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# Lower Thames Crossing Study

## Comparative Air Quality Assessment of Options for the Lower Thames Crossing

May 2014

**This document has been withdrawn as the preferred route for the Lower Thames Crossing has been announced.**

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# 1 Introduction

In May 2013, the Department for Transport published the *Review of Lower Thames Crossing Options: Final Report (April 2013),* together with supporting reports. The Department used this Review report for the purposes of public consultation on the merits of three location options (Options A, B and C; a variant to Option C improving the A229 between the M2 and M20 was also consulted on). The options aim to provide additional highway capacity across the River Thames.

This technical note (Module 1) responds to part of a brief to Jacobs/AECOM (provided by the Department for Transport) that requires a comparative assessment of the air quality impacts of the Lower Thames crossing options.

For the purposes of this analysis it is assumed that the opening year will be 2025. This assessment considers different versions of a new crossing at the alternate location options. Option A and Option A+, Option C and Option C2 are illustrated in Figure 1.

The options assessed are as follows:

**Option A**

- An additional crossing adjacent to the existing Queen Elizabeth 2 (QE2) bridge on the M25 at Dartford.
- The new crossing is assumed to provide 4 lanes northbound, and the existing west tunnel is assumed to provide a further 2 lanes northbound.
- The existing QE2 bridge is assumed to remain as 4 lanes southbound and the existing east tunnel is assumed to provide a further 2 southbound lanes.

**Option A+**

- Created following assessment (in Modules 3 and 4 of the DfT brief) of likely capacity requirements on the strategic roads and junctions adjacent to the crossing once the new crossing may be constructed (2021-2015)
- As per Option A, but with assumed improvements to Junction 30 (see Module 3) and A282 widening between Junctions 1b and 1b, and A282 Smart Motorway Scheme between J2 and J1a (see Module 4).

**Option C**

- A new road crossing connecting the M2 / A2 with the M25.
- The new road is assumed to pass close to South Ockendon, East Tilbury, across West Tilbury Marshes before crossing the River Thames just to the east of Gravesend and Thurrock.

**Option C2**

- An alternative version of Option C (created as part of Module 2 of the DfT brief); with changes to the link south of the river.
- Option C2 assumes an extended tunnel such that the emergence point would avoid the South Thames Estuary & Marshes Ramsar/Site of Special Scientific Interest (SSSI). It would link into the A2 further west than Option C, thereby seeking to avoid the Shorne and Ashenbank Woods SSSI.

# 2 Policy and Legislation

## 2.1 Legislative and Regulatory Background

The assessment considers the relevant air quality legislation which is summarised in Table 2-A, and the process of Local Air Quality Management (LAQM).

| Applicable Law | Description |
|---|---|
| Environment Act 1995, Part IV. | Defines requirements for LAQM |
| The Air Quality (England) Amendment Regulations 2000 / 2002 | Legislates for the Air Quality Objectives for pollutants set out in the 2007 Air Quality Strategy. |
| The National Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland, 2007. | Updates the 2000 Air Quality Strategy. The strategy sets out the plan for meeting EU Limit Values and is the basis of the LAQM Policy and Technical Guidance. |
| The Air Quality Standards Regulations (England & Wales) 2010. | Transpose formalised Limit Values set out in the EU ambient air quality directive 2008/50/EC to UK law. |

***Table 2-A Key Air Quality Legislation***

### 2.1.1 European Legislation

The European Union Framework Directive 2008/50/EC[1] on Ambient Air Quality and Cleaner Air for Europe (CAFE) came into force in May 2008 and had to be implemented by Member States, including the UK, by June 2010.

Directive 2008/50/EC was published to consolidate previous European Directives on ambient air quality. The Air Quality Standards Regulations 2010[2] implement Limit Values prescribed by the Directive 2008/50/EC. The Limit Values are legally binding, and the Secretary of State (on behalf of the UK Government) is responsible for their implementation.

Defra report compliance with the EU Directive Limit Values to the European Commission (EC) annually using the Pollution Climate Mapping (PCM) model. This model is run for representative links across the UK selected by Defra. This is a different modelling method than is used to calculate the impacts of a scheme for Environmental Impact Assessment.

### 2.1.2 National Legislation

Local Authorities have statutory duties for Local Air Quality Management (LAQM), and are obliged to ensure that Air Quality Objectives (AQOs) as set out in the Air Quality Strategy (2007) are achieved as quickly as possible. AQOs only apply at locations where relevant exposure occurs, for example at residential properties along the M25.

[1] Council Directive 2008/50/EC of 21 May 2008 on Ambient Air Quality and Cleaner Air for Europe.
[2] Defra, 2010, The Air Quality Standards (England) Regulations

The Local Air Quality Management (LAQM) process requires local authorities to undertake phased assessments to identify any areas likely to experience exceedences of the Air Quality Objectives (AQO).

Any location likely to exceed the AQOs must be designated an Air Quality Management Area (AQMA) and an Air Quality Action Plan (AQAP) must be prepared and implemented, with the aim of achieving the objectives in the designated area in the shortest time possible.

For the pollutants $NO_2$, NOx and $PM_{10}$, the UK Air Quality Objectives (AQOs) and the EU Limit Values are all identical, however they are legislated and applied differently. Defra assess compliance against the EU Limit Values for reporting to the EC using the PCM model. This LTC air quality assessment reports modelled concentrations at specific receptor locations for comparison with the AQOs, and the risk of altering the conclusions of the Defra reporting to the EC is also considered.

The AQOs of relevance to this assessment are summarised below in Table 2-B. The AQOs are health-based standards and are set at a level to provide protection to the whole population.

| Pollutant | Air Quality Objective (AQO) | | Date to be achieved |
|---|---|---|---|
| | Concentration | As measured | |
| Nitrogen Dioxide ($NO_2$) | 200 µg/m$^3$ not to be exceeded more than 18 times/yr (99.79$^{th}$ percentile) | 1 Hour | 31-12-2005 |
| | 40 µg/m$^3$ | Annual | 31-12-2005 |
| Particulate Matter ($PM_{10}$) | 50 µg/m$^3$ not to be exceeded more than 35 times/ yr | 24 Hour | 31-12-2004 |
| | 40 µg/m$^3$ | Annual | 31-12-2004 |
| Oxides of Nitrogen (NOx) | 30 µg/m$^3$ for the protection of vegetation and ecosystems | Annual | 19-07-2001 |

***Table 2-B*** **Summary of Relevant Air Quality Objectives**

An exceedence of an AQO would be a modelled annual mean concentration which is greater than the annual mean AQO, which is 40 µg/m$^3$ for both $NO_2$ and $PM_{10}$.

There are no assessment methods available which can produce robust predictions of short term concentrations from road traffic. Therefore, assessment against the short term AQOs is assessed by following the guidance presented in Local Air Quality Management Technical Guidance (LAQM TG(09))[3]. This provides a relationship between the annual mean $NO_2$ and $PM_{10}$ concentration and the number of periods per year where the short term AQO is likely to be exceeded. These relationships have been derived from examination of monitoring data across the UK.

Receptors would not be expected to exceed the $NO_2$ 1 hour mean AQO if predicted annual mean concentrations are less than 60 µg/m$^3$, or the $PM_{10}$ 24 hour mean AQO, if predicted annual mean concentrations are less than 32 µg/m$^3$.

### 2.1.3 National Policy

A new National Planning Policy Framework was published in 2012, superseding previous guidance on planning and air quality.

[3] Defra's Local Air Quality Management Technical Guidance LAQM TG(09)

The National Planning Policy Framework (NPPF, 2012) sets out the Government's planning policies for England and how these are expected to be applied. It provides a framework within which local people and their accountable councils can produce their own distinctive local and neighbourhood plans, which reflect the needs and priorities of their communities.

The NPPF document states in Paragraph 124 that: '*Planning policies should sustain compliance with and contribute towards EU limit values or national objectives for pollutants, taking into account the presence of Air Quality Management Areas and the cumulative impacts on air quality from individual sites in local areas. Planning decisions should ensure that any new development in Air Quality Management Areas is consistent with the local air quality action plan.*'.

### 2.1.4 Application of Legislation

The Highways Agency's (HA) approach to assessing the significance of impacts is detailed in section 3.5, and this guidance addresses the implications of the AQOs and the NPPF.

The EU Directive on Ambient Air Quality sets limit values for a range of pollutants. The purpose of the Directive is to protect human health, and the environment as a whole. Defra reports annually (on behalf of the UK government), on the status of air quality to the EC. The Highways Agency's (HA) Compliance Risk Assessment test (IAN 175/13[4]) has been developed to enable decision makers to judge a scheme's likelihood of altering the UK's reported position on compliance with the Air Quality Directive. The Compliance Risk Assessment test also informs professional judgement on air quality significance.

A review of the PCM model predictions for the Defra Compliance Links in the scheme study area has been undertaken, and there are no links which are predicted by Defra to be at risk of exceeding the EU Limit Values in 2025.

All of the scheme options are therefore considered a low risk of non-compliance with the EU Directive.

[4] HA, Interim Advice Note 175/13 - Updated air quality advice on risk assessment related to compliance with the EU Directive on ambient air quality and on the production of Scheme Air Quality Action Plans for user of DMRB Volume 11, Section 3, Part 1 'Air Quality', June 2013

## 3 Methodology

### 3.1 Introduction

The primary purpose of this assessment is to provide a comparison of the air quality risk of constructing a new crossing at the alternate location options. The main pollutants of concern in this assessment are those associated with vehicle exhaust emissions. The assessment has focussed on nitrogen dioxide ($NO_2$) and particulate matter ($PM_{10}$).

This assessment (informed by the Design Manual for Roads and Bridges (DMRB)[5] and LAQM TG(09)) has been undertaken for Options A, A+, C and C2 (referenced in Chapter 1).

The key elements of the assessment are as follows:

- Consideration of relevant Air Quality Review and Assessment (R&A) reports;
- Assessment of existing local air quality based on a review of air quality monitoring data in the local area; and
- Assessment of the effect of changes in vehicle emissions associated with changes in traffic flow characteristics that could be generated by the potential options (following scheme opening) on local air quality.

### 3.2 Traffic Data and Study Area

A new river crossing with associated link roads has the potential to lead to air quality impacts over a very wide spatial area, because the change in traffic flow (as identified by the AECOM review of options) is likely to be substantial. The assessment study area is determined on the AQ scoping criteria (DMRB paragraph 3.15). This is primarily a change in traffic flow on roads due to the scheme (i.e. the With Scheme minus Without Scheme traffic flow).

The assessment study area combines the qualifying links from both Option A and Option C to produce a consistent study area to allow comparison of the options.

It is noted that the traffic consultant (AECOM) consider the traffic modelling to contain a number of out dated source datasets and assumptions. This means that the traffic outputs are subject to considerable uncertainty. Although no route option alignment were fully developed for the traffic modelling that had been previously undertaken, it is considered that the traffic data is suitable for comparison of the overall impacts of the alternate versions of the location options, although the links assessed have been limited to those identified as robust by the traffic consultant (AECOM) (see section 3.6 below: Robustness of Model Predictions).

[5] Highways Agency, The Design Manual for Roads and Bridges Volume 11, Section 3, Part 1 HA207/07 Air Quality, May 2007

This assessment considers the following scenarios:

- 2009 Baseline scenario (i.e. existing conditions at the start of the assessment);
- 2025 Opening Year Do Minimum (DM);
- 2025 Opening Year Do Something (DS) Option A;
- 2025 Opening Year DS Option A+;
- 2025 Opening Year DS Option C; and
- 2025 Opening Year DS Option C2.

To represent the effects of hard shoulder running in Option A+, Jacobs reviewed DfT research[6] on the effects of Hard Shoulder Running and Smart Motorways on motorway traffic flows. This research predicted an increase of 2% above the reference case level, primarily due to traffic diverting from other roads onto the enhanced capacity on the motorways. This assumption was adopted for Option A+, and a 2% uplift in traffic has been applied to the Option A traffic flows on the A282 Dartford Crossing and the M25 J1a to 1b.

Option C2 has not been modelled for this air quality assessment, and the traffic flows were not considered likely to be altered significantly between Option C and Option C2. The impacts of Option C2 are inferred from the Option C modelling which only differs from Option C at the southern junction location with the A2.

A summary of the traffic data used in this assessment is provided in Appendix A.

## 3.3 Background Concentrations

Defra provides empirically-derived national background maps, which provide estimates of background pollutant concentrations at a 1km x 1km grid square resolution. This data is obtained through Defra (http://www.laqm.defra.gov.uk).

The data for NOx, $NO_2$ and $PM_{10}$ use a base year of 2010 from which future years can be projected. Defra have stated that 2010 was an unusually high year for NOx and $NO_2$, and that in order to correct the background maps to other years, the NOx concentrations should be reduced by 15%; this process has been applied in the assessment.

In order to obtain background concentrations for the base year 2009, the Defra 2010 maps were backcast using the relationship between the 2010 and 2015 maps, following a methodology developed by the HA and Defra[7]. A comparison of the 2009 mapped total NOx and $NO_2$ concentrations was undertaken against measured data from monitoring locations in background locations. It was found that the background maps performed reasonably and on average were within +/-10% of background monitoring sites within the study.

The ‘in-grid square’ contribution from motorway, trunk ‘A’ road and primary ‘A’ road sectors have been removed from the background annual mean NOx and $PM_{10}$

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[6] DfT, Modelling Dynamic Hard Shoulder Running In The National Transport Model, 2008
[7] HA, Approach to Creating 2008 / 2009 equivalent maps for use in Source Apportionment Spreadsheet

concentration estimates, and background annual mean $NO_2$ estimates have then been corrected using the Defra's Background $NO_2$ Calculator[8] . This process has been undertaken to avoid double counting of road traffic emissions which are represented in the DMRB model.

## 3.4 Air Quality Model and Prediction of Environmental Concentrations

This assessment used the HA's updated draft DMRB Air Quality model at the approval of the HA and DfT, which has not yet been formally released. The model predicts concentrations of NOx and $PM_{10}$ using traffic data to calculate emission rates. The updated DMRB model is based on the Defra's Emission Factor Toolkit v5.2c.

Each 2-way road link was modelled individually, and a concentration calculated at a series of distances from the road edge (10m, 20m, 50m, 100m). Modelling was based on AADT (Annual Average Daily Traffic) traffic data as issued by AECOM, with % Heavy Duty Vehicles (HDV) and average daily speeds based on the Annual Average Weekday Traffic (AAWT) traffic data because a weekend traffic model is not available.

Assessment of NOx and, if necessary, nitrogen deposition has been undertaken at Designated Habitat sites within 200m of the study area. These are shown in Figure 6.

The air quality model is used to predict the road traffic contributions to NOx and $PM_{10}$ concentrations. Adjustments are applied to the model predictions based on a comparison against measured air quality concentrations, in a process known as model verification and adjustment. The modelled road contributions of NOx, $NO_2$ and $PM_{10}$ were adjusted to correct them against measured road components derived from monitoring data, following an adjustment method described in LAQM TG(09). For further details of the model verification and adjustment process can be found in Appendix B.

$NO_2$ concentrations were calculated using the NOx to $NO_2$ calculator (version 3.2) available on the Defra website. A total pollutant concentration was then produced by addition of the adjusted road contribution to the background concentration.

To predict the concentrations for the assumed opening year, a further adjustment step is then undertaken, to account for the observed trends in ambient roadside NOx and $NO_2$.

In July 2011, Defra published a report examining the long term air quality trends in NOx and $NO_2$ concentrations[9]. This identified that there has been a clear decrease in $NO_2$ concentrations between 1996 and 2002. Thereafter $NO_2$ concentrations have stabilised with little to no reduction between 2004 and 2012. Defra's report presents a similar pattern for the change in NOx concentrations over the same time period. The consequence of the conclusions of Defra's advice on long term trends is that there is now a gap between current projected vehicle emission reductions and

[8] Defra, $NO_2$ Background Sector Tool - for Source Apportioned Background $NO_x$ v3.2
[10] HA Interim Advice Note 170/12 Revision 3 - Updated air quality advice on the assessment of future $NO_x$ and $NO_2$ projections, October 2013
ce Note 170/12 Revision 3 - Updated air quality advice on the assessment of future $NO_x$ and $NO_2$ projections, October 2013

projections on the annual rate of improvements in ambient air quality, which are built into the vehicle emission factors, the projected background maps and the $NO_x$ to $NO_2$ calculator.

The HA has developed the Gap Analysis methodology to adjust model predictions based on the method in LAQM TG(09), to account for the long term NOx and $NO_2$ profiles. This uses the relationship between the Base year vehicle emission rates and the Opening year vehicle emission rates, and the measured trends in roadside air quality concentrations to uplift opening year predicted concentrations to align them better with the long term trends of NOx and $NO_2$ .

The current trends in air quality are based on measurements of emissions from the existing vehicle fleet. New vehicles will need to comply with the more stringent Euro VI/6 emissions standards from September 2014 onwards. Vehicles complying with the Euro VI/6 emissions standard are not yet on the road network, and therefore the performance of these vehicles is not present in the long term air quality monitoring trends. If the Euro VI/6 fleet emissions perform as predicted, then this should lead to substantial reductions in predicted future roadside air quality concentrations.

The HA's Interim Advice Note 170/12 v3[10] provides projection factors ($LTT_{E6}$) which incorporate potential Euro VI/6 improvements to emissions rates into the long term trends. These $LTT_{E6}$ projection factors have been used in this assessment, and are considered by Jacobs to be the most realistic future year forecast methodology published.

With regard to the Designated Habitat Sites assessment, nitrogen deposition is assessed against the Critical Load, which is the rate of nitrogen deposition which a habitat can accept without damage occurring. Critical Loads are assigned to habitat classes of the European Nature Information System (EUNIS) to enable consistency of habitat terminology and understanding across Europe.

Critical Loads are given as ranges in kilograms of nitrogen per hectare per year e.g. 10-20 kgN/ha/yr. These ranges reflect variation in ecosystem response across Europe. Nutrient nitrogen Critical Loads were revised in June 2010. These values have been incorporated into this assessment and supersede Table F1, Annex F in the DMRB guidance. The APIS[11] website was updated in February 2013, updating the habitat types associated with each Designated Site, and the background deposition rates. Designated Habitats sites which do not have critical loads assigned by APIS are not considered to be sensitive to nutrient nitrogen, and have not been included in the assessment.

## 3.5 Assessment of Potential Air Quality Effects

The model results are used to assess whether there would be potentially significant air quality effects as a result of a future scheme.

The HA approach to evaluating significant local air quality effects is set out in Interim Advice Note (IAN) 174/13[12]. This IAN defines bands of magnitude of change in

[10] HA Interim Advice Note 170/12 Revision 3 - Updated air quality advice on the assessment of future $NO_x$ and $NO_2$ projections, October 2013
[11] www.apis.ac.uk
[12] HA, Interim Advice Note 174/13 - Updated air quality advice for evaluating significant local air quality effects; for users of DMRB Volume 11, Section 3, Part 1 Air Quality', June 2013

concentrations to describe the impacts at a receptor, these are presented in Table 3-A.

Where the difference in concentrations are less than 1% of the AQO e.g. less than 0.4 µg/m³ for annual average $NO_2$ or $PM_{10}$, then the change at these receptors is considered to be imperceptible, and they can be scoped out of the judgement on significance.

| Magnitude of Impact Band | Change in $NO_2$ or $PM_{10}$ Concentration (µg/m³) |
|---|---|
| Large | >4 |
| Medium | >2 to 4 |
| Small | >0.4 to 2 |
| Imperceptible | <=0.4 |

***Table 3-A Magnitude of Impact Bands***

As specified in IAN 174/13, the overall judgement of potential air quality effects considers:

- the local air quality impacts compared to the UK AQOs;
- the impacts at Designated Habitats sites; and
- the Compliance Risk Assessment test (IAN 175/13) compared to EU Limit Values.

## 3.6 Robustness of Model Predictions

The prediction of air quality concentrations in distant future years contains inherent uncertainty, both in traffic model projections and also trends in vehicle emissions.

The approach to assessment and use of DMRB model provides a high level prediction of impacts suitable for route options appraisal.

Model predictions at locations where the influence of other road sources is insignificant can be considered robust. Here, the model is built using the standard DMRB methodology, and all appropriate road contributions are captured within the modelling process. The model adjustment and verification process indicates that model performance is good.

The model has not been constructed to provide detailed predictions in the vicinity of junctions. Contributing links are excluded because they are not considered robust for inclusion by the AECOM traffic team and because of the approach applied to the air quality modelling. Therefore, model predictions at road junctions, particularly at motorway junctions or merges, should be treated with caution.

# 4 Baseline Conditions

## 4.1 Introduction

In order to provide an assessment of the impact of any road scheme in terms of air quality, it is necessary to identify and understand the baseline conditions where the option (a future scheme) would be implemented, and the surrounding area. This provides a reference level against which any potential changes in air quality can be assessed.

Since the baseline air quality is predicted to change in the future (mainly because vehicle emissions are changing), the baseline situation is extrapolated forward to the opening year, and so the Do Minimum (DM) scenario is the predicted baseline for the opening year. The Do Something (DS) scenario is the same as the DM, but also includes the proposed scheme. The base year used for this purpose is 2009.

## 4.2 Local Air Quality Management

Local authorities are required to undertake regular reviews of air quality within their regions, and to assess their compliance with the AQS Objectives.

Option A and Option A+ are located within the area governed by Dartford Borough Council and Thurrock Council, whilst Option C and Option C2 is in the area governed by Gravesham Borough Council, Thurrock Council and the London Borough of Havering.

However, the air quality impacts would extend along the wider road network affected by a future scheme and therefore includes local authority areas that lie beyond this. The baseline assessment includes a brief review and summary of the Local Air Quality Management (LAQM) reports, and monitoring data has been obtained directly from the relevant local authorities..

A summary of the most recent LAQM reports obtained is provided in Table 4-A. The location of the AQMAs are shown in Figure 1.

| Local Authority | LAQM Report | Year | Conclusion Summary |
|---|---|---|---|
| Brentwood Borough Council | Progress Report | 2010 | The review of 2009 monitoring data identified 9 monitoring locations exceeding the annual mean Objective for $NO_2$. 8 sites are within the AQMA. The remaining site (High street traffic island) was considered to be unrepresentative of relevant exposure and is no longer in use. Monitoring at the Junction of High Street and Kings Road will be continued. |
| Bexley Council | Updating and Screening Assessment | 2012 | A Borough wide AQMA was declared in 2007 for Annual mean $NO_2$ and $PM_{10}$, and for daily $PM_{10}$ at Manor Road AQMA. Subsequent USAs have shown no change to the AQMA extent. |
| Dartford Borough Council | Progress Report | 2011 | The Borough has declared four AQMAs where exceedences of annual mean $NO_2$ and $PM_{10}$ are measured. Monitoring has been extended around the AQMAs to check the extent is sufficient. 2012 results showed no exceedence beyond the AQMA boundary, the decision is deferred and monitoring continued. |
| Gravesham Borough Council | Updating and Screening Assessment | 2012 | The borough has declared seven AQMAs. No exceedences for annual mean $NO_2$ outside of the AQMAs has occurred. Recent changes to the A2 alignment have resulted in a reduction in $NO_2$ concentrations. The extent of the AQMA is in the process of being revised following the results of the further assessment 2011. |
| Greenwich | Updating and Screening Assessment | 2012 | A borough wide AQMA for annual mean $NO_2$ and $PM_{10}$ remains unchanged in this assessment. |
| Maidstone | Kent and Medway Air Quality Monitoring Network | 2012 | The Borough has declared an urban wide AQMA to include the six areas around the town, which exceed annual mean $NO_2$ objectives. |
| Sevenoaks | Progress Report | 2011 | The District has declared 11 AQMAs for annual mean $NO_2$ and is currently undertaking two further detailed assessments. Likely exceedences of the 1-hour $NO_2$ objective have been identified and a decision to extend and amalgamate the existing AQMAs into one corridor is being considered. |
| Thurrock Council | Progress Report | 2010 | The council has declared 23 AQMAs for annual mean NO2 and daily mean $PM_{10}$. There is no change to these to date. |
| Tonbridge and Malling Borough Council | Kent and Medway Air Quality Monitoring Network | 2012 | The Borough has declared seven AQMAs. The most recent was declared in 2013. There have been no new exceedences identified and a detailed assessment is underway of Borough Green AQMA. Objectives have been met at Ditton AQMA in recent years and consideration to revoke the AQMA is under discussion. Further monitoring at Wateringbury AQMA is being undertaken for potential 1-hour mean objective exceedences. |

***Table 4-A    Summary of LAQM Reports for Local Authorities within the Air Quality Study***

Air quality monitoring data collated for the options is presented in Appendix A, and presented in Figure 2.

## 4.3 Designated Habitats

There are a number of Designated Habitats sites in the air quality study area. Where the annual mean concentration of NOx exceeds the AQS objectives for vegetation and ecosystems (30 $\mu g/m^3$), and the change in concentration is greater than imperceptible (i.e. >0.4 $\mu g/m^3$) then the impact of nitrogen deposition has also been calculated.

Table 4-B presents the habitat Critical Loads and background deposition rates and NOx concentrations for each Designated Site. Exceedence of the AQS objective or lower threshold of the Critical Load is shown in bold. The location of these Designated Sites is shown in Figure 6.

The baseline deposition data is published by APIS for the average of years 2009-2011. This has been used for the Base and Future year scenarios.

| Designated Site | Habitat Type | Background NOx Concentration ($\mu g/m^3$) | Critical Load Lower Threshold (KgN/ha/yr) | Background Deposition Rate (KgN/ha/yr) |
|---|---|---|---|---|
| Darenth Wood SSSI | Broadleaved and Mixed Woodland | **32.7** | 5 | **35.42** |
| Curtismill Green SSSI | Broadleaved and Mixed Woodland | 27.6 | 5 | **38.08** |
| Cobham Woods SSSI | Broadleaved and mixed Woodlands | 24.2 | 5 | **39.34** |
| Inner Thames Marshes SSSI | Neutral grassland lowland | 29.3 | 20 | **27.30** |
| Oxleas Woodlands SSSI | Broadleaved and Mixed Woodlands | **37.7** | 5 | **32.90** |
| Queendown Warren SSSI | Broadleaved and Mixed Woodlands | 23.2 | 5 | **37.66** |
| Shorne & Ashenbank Woods SSSI south | Broadleaved and Mixed Woodlands | 24.0 | 5 | **34.16** |
| Shorne & Ashenbank Woods SSSI east | Broadleaved and Mixed Woodlands | 15.0 | 5 | **34.16** |
| South Thames Estuary & Marshes Ramsar SSSI | Neutral grassland lowland | 24.5 | 20 | 18.06 |
| Thorndon Park SSSI | Broadleaved and Mixed Woodlands | 24.4 | 5 | **40.18** |
| Westerham Wood SSSI | Broadleaved and Mixed Woodlands | 22.0 | 5 | **39.34** |
| Titsey Woods SSSI | Broadleaved and Mixed Woodlands | 21.4 | 5 | **39.34** |
| Vange & Fobbing Marshes SSSI | Fens and Marshes | 24.8 | 10 | **29.26** |
| Wouldham to Detling Escarpment SSSI | Broadleaved and mixed woodlands | 23.2 | 5 | **39.20** |
| Woldingham & Oxted Downs SSSI | Broadleaved and mixed woodlands | 22.5 | 5 | **39.62** |
| North Downs Woodlands SAC | Taxus baccata woods | 24.9 | 5 | **38.78** |

***Table 4-B Assessed Designated Habitat Sites and Critical Loads***

The accumulation of organic nitrogen occurs when inputs into the soil exceed the rate at which soil micro-organisms can mineralize the organic nitrogen input. The build-up of an organic nitrogen pool is essential for a development of an ecosystem. The rate at which nutrients are then made available for plant uptake, by mineralization processes, is essential for ecosystem functioning and different Designated Habitats have different available nitrogen requirements.

The Critical Load is exceeded by the background deposition rate at all of the assessed Designated Habitats sites, with the exception of the South Thames Estuary and Marshes Ramsar SSSI. The background NOx concentrations exceed the AQS objective at Darenth Wood SSSI and Oxleas Woodlands SSSI. All Designated Habitats sites where the background deposition Critical Loads are exceeded will have eutrophication issues without the crossing and potential changes to their plant community structure.

Available nitrogen is a limiting factor for species and communities and therefore the distribution and abundance of plant species and communities can vary with concentrations of available mineral nitrogen which is why the Critical Loads from the scheme in context of background deposition and the species composition of the habitats are relevant to understanding the scheme's implications. Atmospheric nitrogen inputs into ecosystems can affect plant species present, plant community composition as well as biomass of populations within Designated Habitat sites.

Plant available nitrogen is influenced by a range of edaphic parameters such as leaching rate, plant uptake, microbial activity and soil pH, so the extrapolation of changes to Designated Habitat sites is complex to predict. However, anthropogenic nitrogen inputs into ecosystems artificially change the ecosystem nutrient cycling functions and nitrogen available to plants on a temporal scale. Excess nitrogen can be toxic or give competitive advantages to other non-limited species which then preclude and alter the plant community. Where background deposition exceed Critical Loads for Designated Habitat sites adapted for nitrogen limited systems, these changes will already be influencing the plant community structure.

# 5 Model Results

## 5.1 Local Air Quality

The 2025 opening year model results are presented in Appendix C for each scenario. The results show the modelled $NO_2$ and $PM_{10}$ concentrations, and the change due to each option (i.e. the difference between DM and DS scenarios).

The results for the 10m distance band for Option A, Option A+ and Option C are shown in Figure 3, Figure 4 and Figure 5, respectively. Option C2 is not considered likely to have materially different traffic data to Option C. To date C2 has only been scoped, costed and assessed for it's likely major impacts. It has not been explicitly modelled for this air quality assessment, and therefore there is not an associated figure. Concentrations and change due to the scheme at the 20m, 50m and 100m distance bands are lower than the 10m distance band results for each link and have therefore not been presented.

The maximum modelled concentration of $PM_{10}$ at any location in either the DM or DS scenarios is 28.4 $\mu g/m^3$. This is less than the annual mean (40 $\mu g/m^3$) and the equivalent 24 hour mean (32.4 $\mu g/m^3$) AQOs. Therefore, there are not predicted to be any significant $PM_{10}$ impacts for any scenario.

### Option A

The model results indicate that there will be medium magnitude increases in concentration and exceedence of the $NO_2$ annual mean AQO at the Dartford Crossing 10m distance band (Link 4: +2.2 $\mu g/m^3$). Small magnitude increases and exceedence of the $NO_2$ annual mean AQO occur along the M25 J28-31 (Link 2: +1.1 $\mu g/m^3$ & Link 3: +1.0 $\mu g/m^3$) and M25 J1a-2 (Link 5: +0.9 $\mu g/m^3$).

Air quality concentrations decrease rapidly with increased distance from the road source. In the 20m distance band, only the Dartford Crossing and M25 J30-31 is predicted to exceed the $NO_2$ annual mean AQO. In these locations, small magnitude increases in concentration are predicted to occur.

All predicted changes to $NO_2$ on the wider road network are considered imperceptible (<=0.4 $\mu g/m^3$), and there are no areas of improvements in air quality.

The increase in air quality concentrations is caused by additional traffic at the Dartford Crossing and adjacent sections of the M25, which would be attracted by a potential future scheme. Total AADT traffic flows at the Dartford Crossing are predicted to increase by ~13,000 veh/day, whilst on the M25 one junction beyond the crossing (i.e. M25 J30-31 and M25 J1a-1b (Link 5)), vehicle flows increase by ~4,000 veh/day.

The area north of the River Thames is predominantly industrial, and there are no residential properties along the M25 mainline within 20m. However, there are three sections of the Thurrock AQMA declared for hotels (one east of the Dartford Crossing and two at M25 J31) which could be adversely affected by a potential future scheme.

The area south of the River Thames bordering the M25 J1a-2 is heavily populated in close proximity to the M25. Because there are exceedences of the $NO_2$ annual mean AQO predicted in 2025, and an increase in concentration due to a potential future scheme, this area could be adversely affected by a potential future scheme.

## Option A+

The changes to the Option A traffic data to represent Option A+ were applied to the A282 Dartford Crossing and the M25 J1a-1b. The wider study area is identical to Option A.

The model results indicate that there will be medium magnitude increases in concentration and exceedence of the $NO_2$ annual mean AQO at the Dartford Crossing 10m distance band (Link 4: +2.7 µg/m$^3$). Small magnitude increases and exceedence of the $NO_2$ annual mean AQO occur along the M25 J1a-1b (Link 5: +1.4 µg/m$^3$).

The increases due to Option A+ only differ from Option A at Link 4 & 5. At both of the links, the Option A+ scenario worsening is 0.5 µg/m$^3$ greater than for Option A, as a result of increased traffic flow along the M25 and A282.

## Option C

There are no exceedences of AQOs predicted along the new sections of road that are assumed for Option C (Link 25 & 26) for any distance band.

There is predicted to be a medium magnitude increase between the new junction of Option C with the M25 and M25 J29 (Link 2: +2.6 µg/m$^3$), where traffic flows increase by ~12,000 veh/day. Small magnitude increases in annual mean $NO_2$ concentrations occur on the M25 further north of the Option C junction between M25 J28-J29 (Link 1: +1.3 µg/m$^3$) in the 10m distance band. These sections of the M25 are predicted to be in exceedence of the $NO_2$ annual mean AQO for the 10m distance band, but not for the 20m distance band. There are no properties within 20m of the motorway in these areas.

Large magnitude benefits are predicted on the A2 linking the M25 and M2 (Link 14: -4.1 µg/m$^3$ & Link 15: -5.9 µg/m$^3$) which experience a reduction in flow of ~14,000 and 21,000 veh/day, respectively, at Gravesend.

Large magnitude benefits also predicted to occur on the M25 between the new Option C junction and M25 J2 (Link 3: -3.5 µg/m$^3$, Link 4: -3.4 µg/m$^3$ & Link 5: -3.5 µg/m$^3$) which experience a reduction in flow of ~12,000, ~13,000 and 17,000 veh/day, respectively. All of these sections of road are predicted to be in exceedence of the $NO_2$ annual mean AQO. There are few properties within 10m of the A2, which are in the Gravesham 2 AQMA.

The area south of the River Thames bordering the M25 J1a-2 is heavily populated in close proximity to the M25. Because there are exceedences of the $NO_2$ annual mean AQO predicted in 2025, a decrease in concentration due to a potential future scheme would beneficially affect this area.

## Option C2

The main difference in the impacts between Option C and Option C2 are associated with the length of tunnel and where the southern end of Option C (Link 26) is assumed to join the A2 (Link15). Option C2 comprises a longer tunnel, emerging beyond the designated Ramsar/SSSI, deviates to the west of the Option C alignment north of Shorne and passes through the hamlet of Thong. There are no exceedences of AQOs predicted along the new sections of road built for Option C2 (Link 26) for any distance band, so no exceedences are predicted for properties in Thong.

Traffic predicted to use the A2 to access Option C2 from the east would need to use Link 15. In Option C this link was part of the bypassed section of the A2, and showed a reduction in $NO_2$ concentrations. For Option C2 Link 15 would be expected to experience an increase in $NO_2$ concentrations, and would also be in exceedence of the $NO_2$ annual mean AQO. However, there are no properties located along this section the A2 and exceedence of the AQO would therefore not be relevant.

## 5.2 Designated Habitats

The designated sites included within the assessment are shown in Figure 6. The modelled results for the Designated Habitats sites are presented in Appendix D.

### Option A & Option A+

The model results for Option A and Option A+ are identical at all assessed Designated Habitat sites. The results indicate that Option A or Option A+ could have a potential impact at the Darenth Wood SSSI and Shorne & Ashenbank Woods SSSI, which are in exceedence of the NOx AQS objective (30 $\mu g/m^3$) and increase in by 0.9 $\mu g/m^3$ and 0.5 $\mu g/m^3$, respectively in both Options.

The change in nitrogen deposition rate due to a potential future scheme at these Designated Habitat sites is less than 1% of the relevant Critical Load, and therefore considered insignificant.

### Option C

The results indicate that Option C could have a potential adverse impact at the Cobham Woods SSSI, Inner Thames Marshes SSSI, South Thames Estuary & Marshes Ramsar SSSI, the east side of Shorne and Ashenbank Woods SSSI, Vange & Fobbing Marshes SSSI and the Wouldham to Detling Escarpment SSSI. These Designated Sites are predicted to be in exceedence of the NOx AQS objective (30 $\mu g/m^3$) with a potential future Option C scheme at. The results further indicate that Cobham Woods could experience an increase of 8.1 $\mu g/m^3$, whilst the South Thames Estuary & Marshes Ramsar SSSI could increase by 16.9 $\mu/m^3$ and the east side of Shorne and Ashenbank Woods SSSI by 22.3 $\mu/m^3$.

There are predicted increases in nitrogen deposition rate of greater than 1% of the Critical Load at the east side of Shorne and Ashenbank Woods SSSI, the Cobham Woods SSSI, and Wouldham to Detling Escarpment SSSI. It is, however, not straight-forward to predict the effects of changes due to the differing soil types. The acid soil and community composition at the Cobham Woods SSSI and the acid soil conditions indicated by the ground flora characteristic with many species typical of acid soils of Shorne and Ashenbank Woods SSSI might limit the effect due to the mobility of nitrogen through such soils. The buffering ability of chalk based soils can mean nitrogen is not mobile and is less available to plants, so the increases in nitrogen may not influence plant communities.

Changes of greater than 1% of the Critical Load are predicted at the South Thames Estuary & Marshes Ramsar SSSI, however the Critical Load is not exceeded in either scenario.

It should be noted that if a potential future tunnel would emerge south of the South Thames Estuary Ramsar SSSI there would be no impact at this Designated Site, except at potential ventilation points.

The results indicate that Option C could have a potential beneficial impact at the Darenth Wood SSSI, Oxleas Woodlands SSSI and the south side of Shorne & Ashenbank Woods SSSI which are predicted to be in exceedence of the NOx AQO. Darenth Wood SSSI is predicted to reduce by 12.0 $\mu g/m^3$, whilst Shorne & Ashenbank Woods SSSI is predicted to reduce by 14.3 $\mu g/m^3$. Both of these sites would experience decreases in nitrogen deposition rate of greater than 1% of the Critical Load.

## Option C2

The only Designated Habitat which would be affected by the change in route alignment between Option C and Option C2 is the Shorne and Ashenbank Woods SSSI.

In Option C2, the new road would no longer pass through the east side of Shorne and Ashenbank Woods SSSI, and there would be no adverse impact in this location. However, traffic accessing Option C2 from the east would need to use the existing A2 (Link 15) which passes through the south side of Shorne and Ashenbank Woods SSSI. Therefore, whilst an improvement in nitrogen deposition was predicted here for Option C, there would be a worsening for Option C2.

This scenario has not been modelled for the air quality assessment, as the option has only been scoped for it’s likely major impacts. Therefore, because air quality modelling has not been undertaken quantification of the impacts is not possible. However, it is also noted that unlike Option C, there would be no land take from the Shorne and Ashenbank Woods SSSI for Option C2.

# 6 Conclusions

An air quality assessment has been undertaken into the construction of a new crossing at the alternate location options.

The assessment is based on available information to obtain an indication of the scale of any potential air quality impacts of the new crossing and associated link roads. The model method and traffic data used in this assessment are suitable for assessing relative air quality risk when comparing the options.

## 6.1 Summary of Air Quality Effects

The overall judgement of potential air quality effects considers:

- the local air quality impacts compared to the UK AQOs;
- the impacts at Designated Habitats sites; and
- the Compliance Risk Assessment test (IAN 175/13) compared to EU Limit Values.

The results indicate that overall Option A and Option A+ could lead to adverse air quality effects, based on local air quality impacts to human health receptors.

Conversely the results indicate that overall Option C and Option C2 could lead to beneficial air quality effects. The local air quality impact to human health receptors is the primary reason.

A summary of each aspect informing the overall judgement is provided below.

### 6.1.1 Local Air Quality

The results indicate that overall Option A and Option A+ could lead to adverse air quality effects (primarily at the M25 J1a-2), based on local air quality impact to human health receptors. Option A+ could lead to marginally greater impacts than Option A.

Conversely the results indicate that overall Option C and Option C2 could lead to beneficial air quality effects, again primarily at the M25 J1a-2.

### 6.1.2 Designated Habitats Assessment

The results indicate that Option A and Option A+ could have a potential adverse impact at two Designated Habitat sites for NOx concentrations, but the change in nitrogen deposition rate due to the scheme at these Designated Habitat sites is less than 1% of the relevant Critical Load.

The results indicate that Option C and Option C2 could have a potential adverse impact for both NOx concentrations and nitrogen deposition, most notably at the Shorne and Ashenbank Woods SSSI, Cobham Woods SSSI and the South Thames Estuary & Marshes Ramsar SSSI.

However, if a tunnel structure could emerge south of the South Thames Estuary Ramsar SSSI, there would be no impact at this Designated Site, except at potential ventilation vents which would need to be assessed as part of any future detailed environmental assessments.

The results indicate that Option C could also have a potential beneficial impact, particularly at the Darenth Wood SSSI and the south side of Shorne & Ashenbank Woods SSSI, although as the background levels of depositions are so high this may be a negligible effect.

On balance, the impacts at the Designated Habitat sites are considered to be neutral if Option C is a tunnel which emerges south of the South Thames Estuary & Marshes Ramsar SSSI. However, if Option C is a bridge, then the susceptibility of the South Thames Estuary & Marshes SSSI and the large increase in nitrogen predicted to occur, means that the air quality effects on Designated Habitat sites are not a differentiator between Options A and C.

## 6.2 Summary of the Compliance Risk Assessment

The study area for this assessment contains a number of roads which form part of Defra's assessment for the European Commission on the status of air quality in the UK. Defra's Pollution Climate Mapping (PCM) model dataset has been reviewed to determine whether the scheme may effect non-compliance with the EU directive on Ambient Air Quality.

The values reported by Defra based on the PCM model are all below the EU limit values for the Compliance Risk Road Network in 2025, and the impact of any scheme options is unlikely to lead to increases in concentrations sufficient to alter these conclusions.

The Compliance Risk Assessment has therefore identified that potential future schemes at any of the Options  have a low risk of being non-compliant with the EU Directive on Ambient Air Quality.

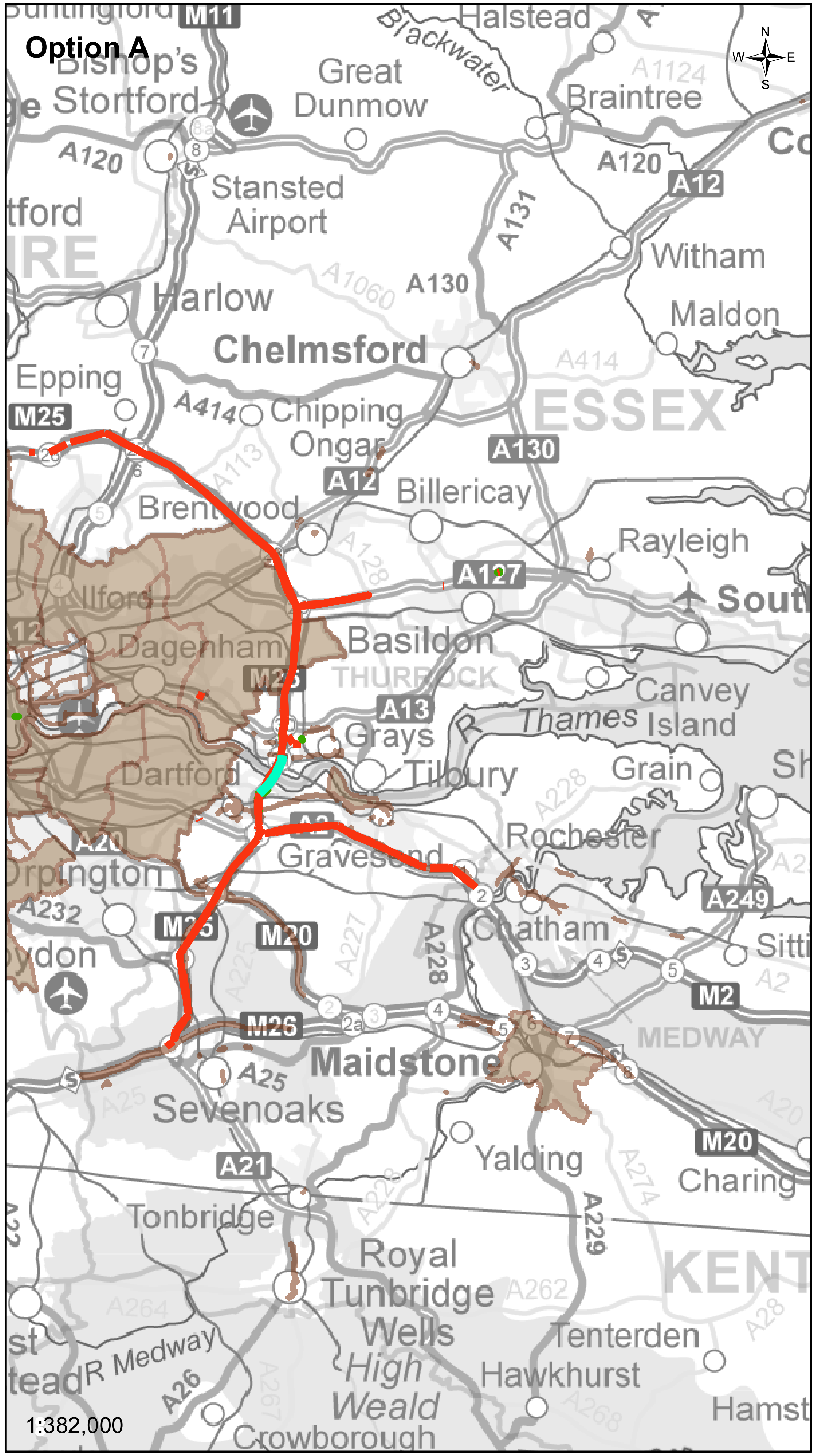
## 6.3 Recommendations

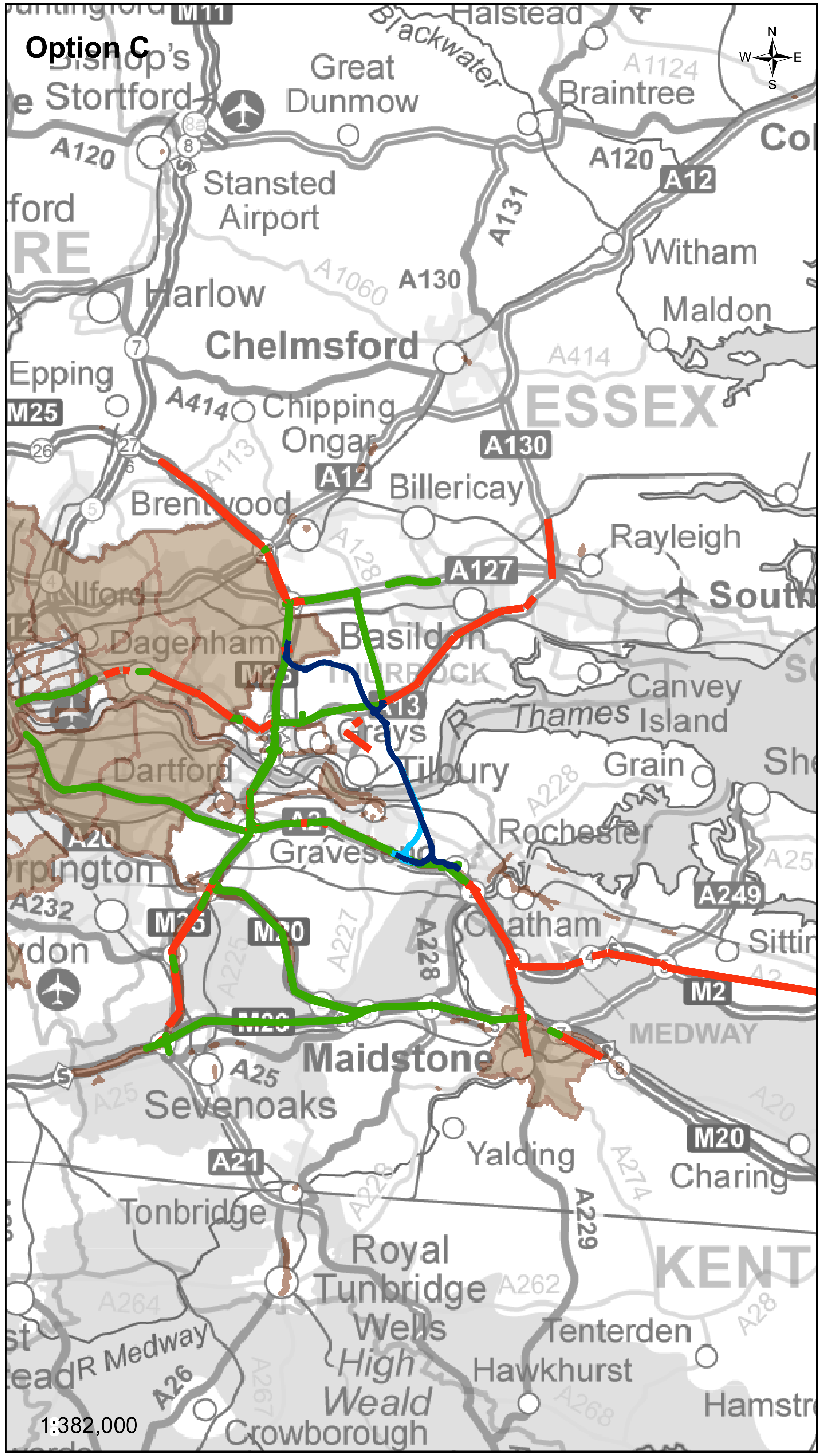
A programme of air quality monitoring should be considered to provide additional information for future phases of assessment. This should focus on $NO_2$ in the main areas of potential impact plus the new Option C route. These are principally the:

- M25 J1a-2
- A282 Dartford Crossing
- M25 J28-31
- A2/M2 junction at Gravesham
- Option C corridor

This monitoring should be put in place to collect information both on annual mean concentrations at specific locations, but also to establish long term trends in $NO_2$. This assessment in based on the published Gap Factors in HA IAN 170/12v3, and the performance of these projections factors could alter the conclusions of this assessment, particularly if trends are found to deviate from 2015 onwards when Euro 6/VI vehicles begin to enter the fleet.

# FIGURE 1




**Legend**

**Air Quality DMRB Study Area**

**Qualifying Links**

- Increase in Traffic Flow
- Decrease in Traffic Flow
- **Air Quality Management Areas**

- **Scheme Option A**
- **Scheme Option C**
- **Scheme Option C2**



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| 0 | JAN14 | Initial Issue | ALS | NJB | NJB | DC |

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Drawing Title

Air Quality Assessment
Constraints Plan

Drawing Status

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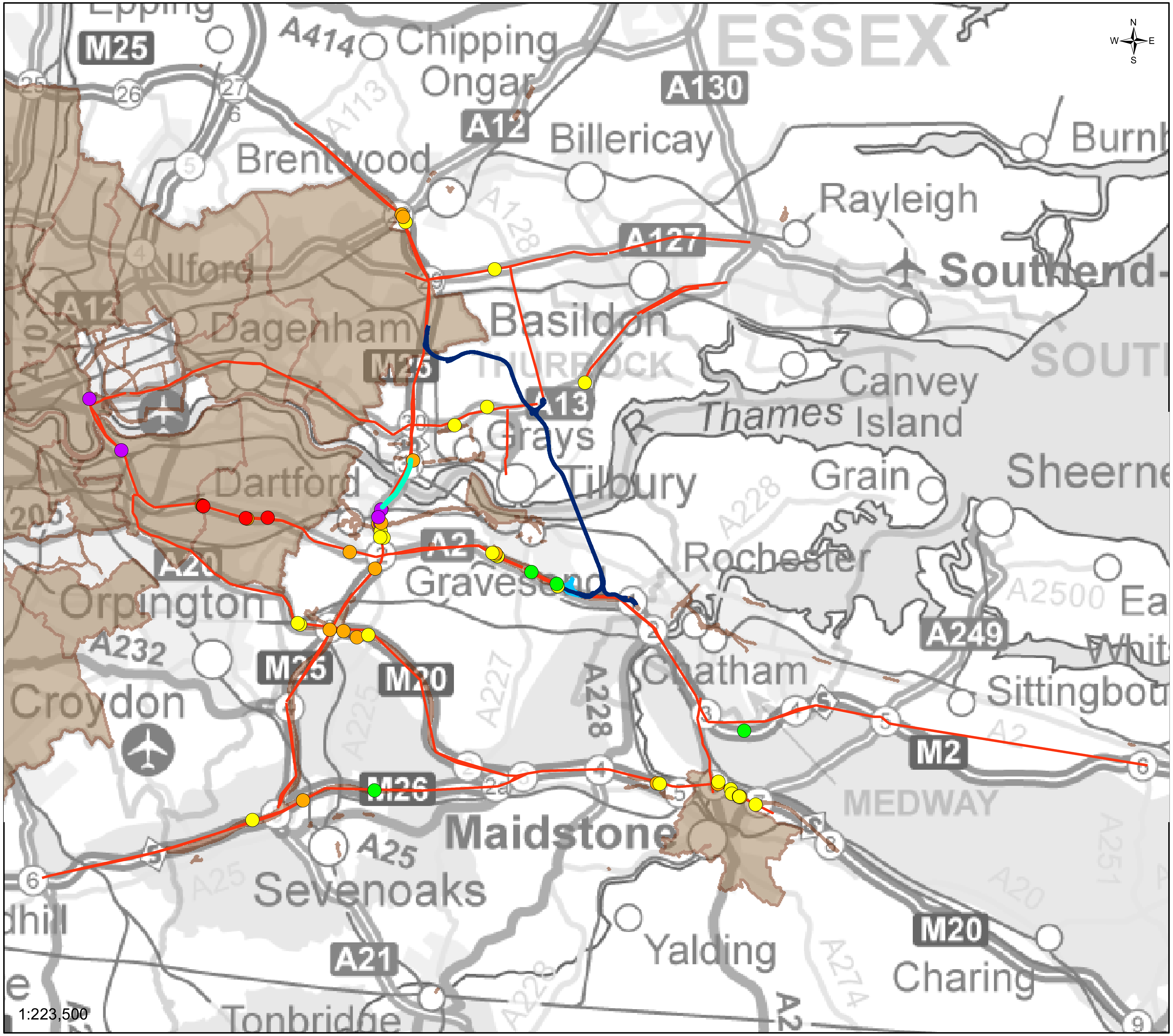
| Client No. | |
| Drawing No. | B1962800_LTC_AQ_Figure1 |

# FIGURE 2




**Legend**

**Local Authority or Highways Agency Monitoring Data**

**2009 Annual $NO_2$ Concentration (ug/m$^3$)**

- 20 to 30
- 30 to 40
- 40 to 50
- 50 to 60
- 60+
- Air Quality Study Area
- **Air Quality Management Areas**

- Scheme Option A
- Scheme Option C
- Scheme Option C2



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Drawing Title: Air Quality Assessment
Local Authority and Highways Agency
Monitoring Data and Study Area

Drawing Status: **FINAL**

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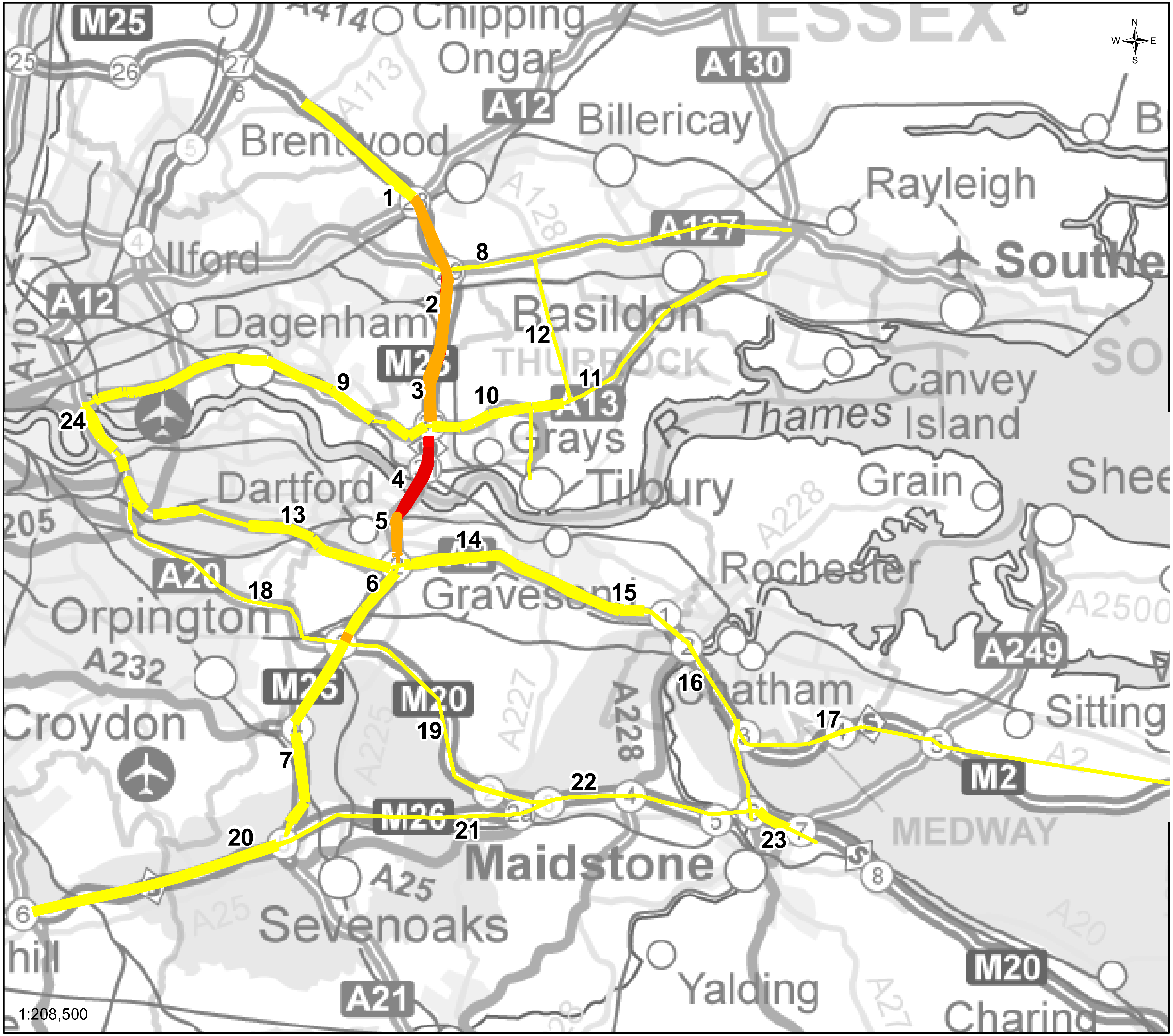


# FIGURE 3

**Legend**

**Change in $NO_2$ Concentration for Option A ($ug/m^3$)**

- > -4.1
- -2.1 to -4
- -1.2 to -2
- -0.5 to -1
- -0.4 to +0.4
- +0.5 to +1
- +1.2 to 2
- +2.1 to +4
- > +4.1

**Thick Links = Links in Exceedance**

**Thin Links = Links not in Exceedance**

**12 Report Link I.D**



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Drawing Title

Air Quality Assessment
Change In Annual Mean $NO_2$ Concentrations
Option A (2025)

Drawing Status

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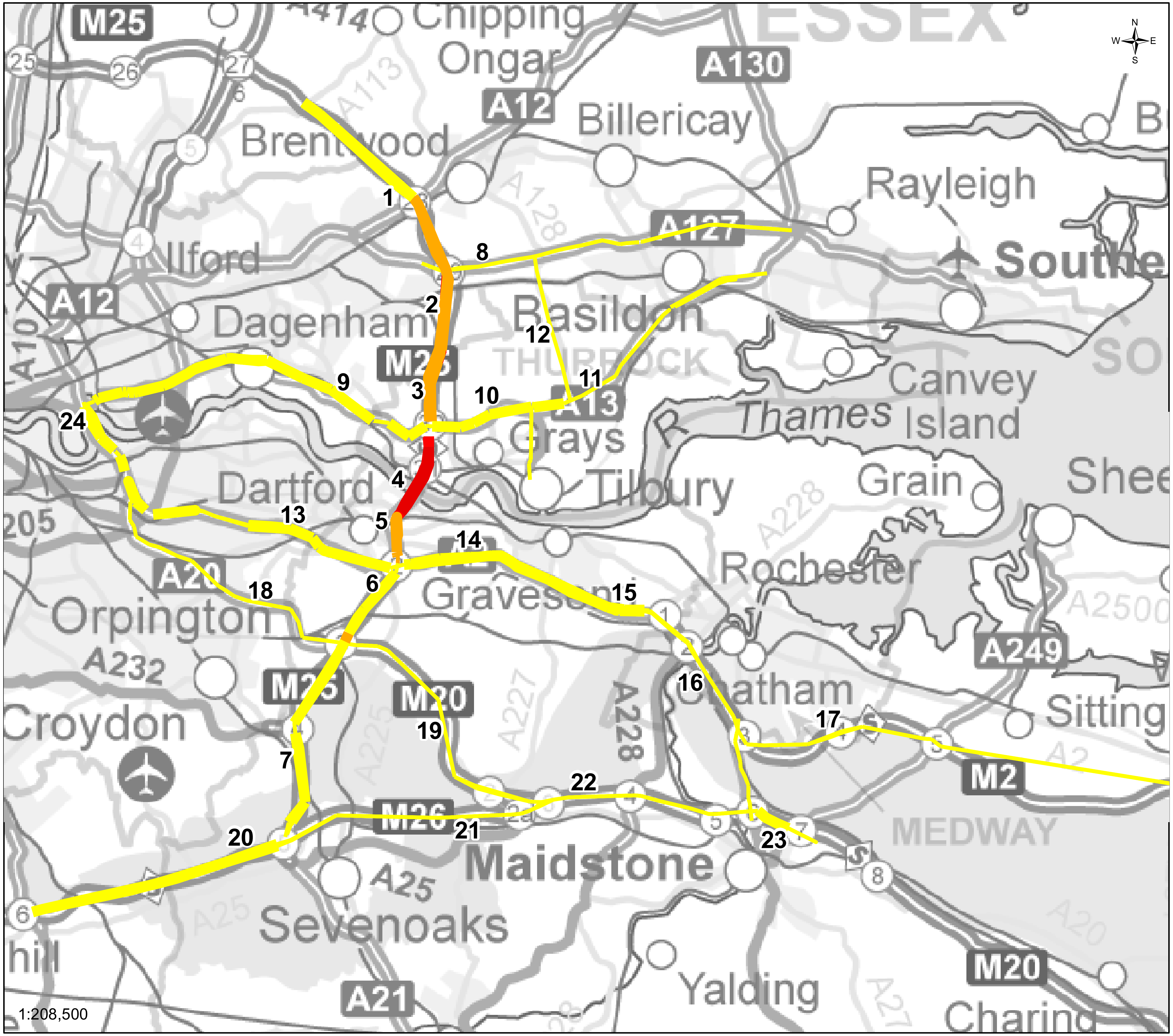


# FIGURE 4

**Legend**

**Change in $NO_2$ Concentration for Option A (ug/m$^3$)**

- > -4.1
- -2.1 to -4
- -1.2 to -2
- -0.5 to -1
- -0.4 to +0.4
- +0.5 to +1
- +1.2 to 2
- +2.1 to +4
- > +4.1

**Thick Links = Links in Exceedance**

**Thin Links = Links not in Exceedance**

**12 Report Link I.D**



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Drawing Title

Air Quality Assessment
Change In Annual Mean $NO_2$ Concentrations
Option A+ (2025)

Drawing Status

**FINAL**

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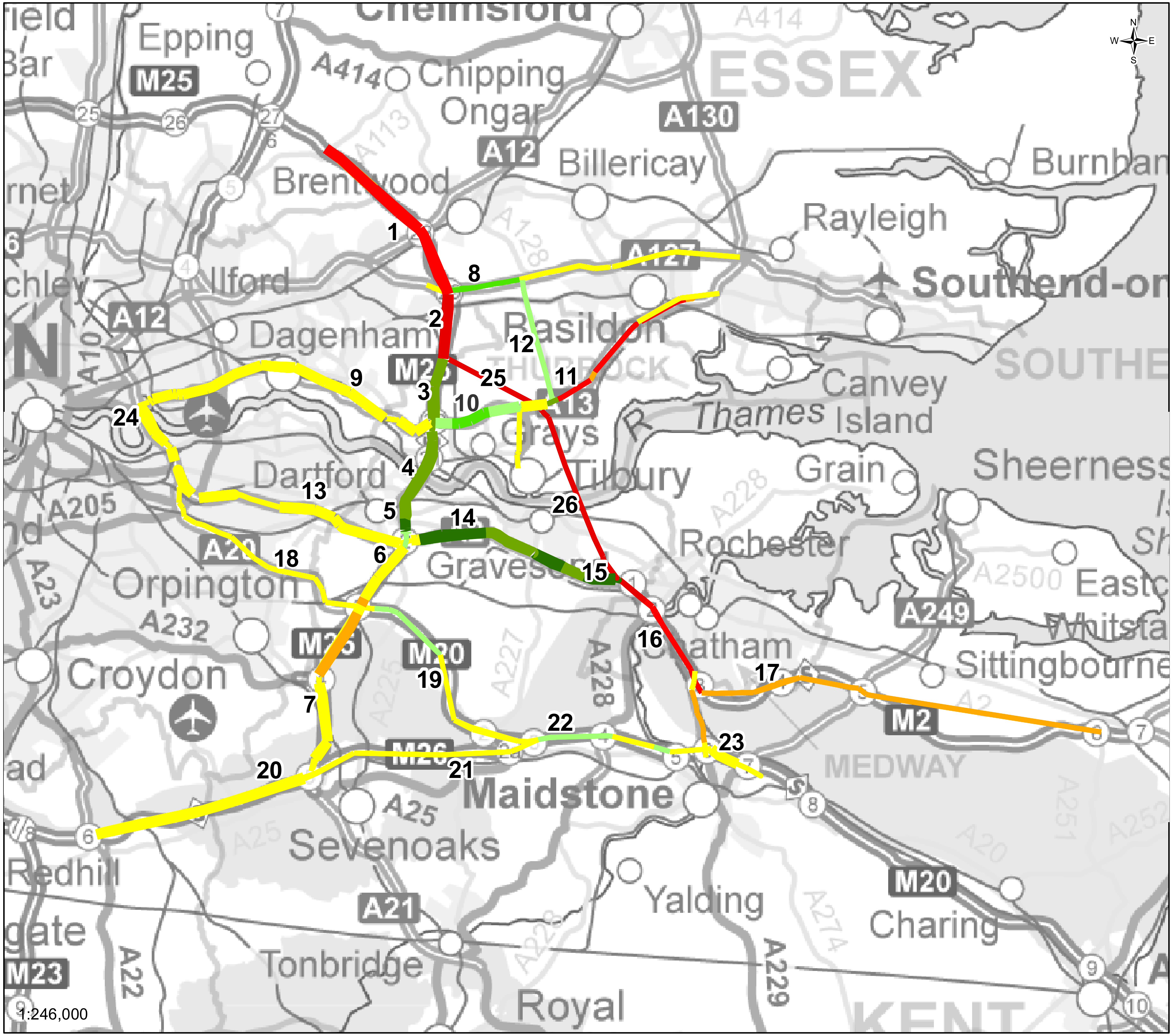
**B1962800_LTC_AQ_Figure 4**

# FIGURE 5




**Legend**

**Change in NO₂ Concentration for Option C**

- > -4.1
- -2.1 to 4
- -1.2 to -2
- -0.5 to -1
- -0.4 to +0.4
- +0.5 to +1
- +1.2 to +2
- +2.1 to +4
- > +4.1

**Thick link lines = links in exceedance.**
**Thin link lines = links not in exceedance.**

**12 Report Link I.D**



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Drawing Title
Air Quality Assessment
Change in Annual Mean $NO_2$ Concentrations
Option C (2025)

Drawing Status
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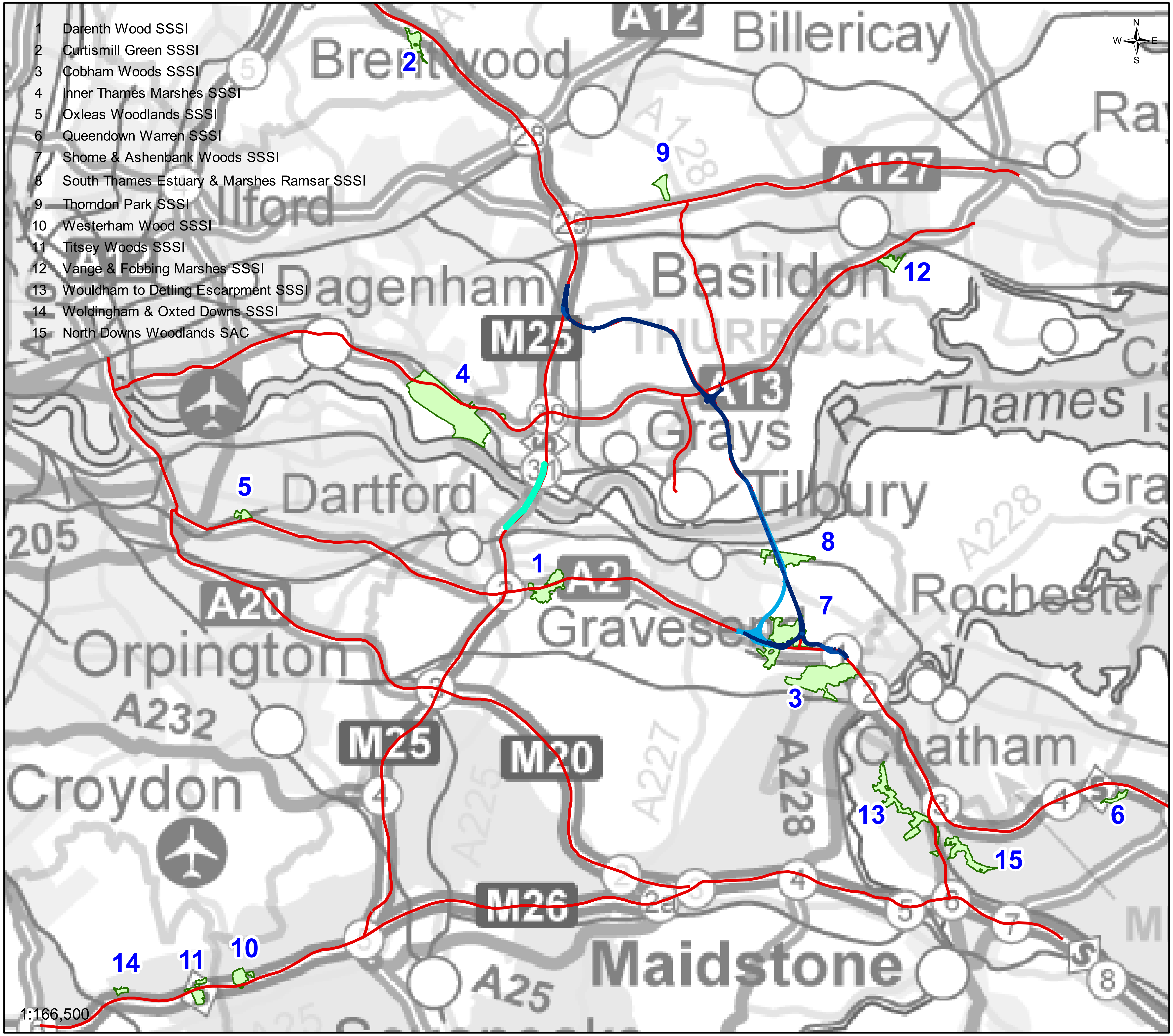
# FIGURE 6




**Legend**

- Air Quality Study Area
- Designated Habitat Sites
- **Scheme Option A**
- **Scheme Option C**
- **Scheme Option C2**
- **12 Designated Site I.D**

**SAC = Special Area of Conservation**
**SSSI = Site of Specific Scientific Interest**



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Drawing Title: Air Quality Assessment
Designated Habitat Sites within 200m of Air Quality Study Area

Drawing Status: **FINAL**

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Drawing No. **B1962800_LTC_AQ_Figure 6**

# Appendix A Traffic Data Summary

A summary of the traffic data used in the assessment is provided in Table A-A. These data are the total 2-way flows on the representative road links identified in Figure 3, Figure 4 and Figure 5.

| Report Link ID | DM Flow | Option A Flow | Option A+ Flow | Option C Flow | Option A Flow Change (DS A DM) | Option A+ Flow Change (DS A+ DM) | Option C Flow Change (DS C DM) |
|---|---|---|---|---|---|---|---|
| 1 | 122,100 | 124,668 | 124,668 | 127,287 | 2,567 | 2,567 | 5,187 |
| 2 | 105,807 | 111,717 | 111,717 | 118,314 | 5,910 | 5,910 | 12,507 |
| 3 | 105,807 | 111,717 | 111,717 | 93,212 | 5,910 | 5,910 | -12,596 |
| 4 | 116,341 | 129,065 | 131,699 | 102,342 | 12,724 | 15,358 | -13,999 |
| 5 | 132,536 | 136,302 | 139,084 | 116,008 | 3,766 | 6,547 | -16,528 |
| 6 | 123,174 | 125,631 | 125,631 | 123,723 | 2,458 | 2,458 | 550 |
| 7 | 99,820 | 101,466 | 101,466 | 101,785 | 1,646 | 1,646 | 1,965 |
| 8 | 65,732 | 66,877 | 66,877 | 61,689 | 1,145 | 1,145 | -4,043 |
| 9 | 86,572 | 87,384 | 87,384 | 88,000 | 812 | 812 | 1,427 |
| 10 | 77,168 | 77,479 | 77,479 | 71,883 | 311 | 311 | -5,285 |
| 11 | 70,977 | 71,260 | 71,260 | 76,938 | 284 | 284 | 5,962 |
| 12 | 15,510 | 15,536 | 15,536 | 12,211 | 26 | 26 | -3,299 |
| 13 | 97,815 | 97,291 | 97,291 | 96,882 | -524 | -524 | -933 |
| 14 | 111,183 | 112,880 | 112,880 | 96,916 | 1,697 | 1,697 | -14,266 |
| 15 | 96,179 | 97,273 | 97,273 | 75,272 | 1,094 | 1,094 | -20,907 |
| 16 | 81,297 | 82,044 | 82,044 | 89,980 | 746 | 746 | 8,683 |
| 17 | 31,458 | 31,951 | 31,951 | 35,928 | 493 | 493 | 4,470 |
| 18 | 53,908 | 54,035 | 54,035 | 54,448 | 127 | 127 | 540 |
| 19 | 47,148 | 47,543 | 47,543 | 45,076 | 395 | 395 | -2,072 |
| 20 | 117,487 | 118,418 | 118,418 | 118,551 | 931 | 931 | 1,064 |
| 21 | 43,256 | 42,868 | 42,868 | 41,954 | -388 | -388 | -1,302 |
| 22 | 84,804 | 84,768 | 84,768 | 82,219 | -35 | -35 | -2,584 |
| 23 | 51,866 | 51,934 | 51,934 | 52,015 | 68 | 68 | 148 |
| 24 | 71,814 | 71,805 | 71,805 | 71,484 | -10 | -10 | -331 |
| 25 | - | - | | 29,814 | - | - | 29,814 |
| 26 | - | - | | 45,053 | - | - | 45,053 |

***Table A-A Traffic Data Summary (AADT flow – vehicles/day)***

Links 25 and 26 are the new Option C route, so these links do not exist in the DM or Option A scenarios.

# Appendix B Air Quality Monitoring Data and Model Verification

## Air Quality Monitoring Data

Air quality monitoring data held by the local authority and the HA within the study area has been collated and reviewed for use in the assessment. Table B-A presents the monitoring locations and the 2009 annual mean measurement data used in this assessment. The locations of the monitoring collated for the assessment is presented in Figure 2.

| ID | Location | Local Authority | Road Type | x | y | $NO_2$ Conc 2009 (µg/m$^3$) | Data Capture (%) |
|---|---|---|---|---|---|---|---|
| GRE_3 | Woolwich Flyover A102 | Greenwich | London Inner | 540200 | 178367 | 82.0 | 97 |
| THAM_5 | Blackwall A12 | Tower Hamlets | London Inner | 538290 | 181452 | 64.0 | 95 |
| MAID_8 | Maid 10 | Maidstone | Motorway | 575694 | 158499 | 40.8 | 100 |
| MAID_9 | Maid 11 | Maidstone | Motorway | 575718 | 158653 | 37.9 | 100 |
| MAID_10 | Maid 12 | Maidstone | Motorway | 576473 | 158198 | 35.2 | 67 |
| MAID_12 | Maid 14 | Maidstone | Motorway | 577018 | 157758 | 39.0 | 100 |
| MAID_21 | Maid 23 | Maidstone | Motorway | 577936 | 157271 | 37.7 | 100 |
| MAID_22 | Maid 24 | Maidstone | Motorway | 576536 | 157927 | 33.2 | 92 |
| MAID_36 | Maid 41 | Maidstone | Motorway | 576964 | 157781 | 51.2 | 92 |
| MAID_57 | Maid 63 | Maidstone | Motorway | 577037 | 157739 | 47.7 | 75 |
| MAID_58 | Maid 64 | Maidstone | Motorway | 577256 | 161695 | 26.4 | 42 |
| GR_200 | A2 Roadside Painters Ash School | Gravesham | Urban | 562589 | 172076 | 37.6 | 99 |
| GR_8 | Painters Ash School Northfleet (triplicate) | Gravesham | Urban | 562589 | 172076 | 37.0 | 100 |
| GR_64 | 2 Longview, Henhurst Road, Gravesend | Gravesham | Urban | 566155 | 170284 | 31.0 | 42 |
| GR_104 | 8 Roman Road (Downpipe), Northfleet | Gravesham | Urban | 562445 | 172169 | 39.0 | 100 |
| GR_106 | 36 Saxon Close, Northfleet | Gravesham | Urban | 562480 | 172234 | 47.0 | 100 |
| GR_109 | 30 Old Road East (Facade) | Gravesham | Urban | 562271 | 172279 | 36.0 | 100 |
| GR_108 | 77 Pepper Hill (Facade), Northfleet | Gravesham | Urban | 566104 | 170433 | 28.0 | 42 |
| THU_10 | Ibis Hotel (UB) | Thurrock | Motorway | 557570 | 177789 | 47.6 | 100 |
| THU_19 | Park Road (R) | Thurrock | Urban | 567781 | 182400 | 31.3 | 100 |
| THU_27 | William Edwards School (R) | Thurrock | Urban | 561958 | 180967 | 32.7 | 100 |
| SO_74 | 193 London Road Dunton Green | Sevenoaks | Motorway | 551007 | 157545 | 42.0 | 100 |

| ID | Location | Local Authority | Road Type | x | y | $NO_2$ Conc 2009 ($\mu g/m^3$) | Data Capture (%) |
|---|---|---|---|---|---|---|---|
| SO_13 | Wested Lane Swanley | Sevenoaks | Motorway | 552606 | 167692 | 44.6 | 100 |
| SO_81 | Farningham Hill Road Swanley | Sevenoaks | Motorway | 553416 | 167615 | 40.1 | 92 |
| SO_26 | Farningham | Sevenoaks | Motorway | 554217 | 167252 | 45.7 | 100 |
| DA_14 | Bow Arrow Lane | Dartford | Motorway | 555484 | 174441 | 67.0 | 100 |
| DA_20 | Eliot Road | Dartford | Motorway | 555660 | 174863 | 52.0 | na |
| DA_21 | Brentfield Road | Dartford | Motorway | 555497 | 174025 | 41.0 | 92 |
| DA_22 | Brent Way | Dartford | Motorway | 555605 | 174024 | 65.0 | 75 |
| DA_24 | Wayville Road | Dartford | Motorway | 555632 | 173558 | 40.0 | 83 |
| DA_25 | Queens Gardens | Dartford | Motorway | 555800 | 173194 | 40.0 | 92 |
| DA_44 | Brent Close | Dartford | Motorway | 555656 | 174053 | 47.0 | 100 |
| DA_48 | Hawley Road | Dartford | Motorway | 555297 | 171327 | 42.0 | 92 |
| DA_50 | A2/Bridge | Dartford | London Outer | 553785 | 172317 | 45.0 | 100 |
| DA_63 | Churchill Close | Dartford | Motorway | 555612 | 173210 | 34.0 | na |
| BEX_206 | Crown Woods Way | Bexley | London Outer | 544997 | 175098 | 44.9 | 100 |
| BEX_2 | Lamp post 4A15 o/s 983/5 East Rochester Way | Bexley | London Outer | 545038 | 175081 | 60.0 | na |
| BEX_3 | Lamp post 4A16 o/s 969/971 East Rochester Way | Bexley | London Outer | 545080 | 175067 | 54.0 | na |
| BEX_16 | 87 Woodside Lane bathroom down pipe | Bexley | London Outer | 547677 | 174328 | 43.0 | na |
| BEX_24 | Lamp post 4J4 East Rochester Way | Bexley | London Outer | 547608 | 174344 | 60.0 | na |
| BEX_66 | 22 Arundel Close Downpipe | Bexley | London Outer | 548905 | 174364 | 52.0 | na |
| BRW_04 | 73 Brook Street | Brentwood | Motorway | 556890 | 192435 | 44.9 | 100 |
| BRW_05 | Brook Street facing Brook Street roundabout | Brentwood | Motorway | 556887 | 192412 | 48.2 | 100 |
| BRW_07 | 13 Nags Head Lane | Brentwood | Motorway | 557118 | 191978 | 30.9 | 100 |
| BRW_32 | The Poplars, Brook Street | Brentwood | Motorway | 556958 | 192289 | 37.8 | 100 |
| BRW_39 | Thorndon Avenue | Brentwood | Urban | 562412 | 189153 | 39.4 | 100 |
| BRW_HA SRN 26 | Brook Street Roadside (M25/A12) | Brentwood | Motorway | 556888 | 192423 | 46.3 | 92 |
| BRW_HA SRN 27 | Poplars Farm, Brook Street | Brentwood | Motorway | 556961 | 192283 | 41.1 | 100 |
| DA_HA SRN 56 | End of Eliot Rd / Bow Arrow Lane | Dartford | Motorway | 555677 | 174867 | 63.4 | 100 |
| DA_HA SRN 57 | Slip Rd off A282 | Dartford | Motorway | 555483 | 174408 | 73.7 | 100 |
| GR_HA SRN 70 | Bembridge, Watling Street | Gravesham | Urban | 564610 | 171146 | 27.4 | 100 |
| MAID_HA SRN 97 | Amberleight - Harbourland Close | Maidstone | Motorway | 576981 | 157765 | 38.2 | 83 |
| SO_HA SRN 156 | Heather End, Swanley (A20) | Sevenoaks | London Outer | 550847 | 168003 | 33.8 | 100 |
| SO_HA SRN 157 | Ladds Way, Swanley (A20) | Sevenoaks | London Outer | 550704 | 168110 | 31.9 | 100 |

| ID | Location | Local Authority | Road Type | x | y | $NO_2$ Conc 2009 (µg/m³) | Data Capture (%) |
|---|---|---|---|---|---|---|---|
| SO_HA SRN 158 | Old Dartford Road, Farningham (M20) | Sevenoaks | Motorway | 554885 | 167385 | 37.0 | 100 |
| SO_HA SRN 159 | Ovenden Road, Sundridge (M25) | Sevenoaks | Motorway | 547994 | 156366 | 33.7 | 100 |
| SO_HA SRN 160 | 88 Park Lane, Kemsing (M26) | Sevenoaks | Motorway | 555260 | 158150 | 25.2 | 83 |
| THU_HA SRN 216 | Lydden Clockhouse Lane | Thurrock | Urban | 560040 | 179882 | 36.5 | 100 |
| THU_HA SRN 218 | Hotel (Only Property in AQMA) | Thurrock | Motorway | 557555 | 177766 | 45.7 | 83 |
| TON_HA SRN 222 | Teapot Lane - HB | Tonbridge Malling | Motorway | 572065 | 158555 | 49.1 | 100 |
| TON_HA SRN 223 | Rowan Close | Tonbridge Malling | Motorway | 572228 | 158528 | 34.2 | 100 |

na – not available

***Table B-A** **$NO_2$ 2009 Annual Mean Monitoring Data Summary***

The measurements show that concentrations in exceedence of the $NO_2$ annual mean AQO (40 µg/m³) occur along much of the motorway network. They also occur at locations on the non-motorway network in urban centres.

Very high concentrations (above 60 µg/m³), which indicate the potential for exceedence of the 1 hour mean objective, also occur, typically close to the motorway highway boundary, although also along busy roads such as the A2, A182 and A12. It should be noted that the monitoring locations tend to be sited in worst-case locations (such as kerbside street furniture), and may not necessarily be representative of public exposure.

## Model verification

The comparison of modelled concentrations with local monitored concentrations is a process termed 'verification'. Model verification investigates the discrepancies between modelled and measured concentrations, which can arise due to modelling and monitoring data assumptions, or uncertainties in model input data. The following are examples of potential causes of such discrepancy:

- Estimates of background pollutant concentrations
- Traffic data uncertainty
- Air quality monitoring data uncertainty
- differences in the localised $NO_2$ / $NO_x$ relationship
- Limitations of the air quality model

An evaluation of model performance has been undertaken to establish confidence in model results. LAQM TG(09) identifies a number of statistical procedures that are appropriate to evaluate model performance and assess uncertainty. The statistical parameters used in this assessment are:

- Root mean square error (RMSE);
- Fractional bias (FB); and
- Correlation coefficient (CC).

A brief for explanation of each statistic is provided in Table B-B, and further details can be found in LAQM TG(09) Box A3.7.

| Statistical Parameter | Comments | Ideal value |
|---|---|---|
| **RMSE** | RMSE is used to define the average error or uncertainty of the model. The units of RMSE are the same as the quantities compared.<br>If the RMSE values are higher than 25% of the objective being assessed, it is recommended that the model inputs and verification should be revisited in order to make improvements.<br>For example, if the model predictions are for the annual mean $NO_2$ objective of 40 µg/m$^3$, if an RMSE of 10 µg/m$^3$ or above is determined for a model it is advised to revisit the model parameters and model verification.<br>Ideally an RMSE within 10% of the air quality objective would be derived, which equates to 4 µg/m$^3$ for the annual mean $NO_2$ objective. | 0.01 |
| **FB** | FB is used to identify if the model shows a systematic tendency to over or under predict.<br>FB values vary between +2 and -2 and has an ideal value of zero. Negative values suggest a model over-prediction and positive values suggest a model under-prediction. | 0.00 |
| **CC** | CC is used to measure the linear relationship between predicted and observed data. A value of zero means no relationship and a value of 1 means absolute relationship.<br>This statistic can be particularly useful when comparing a large number of model and observed data points. | 1.00 |

***Table B-B NO$_2$ 2009 Annual Mean Monitoring Data Summary***

These parameters estimate how the model results agree or diverge from the observations. These calculations have been carried out prior to, and after adjustment and provide information on the improvement of the model predictions as a result of the application of the verification adjustment factors.

The verification process involves a review of the modelled pollutant concentrations against corresponding monitoring data to determine how well the air quality model has performed. Depending on the outcome it may be considered that the model has performed adequately and that there is no need to adjust any of the modelled results.

Alternatively the model may perform poorly against the monitoring data, in which case there is a need to check all the input data to ensure that it is reasonable and accurately represented by the air quality modelling process. Where all input data, such as traffic data, emissions rates and background concentrations have been checked and considered reasonable, then the modelled results may require adjustment to improve alignment with the monitoring data. This adjustment may be either using by a single verification adjustment factor to be applied to the modelled concentrations across the study area or a range of different adjustment factors to account for different situations in the study area.

Monitoring sites were excluded from the verification process where:

- sites could not be accurately identified,
- data capture was less than 75%, or
- were missing significant road component emissions due to the model set up approach.

The DMRB air quality model is very sensitive in the near-field, and monitoring locations less than 5m from the kerb were excluded (THAM_5 and BRW_39) because they were not representative of the distance bands used in the assessment. In total 28 out of 63 monitoring locations were used in the verification process.

### Verification Methodology – NOx / $NO_2$

The first stage of verification was undertaken by comparing the modelled versus monitored Road NOx. Road NOx measured at the diffusion tubes were calculated using the latest Defra NOx to $NO_2$ calculator, because diffusion tubes only measure $NO_2$ and do not directly measure NOx.

Once the modelled Road NOx component had been adjusted, this value was used in the Defra NOx to $NO_2$ calculator, and the calculated Road $NO_2$ component was adjusted following comparison with the monitored Road $NO_2$.

### Verification Summary: NOx / $NO_2$

The verification method followed the process detailed in LAQM TG(09). An initial comparison of the modelled versus monitored results indicated a high degree of uncertainty or scatter in the model predictions.

A review was undertaken of the modelled versus monitoring performance across the whole study area. It was noted that groups of monitoring sites tended to display similar Road NOx model performance, which was defined by the road type used for the DMRB model. As a result a number of verification zones were defined with the intention of improving the model performance. The description of the verification zones are presented below:

- Zone 1 – London Roads;
- Zone 2 – Motorways; and
- Zone 3 – Urban Roads (outside London).

The summary results and model performance statistics defined in LAQM TG(09) are provided in Table B-C.

| Parameter | No adjustment (all zones) | ZONE 1 | ZONE 2 | ZONE 3 |
|---|---|---|---|---|
| No. of monitoring sites | 28 | 8 | 16 | 4 |
| NOx road adjustment factor | - | 0.869 | 1.790 | 0.931 |
| $NO_2$ road adjustment factor | - | 1.013 | 0.984 | 1.013 |
| RMSE | 11.2 | 6.4 | 7.2 | 3.7 |
| FB | 0.2 | 0.0 | 0.0 | 0.0 |
| CC | 0.69 | 0.85 | 0.84 | 0.75 |
| No. sites within +/- 25% | 21 | 8 | 15 | 4 |

***Table B-C Verification Zone Model Performance Statistics – $NO_2$***

The statistics support the methodology adopted. The statistics show that the RMSE and CC are improved when a zonal factor is used for adjustment, when compared to the RMSE and FB for results unadjusted across the whole study area.

In the absence of sufficient $PM_{10}$ monitoring data for model verification, this adjustment factor has also been applied to the modelled $PM_{10}$ road contributions, following guidance in LAQM TG(09).

# Appendix C Local Air Quality Model Results Tables

The local air quality model results are presented in this appendix. Exceedence of the annual mean AQO is presented in bold. Where the concentration is in exceedence of the AQO and the change is not imperceptible then these links are coloured red for worsening and green for improvement.

Links 25 and 26 are the new Option C bypass, so there are no values at these locations for Option A or Option A+.

| Report Link ID | DM 2025 (µg/m³) | | Option A 2025 (µg/m³) | | Option A+ 2025 (µg/m³) | | Option C 2025 (µg/m³) | | Change in Concentrations Option A (DS DM) (µg/m³) | | Change in Concentrations Option A+ (DS DM) (µg/m³) | | Change in Concentrations Option C (DS DM) (µg/m³) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ | $PM_{10}$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ |
| 1 | **51.1** | 23.8 | **51.5** | 23.9 | **51.5** | 23.9 | **52.4** | 24.1 | 0.4 | 0.1 | 0.4 | 0.1 | 1.3 | 0.3 |
| 2 | **48.5** | 24.4 | **49.6** | 24.6 | **49.6** | 24.6 | **51.1** | 24.9 | 1.1 | 0.2 | 1.1 | 0.2 | 2.6 | 0.5 |
| 3 | **48.5** | 23.5 | **49.5** | 23.7 | **49.5** | 23.7 | **45.0** | 22.4 | 1.0 | 0.2 | 1.0 | 0.2 | -3.5 | -1.1 |
| 4 | **52.9** | 25.6 | **55.1** | 26.2 | **55.6** | 26.2 | **49.5** | 24.2 | 2.2 | 0.6 | 2.7 | 0.6 | -3.4 | -1.4 |
| 5 | **53.3** | 26.3 | **54.2** | 26.5 | **54.7** | 26.5 | **49.8** | 24.8 | 0.9 | 0.2 | 1.4 | 0.2 | -3.5 | -1.5 |
| 6 | **46.1** | 24.8 | **46.4** | 24.9 | **46.4** | 24.9 | **46.1** | 24.7 | 0.3 | 0.1 | 0.3 | 0.1 | 0.0 | -0.1 |
| 7 | **40.5** | 21.3 | **40.9** | 21.4 | **40.9** | 21.4 | **40.9** | 21.4 | 0.4 | 0.1 | 0.4 | 0.1 | 0.4 | 0.1 |
| 8 | 35.5 | 23.8 | 35.7 | 23.9 | 35.7 | 23.9 | 34.3 | 23.3 | 0.2 | 0.1 | 0.2 | 0.1 | -1.2 | -0.5 |
| 9 | **47.3** | 26.1 | **47.5** | 26.1 | **47.5** | 26.1 | **47.7** | 26.2 | 0.2 | 0.0 | 0.2 | 0.0 | 0.4 | 0.1 |
| 10 | **44.5** | 26.7 | **44.5** | 26.7 | **44.5** | 26.7 | **43.0** | 26.0 | 0.0 | 0.0 | 0.0 | 0.0 | -1.5 | -0.7 |
| 11 | 37.7 | 24.0 | 37.9 | 24.1 | 37.9 | 24.1 | 39.6 | 24.8 | 0.2 | 0.1 | 0.2 | 0.1 | 1.9 | 0.8 |
| 12 | 15.1 | 18.3 | 15.1 | 18.3 | 15.1 | 18.3 | 14.5 | 18.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.6 | -0.3 |
| 13 | **43.1** | 26.2 | **43.0** | 26.2 | **43.0** | 26.2 | **42.8** | 26.1 | -0.1 | 0.0 | -0.1 | 0.0 | -0.3 | -0.1 |
| 14 | **52.1** | 31.2 | **52.4** | 31.4 | **52.4** | 31.4 | **48.0** | 28.6 | 0.3 | 0.2 | 0.3 | 0.2 | -4.1 | -2.6 |
| 15 | **47.8** | 28.3 | **48.0** | 28.4 | **48.0** | 28.4 | **41.9** | 25.1 | 0.2 | 0.1 | 0.2 | 0.1 | -5.9 | -3.2 |
| 16 | 36.3 | 21.6 | 36.5 | 21.7 | 36.5 | 21.7 | 38.3 | 22.1 | 0.2 | 0.1 | 0.2 | 0.1 | 2.0 | 0.5 |
| 17 | 23.4 | 17.3 | 23.4 | 17.3 | 23.4 | 17.3 | 24.2 | 17.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.2 |
| 18 | 28.4 | 19.8 | 28.4 | 19.9 | 28.4 | 19.9 | 28.6 | 19.9 | 0.0 | 0.1 | 0.0 | 0.1 | 0.2 | 0.1 |
| 19 | 23.0 | 17.3 | 23.0 | 17.3 | 23.0 | 17.3 | 22.6 | 17.1 | 0.0 | 0.0 | 0.0 | 0.0 | -0.4 | -0.2 |
| 20 | **45.8** | 23.5 | **46.0** | 23.5 | **46.0** | 23.5 | **46.0** | 23.5 | 0.2 | 0.0 | 0.2 | 0.0 | 0.2 | 0.0 |
| 21 | 26.2 | 19.0 | 26.0 | 19.0 | 26.0 | 19.0 | 25.8 | 18.9 | -0.2 | 0.0 | -0.2 | 0.0 | -0.4 | -0.1 |
| 22 | 34.9 | 20.7 | 34.9 | 20.7 | 34.9 | 20.7 | 34.2 | 20.5 | 0.0 | 0.0 | 0.0 | 0.0 | -0.7 | -0.2 |
| 23 | 21.3 | 19.0 | 21.4 | 19.0 | 21.4 | 19.0 | 21.4 | 18.9 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 | -0.1 |
| 24 | **43.5** | 26.3 | **43.5** | 26.3 | **43.5** | 26.3 | **43.4** | 26.2 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | -0.1 |
| 25 | 15.1 | 17.4 | - | - | - | - | 20.9 | 19.3 | - | - | - | - | 5.8 | 1.9 |
| 26 | 24.4 | 14.2 | - | - | - | - | 33.3 | 16.9 | - | - | - | - | 8.9 | 2.7 |

***Table C-A** Modelled $NO_2$ and $PM_{10}$ Opening Year (2025) Annual Mean Concentrations at Representative Road Links – 10m Distance Band*

| Report Link ID | DM 2025 | | Option A 2025 | | Option A+ 2025 | | Option C 2025 | | Change in Concentrations Option A (DS DM) | | Change in Concentrations Option A+ (DS DM) | | Change in Concentrations Option C (DS DM) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (µg/m$^3$) | | (µg/m$^3$) | | (µg/m$^3$) | | (µg/m$^3$) | | (µg/m$^3$) | | (µg/m$^3$) | | (µg/m$^3$) | |
| | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ |
| 1 | 37.2 | 21.1 | 37.6 | 21.2 | 37.6 | 18.3 | 38.0 | 21.3 | 0.4 | 0.1 | 0.4 | 0.1 | 0.8 | 0.2 |
| 2 | 36.0 | 21.9 | 36.6 | 22.0 | 36.6 | 18.3 | 37.6 | 22.2 | 0.6 | 0.1 | 0.6 | 0.1 | 1.6 | 0.3 |
| 3 | 36.3 | 21.0 | 37.1 | 21.1 | 37.1 | 20.2 | 34.3 | 20.3 | 0.8 | 0.1 | 0.8 | 0.1 | -2.0 | -0.7 |
| 4 | **41.0** | 22.9 | **42.3** | 23.2 | **42.6** | 27.5 | 38.9 | 22.0 | 1.3 | 0.3 | 1.6 | 0.3 | -2.1 | -0.9 |
| 5 | **40.8** | 23.3 | **41.4** | 23.5 | **41.7** | 28.0 | 38.8 | 22.5 | 0.6 | 0.2 | 0.9 | 0.2 | -2.0 | -0.8 |
| 6 | 34.8 | 22.3 | 35.1 | 22.4 | 35.1 | 21.3 | 34.8 | 22.3 | 0.3 | 0.1 | 0.3 | 0.1 | 0.0 | 0.0 |
| 7 | 30.0 | 19.3 | 30.1 | 19.4 | 30.1 | 16.5 | 30.1 | 19.3 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 |
| 8 | 26.8 | 21.0 | 26.8 | 21.0 | 26.8 | 16.0 | 26.0 | 20.7 | 0.0 | 0.0 | 0.0 | 0.0 | -0.8 | -0.3 |
| 9 | 35.8 | 22.2 | 36.0 | 22.2 | 36.0 | 20.6 | 36.2 | 22.2 | 0.2 | 0.0 | 0.2 | 0.0 | 0.4 | 0.0 |
| 10 | 33.5 | 22.9 | 33.7 | 22.9 | 33.7 | 19.4 | 32.8 | 22.6 | 0.2 | 0.0 | 0.2 | 0.0 | -0.7 | -0.3 |
| 11 | 28.5 | 21.0 | 28.5 | 21.0 | 28.5 | 17.8 | 29.6 | 21.5 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | 0.5 |
| 12 | 12.7 | 17.7 | 12.7 | 17.7 | 12.7 | 11.2 | 12.4 | 17.5 | 0.0 | 0.0 | 0.0 | 0.0 | -0.3 | -0.2 |
| 13 | 32.9 | 22.3 | 32.9 | 22.3 | 32.9 | 20.3 | 32.7 | 22.2 | 0.0 | 0.0 | 0.0 | 0.0 | -0.2 | -0.1 |
| 14 | 39.1 | 26.1 | 39.3 | 26.1 | 39.3 | 23.4 | 36.4 | 24.5 | 0.2 | 0.0 | 0.2 | 0.0 | -2.7 | -1.6 |
| 15 | 35.6 | 23.7 | 35.6 | 23.8 | 35.6 | 21.0 | 31.9 | 21.8 | 0.0 | 0.1 | 0.0 | 0.1 | -3.7 | -1.9 |
| 16 | 27.4 | 20.0 | 27.5 | 20.0 | 27.5 | 17.5 | 28.5 | 20.3 | 0.1 | 0.0 | 0.1 | 0.0 | 1.1 | 0.3 |
| 17 | 18.8 | 16.6 | 18.8 | 16.6 | 18.8 | 13.2 | 19.2 | 16.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.1 |
| 18 | 22.8 | 17.9 | 22.8 | 17.9 | 22.8 | 16.3 | 22.9 | 17.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 |
| 19 | 18.0 | 16.4 | 18.0 | 16.5 | 18.0 | 12.4 | 17.8 | 16.4 | 0.0 | 0.1 | 0.0 | 0.1 | -0.2 | 0.0 |
| 20 | 33.9 | 21.0 | 34.1 | 21.0 | 34.1 | 16.8 | 34.1 | 21.0 | 0.2 | 0.0 | 0.2 | 0.0 | 0.2 | 0.0 |
| 21 | 20.1 | 18.1 | 20.1 | 18.1 | 20.1 | 12.2 | 20.0 | 18.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | -0.1 |
| 22 | 26.0 | 19.1 | 26.0 | 19.1 | 26.0 | 15.9 | 25.5 | 19.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.5 | -0.1 |
| 23 | 17.7 | 18.1 | 17.7 | 18.1 | 17.7 | 14.4 | 17.7 | 18.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 24 | 35.6 | 23.0 | 35.6 | 23.0 | 35.6 | 25.4 | 35.5 | 23.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 |
| 25 | 15.1 | 17.4 | - | - | - | - | 18.6 | 18.5 | - | - | - | - | 3.5 | 1.1 |
| 26 | 24.4 | 14.2 | - | - | - | - | 29.8 | 15.8 | - | - | - | - | 5.4 | 1.6 |

***Table C-B Modelled $NO_2$ and $PM_{10}$ Opening Year (2025) Annual Mean Concentrations at Representative Road Links – 20m Distance Band***

| Report Link ID | DM 2025 (µg/m$^3$) | | Option A 2025 (µg/m$^3$) | | Option A+ 2025 (µg/m$^3$) | | Option C 2025 (µg/m$^3$) | | Change in Concentrations Option A (DS DM) (µg/m$^3$) | | Change in Concentrations Option A+ (DS DM) (µg/m$^3$) | | Change in Concentrations Option C (DS DM) (µg/m$^3$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ |
| 1 | 24.8 | 19.1 | 25.0 | 19.2 | 25.0 | 19.2 | 25.2 | 19.2 | 0.2 | 0.1 | 0.2 | 0.1 | 0.4 | 0.1 |
| 2 | 25.0 | 20.1 | 25.4 | 20.1 | 25.4 | 20.1 | 25.8 | 20.2 | 0.4 | 0.0 | 0.4 | 0.0 | 0.8 | 0.1 |
| 3 | 25.7 | 19.1 | 25.9 | 19.2 | 25.9 | 19.2 | 24.7 | 18.8 | 0.2 | 0.1 | 0.2 | 0.1 | -1.0 | -0.3 |
| 4 | 30.7 | 20.8 | 31.3 | 21.0 | 31.5 | 21.0 | 29.7 | 20.4 | 0.6 | 0.2 | 0.8 | 0.2 | -1.0 | -0.4 |
| 5 | 30.0 | 21.2 | 30.2 | 21.2 | 30.4 | 21.2 | 28.9 | 20.7 | 0.2 | 0.0 | 0.4 | 0.0 | -1.1 | -0.5 |
| 6 | 24.7 | 20.5 | 24.9 | 20.5 | 24.9 | 20.5 | 24.7 | 20.5 | 0.2 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 |
| 7 | 20.6 | 17.8 | 20.8 | 17.8 | 20.8 | 17.8 | 20.8 | 17.8 | 0.2 | 0.0 | 0.2 | 0.0 | 0.2 | 0.0 |
| 8 | 19.4 | 18.9 | 19.6 | 18.9 | 19.6 | 18.9 | 19.1 | 18.8 | 0.2 | 0.0 | 0.2 | 0.0 | -0.3 | -0.1 |
| 9 | 25.7 | 19.3 | 25.9 | 19.3 | 25.9 | 19.3 | 25.9 | 19.3 | 0.2 | 0.0 | 0.2 | 0.0 | 0.2 | 0.0 |
| 10 | 24.0 | 20.1 | 24.0 | 20.1 | 24.0 | 20.1 | 23.6 | 19.9 | 0.0 | 0.0 | 0.0 | 0.0 | -0.4 | -0.2 |
| 11 | 20.6 | 18.8 | 20.6 | 18.8 | 20.6 | 18.8 | 21.2 | 19.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.2 |
| 12 | 12.1 | 17.3 | 12.2 | 17.3 | 12.2 | 17.3 | 11.8 | 17.2 | 0.1 | 0.0 | 0.1 | 0.0 | -0.3 | -0.1 |
| 13 | 23.8 | 19.4 | 23.8 | 19.4 | 23.8 | 19.4 | 23.8 | 19.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 14 | 27.3 | 22.2 | 27.3 | 22.2 | 27.3 | 22.2 | 25.9 | 21.4 | 0.0 | 0.0 | 0.0 | 0.0 | -1.4 | -0.8 |
| 15 | 24.5 | 20.3 | 24.5 | 20.3 | 24.5 | 20.3 | 22.6 | 19.3 | 0.0 | 0.0 | 0.0 | 0.0 | -1.9 | -1.0 |
| 16 | 19.8 | 18.7 | 19.8 | 18.7 | 19.8 | 18.7 | 20.3 | 18.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.2 |
| 17 | 15.2 | 16.0 | 15.2 | 16.1 | 15.2 | 16.1 | 15.4 | 16.1 | 0.0 | 0.1 | 0.0 | 0.1 | 0.2 | 0.1 |
| 18 | 18.3 | 16.5 | 18.3 | 16.5 | 18.3 | 16.5 | 18.4 | 16.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 |
| 19 | 14.1 | 15.8 | 14.1 | 15.8 | 14.1 | 15.8 | 14.0 | 15.8 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 |
| 20 | 22.8 | 19.1 | 22.8 | 19.2 | 22.8 | 19.2 | 22.8 | 19.2 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 |
| 21 | 15.4 | 17.4 | 15.4 | 17.4 | 15.4 | 17.4 | 15.3 | 17.4 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 |
| 22 | 18.4 | 17.9 | 18.4 | 17.8 | 18.4 | 17.8 | 18.2 | 17.8 | 0.0 | -0.1 | 0.0 | -0.1 | -0.2 | -0.1 |
| 23 | 14.9 | 17.5 | 14.9 | 17.5 | 14.9 | 17.5 | 14.9 | 17.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 24 | 28.7 | 20.6 | 28.7 | 20.6 | 28.7 | 20.6 | 28.6 | 20.5 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | -0.1 |
| 25 | 15.1 | 17.4 | - | - | - | - | 16.8 | 18.0 | - | - | - | - | 1.7 | 0.6 |
| 26 | 24.4 | 14.2 | - | - | - | - | 27.2 | 15.0 | - | - | - | - | 2.8 | 0.8 |

***Table C-C Modelled $NO_2$ and $PM_{10}$ Opening Year (2025) Annual Mean Concentrations at Representative Road Links – 50m Distance Band***

| Report Link ID | DM 2025 (µg/m³) | | Option A 2025 (µg/m³) | | Option A+ 2025 (µg/m³) | | Option C 2025 (µg/m³) | | Change in Concentrations Option A (DS DM) (µg/m³) | | Change in Concentrations Option A+ (DS DM) (µg/m³) | | Change in Concentrations Option C (DS DM) (µg/m³) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ | $NO_2$ | $PM_{10}$ |
| 1 | 19.0 | 18.2 | 19.1 | 18.3 | 19.1 | 18.3 | 19.1 | 18.3 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| 2 | 19.5 | 19.2 | 19.7 | 19.3 | 19.7 | 19.3 | 19.5 | 19.3 | 0.2 | 0.1 | 0.2 | 0.1 | 0.0 | 0.1 |
| 3 | 20.4 | 18.3 | 20.5 | 18.4 | 20.5 | 18.4 | 20.4 | 18.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | -0.2 |
| 4 | 25.5 | 19.9 | 25.8 | 20.0 | 25.9 | 20.0 | 24.9 | 19.6 | 0.3 | 0.1 | 0.4 | 0.1 | -0.6 | -0.3 |
| 5 | 24.3 | 20.2 | 24.5 | 20.2 | 24.5 | 20.2 | 23.8 | 19.9 | 0.2 | 0.0 | 0.2 | 0.0 | -0.5 | -0.3 |
| 6 | 20.0 | 19.7 | 20.1 | 19.7 | 20.1 | 19.7 | 20.0 | 19.7 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| 7 | 16.2 | 17.1 | 16.2 | 17.1 | 16.2 | 17.1 | 16.2 | 17.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 8 | 16.1 | 18.0 | 16.1 | 18.0 | 16.1 | 18.0 | 15.8 | 17.9 | 0.0 | 0.0 | 0.0 | 0.0 | -0.3 | -0.1 |
| 9 | 20.6 | 18.0 | 20.7 | 18.0 | 20.7 | 18.0 | 20.7 | 18.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 |
| 10 | 19.3 | 18.9 | 19.3 | 18.9 | 19.3 | 18.9 | 19.0 | 18.8 | 0.0 | 0.0 | 0.0 | 0.0 | -0.3 | -0.1 |
| 11 | 16.9 | 17.8 | 16.9 | 17.8 | 16.9 | 17.8 | 17.1 | 17.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.1 |
| 12 | 11.9 | 17.1 | 11.9 | 17.1 | 11.9 | 17.1 | 11.7 | 17.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.2 | -0.1 |
| 13 | 19.5 | 18.1 | 19.5 | 18.1 | 19.5 | 18.1 | 19.4 | 18.1 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 |
| 14 | 21.2 | 20.5 | 21.4 | 20.5 | 21.4 | 20.5 | 20.5 | 20.0 | 0.2 | 0.0 | 0.2 | 0.0 | -0.7 | -0.5 |
| 15 | 19.0 | 18.8 | 19.0 | 18.8 | 19.0 | 18.8 | 18.0 | 18.2 | 0.0 | 0.0 | 0.0 | 0.0 | -1.0 | -0.6 |
| 16 | 16.1 | 18.2 | 16.2 | 18.2 | 16.2 | 18.2 | 16.5 | 18.2 | 0.1 | 0.0 | 0.1 | 0.0 | 0.4 | 0.0 |
| 17 | 13.7 | 15.8 | 13.7 | 15.8 | 13.7 | 15.8 | 13.8 | 15.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 |
| 18 | 16.2 | 15.9 | 16.4 | 15.9 | 16.4 | 15.9 | 16.4 | 15.9 | 0.2 | 0.0 | 0.2 | 0.0 | 0.2 | 0.0 |
| 19 | 12.1 | 15.6 | 12.1 | 15.6 | 12.1 | 15.6 | 12.1 | 15.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 |
| 20 | 17.3 | 18.3 | 17.3 | 18.3 | 17.3 | 18.3 | 17.3 | 18.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 21 | 13.2 | 17.1 | 13.2 | 17.1 | 13.2 | 17.1 | 13.2 | 17.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 22 | 15.0 | 17.3 | 15.0 | 17.3 | 15.0 | 17.3 | 14.9 | 17.3 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 |
| 23 | 13.6 | 17.3 | 13.6 | 17.3 | 13.6 | 17.3 | 13.6 | 17.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 24 | 25.5 | 19.5 | 25.5 | 19.5 | 25.5 | 19.5 | 25.5 | 19.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 25 | 15.1 | 17.4 | - | - | | | 16.1 | 17.7 | - | - | - | - | 1.0 | 0.3 |
| 26 | 24.4 | 14.2 | - | - | | | 25.8 | 14.7 | - | - | - | - | 1.4 | 0.5 |

***Table C-D Modelled $NO_2$ and $PM_{10}$ Opening Year (2025) Annual Mean Concentrations at Representative Road Links – 100m Distance Band***

# Appendix D Designated Habitats Model Results Tables

This appendix presents the results from the air quality assessment of designated habitats. Exceedence of the annual mean NOx AQS objective of 30 μg/m$^3$ is presented in bold. Where the concentration is in exceedence of the AQS objective and the change is not imperceptible then these links are coloured red for worsening and green for improvement. The location of the habitat sites are shown in Figure 6.

Modelled annual mean NOx concentrations are presented in Table D-A.

| Designated Site | DM 2025 | Option A & A+ 2025 | Option C 2025 | Change in Conc Option A & A+ (DS DM) | Change in Conc Option C (DS DM) |
|---|---|---|---|---|---|
| | (μg/m$^3$) | (μg/m$^3$) | (μg/m$^3$) | (μg/m$^3$) | (μg/m$^3$) |
| | $NO_x$ | $NO_x$ | $NO_x$ | $NO_x$ | $NO_x$ |
| Darenth Wood SSSI | **110.8** | **111.7** | **98.8** | **0.9** | **-12.0** |
| Curtismill Green SSSI | 26.1 | 26.3 | 26.5 | 0.2 | 0.4 |
| Cobham Woods SSSI | **62.1** | **62.4** | **70.2** | 0.3 | **8.1** |
| Inner Thames Marshes SSSI | **89.1** | **89.5** | **89.9** | 0.4 | **0.8** |
| Oxleas Woodlands SSSI | **67.6** | **67.4** | **66.9** | -0.2 | **-0.7** |
| Queendown Warren SSSI | 16.1 | 16.2 | 16.3 | 0.1 | 0.2 |
| Shorne & Ashenbank Woods SSSI (south) | **92.4** | **92.9** | **78.1** | **0.5** | **-14.3** |
| Shorne & Ashenbank Woods SSSI (east) | 15.0 | 15.0 | **37.3** | 0.0 | **22.3** |
| South Thames Estuary & Marshes Ramsar SSSI* | **33.1** | **33.1** | **50.0** | 0.0 | **16.9** |
| Thorndon Park SSSI | 20.4 | 20.5 | 20.1 | 0.1 | -0.3 |
| Westerham Wood SSSI | **89.8** | **90.2** | **90.2** | 0.4 | 0.4 |
| Titsey Woods SSSI | **80.5** | **80.9** | **80.8** | 0.4 | 0.3 |
| Vange & Fobbing Marshes SSSI | **39.9** | **39.9** | **41.1** | 0.0 | **1.2** |
| Wouldham to Detling Escarpment SSSI | **46.3** | **46.4** | **48.1** | 0.1 | **1.8** |
| Woldingham & Oxted Downs SSSI | 25.3 | 25.3 | 25.3 | 0.0 | 0.0 |
| North Downs Woodlands SAC | 19.3 | 19.3 | 19.5 | 0.0 | 0.2 |

* Option C is not finalised, the tunnel could emerge south of the South Thames Estuary Ramsar SSSI which would mean there would be no air quality impact at this Designated Site, except at potential ventilation sites.

***Table D-A Modelled $NO_x$ Opening Year (2025) Annual Mean Concentrations at Designated Habitat Sites***

Calculation of nitrogen deposition rate has been undertaken for those sites where the annual mean NOx AQS objective is exceeded and the change in concentration is greater than 0.4 μg/m$^3$, following guidance in IAN 174/13.The change due to the scheme is considered imperceptible where it is less than 1% of the Critical Load.

The results of the critical load calculations are presented in Table D-B for Option A & Option A+ (which are the same at all sites) and Table D-C for Option C.

| Designated Site | Critical Load | DM 2025 | Option A & A+ 2025 | Change in Deposition Rate Option A & A+ | Change as a % of Critical Load |
|---|---|---|---|---|---|
| Darenth Wood SSSI | 5 | **37.39** | **37.41** | 0.02 | 0.4% |
| Shorne & Ashenbank Woods SSSI (south) | 5 | **35.84** | **35.86** | 0.02 | 0.2% |
| Shorne & Ashenbank Woods SSSI (east) | 5 | **37.66** | **37.66** | 0.00 | 0.0% |

***Table D-B Modelled Opening Year (2025) Nitrogen Deposition Rates (kgN/ha/yr) at Designated Habitat Sites - Option A & A+***

| Designated Site | Critical Load | DM 2025 | Option C 2025 | Change in Deposition Rate Option C | Change as a % of Critical Load |
|---|---|---|---|---|---|
| Darenth Wood SSSI | 5 | **37.39** | **37.12** | -0.27 | -5.4% |
| Cobham Woods SSSI | 5 | **40.37** | **40.59** | 0.22 | 4.4% |
| Inner Thames Marshes SSSI | 20 | **28.74** | **28.76** | 0.02 | 0.1% |
| Oxleas Woodlands SSSI | 5 | **33.98** | **33.96** | -0.02 | -0.4% |
| Shorne & Ashenbank Woods SSSI (south) | 5 | **35.84** | **35.50** | -0.34 | -6.8% |
| Shorne & Ashenbank Woods SSSI (east) | 5 | **37.66** | **38.29** | 0.63 | **12.6%** |
| South Thames Estuary & Marshes Ramsar SSSI* | 20 | 18.06 | 18.67 | 0.61 | 3.1% |
| Vange & Fobbing Marshes SSSI | 10 | **29.86** | **29.90** | 0.04 | 0.4% |
| Wouldham to Detling Escarpment SSSI | 5 | **39.96** | **40.01** | 0.05 | 1.0% |

* Option C is not finalised, the tunnel could emerge south of the South Thames Estuary Ramsar SSSI which would mean there would be no impact at this Designated Site, except at potential ventilation sites.

***Table D-C Modelled Opening Year (2025) Nitrogen Deposition Rates (kgN/ha/yr) at Designated Habitat Sites - Option C***