its Committee on Aviation Environmental Protection (CAEP). A standard for NOx in the LTO cycle was first adopted in 1981, with a subsequent series of meetings that defined required improvements relative to a baseline position: CAEP/2 (1993), CAEP/4 (1999), CAEP/6 (2005), CAEP/8 (2011). The standards are technology following, i.e. the engines entering service tend to comply with the current CAEP defined standard, each of which represents a progressive reduction on the previous standard. For example, CAEP/8 has an applicability date of 1 January 2014 and requires a 15% reduction in NOx emissions relative to the CAEP/6 standard. The production cut-off date for CAEP/6 was set by ICAO at 1 January 2013.

[27] Morrell P and Dray L (2009) Environmental aspects of fleet turnover, retirement and life cycle. Final report by Omega (Cranfield University and the Institute for Aviation and the Environment, Cambridge)

[28] Seymour C (2011) Aircraft Life Cycles and Fleet Turnover *Greener by Design Conference* 18 October 2011

This gradual improvement in the emission performance of engines for NOx has been achieved by refinements to the combustion process, which may also influence emissions of CO2 emissions and particulate matter. For example, increasing engine operating temperatures increases engine efficiency and reduces fuel burn, but also increases NOx emissions. NOx formation depends on the amount of fuel burned and the conditions in the combustor. The highest amounts of NOx (per kg of fuel burnt) are generated at high power settings (at take off) when the air entering the combustor is at its highest temperature and pressure, combined with peak combustion temperatures. In spite of the technical challenges faced by the engine designers, their solutions in the form of adjustments to the fuel/air mix, staged fuel combustion and other refinements continue to deliver improved performance and the industry expects that these will continue for newer engines introduced in the near future. The ICAO has set 'mid term' and 'long term' goals for NOx reduction of -45% of CAEP/6 by 2016 and -60% of CAEP/6 by 2026. Test data on engine prototypes by Rolls Royce and others suggest that these goals are achievable.

Looking beyond the next decade, policy makers have set out ambitious targets for reductions in CO_2, NOx and noise emissions from new aircraft. European Commission policy, for example, is to reduce NOx emissions by 90% relative to performance in the year 2000 (roughly equivalent to CAEP/6) , as set out in its 'Flightpath 2050' goals. In the US, the NASA long term goal (N+3) is for an 80% reduction by 2030-35, relative to CAEP/6. To meet these targets, and the similarly ambitious targets for reductions in CO_2 and noise, will require revolutionary radical departures from the current technologies. It is probable that, by 2040, markedly different designs for aircraft will be entering service to meet the new demands of fuel efficiency and other considerations.

There is little in the current emissions databank that is relevant for extrapolating forwards to the 'new concept' aircraft that are likely to be emerging on a 30-40 year horizon. Instead, it is possible only to assume that these policy goals for emissions will be met and that the fleet in 2040 will comprise approximately 50% of older aircraft corresponding to the best performing of today's engines and the other 50% that perform considerably better. Indeed, this is the assumption used in the modelling carried out to date, which has almost exactly 50% of aircraft engines in 2040 meeting the CAEP/8 standard.

The likelihood is that the overall aircraft fleet in 2040 will be emitting NOx in the LTO cycle at rates that are at least 50% lower than in the 2010 case, on a per engine basis. This is a relatively cautious view of emissions, given that evolutionary improvements in 'conventional' jet engines alone will probably deliver this level of reduction. For Gatwick, there is a 'built-in' fall in emissions from the removal of pre-CAEP/6 engines by this date, which accounts for approximately 40% of the aircraft movements in the 2010 inventory. For comparison, there was an estimated 27% reduction in ground level NOx emissions from the aircraft movements at Gatwick in the period 2005-2010 (when the number of aircraft movements was broadly consistent).

Previous assessments undertaken for Gatwick have assumed a gradually reducing NOx emission rate of 0.75% a year plus two technology changes for each major aircraft type. This results in emission reductions that are rather lower than the anticipated technology changes and policy goals. To maintain consistency with the previous assessments, however, the same assumptions have been maintained in the current study. This is considered to be very much a worse case assessment for the future situation where it is clear that policy goals are to drive down NOx emissions to much lower levels.