Options for an Exposure-Reduction Approach to Air Quality Management in the UK

Air Quality Consultants

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Executive Summary

This report considers various options to introduce an Exposure-Reduction approach into the revised Air Quality Strategy (AQS), to support the air quality objectives and limit values for Particulate Matter (PM). It builds upon an earlier report which considered the Exposure-Reduction approach at the European level. The European Commission (EC) has recently set out its proposals for an Exposure-Reduction target for $PM_{2.5}$.

Detailed consideration is given to the different geographical and political scales within the UK at which an Exposure-Reduction approach for PM could be applied. After consideration of the advantages and disadvantages, it is concluded that the approach could be adopted at either the UK level, or at the level of the Devolved Administrations (including Greater London), but would be impractical at the local authority level. The practicalities of implementing the approach at the Devolved Administrations and Greater London level are explored. It is recommended that the approach is applied to agglomerations over 100,000 people. It could be applied to either PM_{10} or $PM_{2.5}$, although the latter would be consistent with the proposed EC Directive.

The report also considers: targets that could be set for Exposure Reduction; the potential for implementation in combination with air quality objectives; and the impact of the approach in terms of a cost and benefits analysis. These analyses are carried out using two packages of future control measures, which have been established by Defra and the Devolved Administrations to support the revision of the AQS. The outcome of both packages is a net positive benefit (i.e. the benefits are greater than the costs). Further analysis shows that, with these packages, a 2020 annual mean objective of about 32 µg/m^3 (PM_{10}) or 16 µg/m^3 ($PM_{2.5}$) in conjunction with Exposure-Reduction targets of about 10% (PM_{10}) or 16% ($PM_{2.5}$) could be adopted at the UK level. Exposure Reduction together with objectives would deliver significant health benefits from a reduction in population exposure, while also controlling PM concentrations at hot spots, and thus both together provide the optimum approach to PM management in the UK.

Finally, the potential for applying the Exposure-Reduction approach to other non-threshold pollutants is considered, including benzene, 1,3-butadiene, ozone and PAH. It is concluded, for a variety of reasons, that the approach would not be well suited to any of these pollutants at this time.

1 Introduction

1.1 Air Quality Consultants Ltd prepared a report[1] for Defra in January 2005 that set out options for applying an Exposure-Reduction approach to the management of pollutants without a threshold for health effects. The report examined the options in general terms and related the Exposure-Reduction approach to the existing approaches of Limit Values and National Emission Ceilings. The focus was on application at the UK level, as part of a European-wide initiative. Since the report was released, the Clean Air for Europe (CAFE) Thematic Strategy has been published[2], which draws upon many of the recommendations within the report for an Exposure-Reduction approach. The Thematic Strategy and the associated proposal for a Directive on ambient air quality and cleaner air for Europe[3], propose the introduction of an Exposure-Reduction target for $PM_{2.5}$ of 20%, to be achieved between 2010 and 2020. This target applies to the average concentration measured at urban background sites across the Member State. The target would be supplemented by a concentration cap of 25 µg/m^3, to be achieved by 2010.

1.2 As a consequence of these developments, Defra has commissioned Air Quality Consultants to extend its earlier work, to an examination of how the new approach might be integrated into the UK Air Quality Strategy.

1.3 This report sets out how an Exposure-Reduction approach could be applied in the UK alongside Objectives and Limit Values. It considers a number of approaches that could be used and the target reductions that could be applied, and then examines the health benefits that the recommended approach could deliver, together with the costs.

1.4 The specific requirements are:

- to develop an approach relying upon both Exposure Reduction and Objectives/Limit-Values. More specifically, to consider four scenarios as follows[4]:
  - Ø PM_{10} Exposure Reduction with a new PM_{10} Objective
  - Ø PM_{10} Exposure Reduction with $PM_{2.5}$ Objective
  - Ø $PM_{2.5}$ Exposure Reduction with a new PM_{10} Objective
  - Ø $PM_{2.5}$ Exposure Reduction with $PM_{2.5}$ Objective

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1 Options for an Exposure-Reduction Approach to Air Quality management in the UK and the EU for Non-Threshold Pollutants. Prepared by AQC on behalf of Defra. January 2005.

2 Thematic Strategy on air pollution. COM (2005) 446 Final.

3 Proposal for Directive on ambient air quality and cleaner air for Europe COM (2005) 447

4 These scenarios are in addition to the continuation of the 2005 EU Limit Value, which will remain in place.

- to ensure that the Exposure-Reduction approach is straightforward to apply;
- to consider the implications of developing the Exposure-Reduction approach for both PM_{10} and $PM_{2.5}$.
- to consider the implications and practicality of applying the Exposure-Reduction approach at the UK level and at other geographic and political scales;
- to consider the potential application of the Exposure-Reduction approach to other non-threshold pollutants, such as benzene, 1,3-butadiene, ozone and benzo[a]pyrene (B[a]P).

1.5 The views expressed and conclusions reached are those of the authors and not necessarily those of Defra, the Devolved Administrations or the UK Government.

2 Application of Exposure-Reduction to PM in the UK

2.1 This section explores the application of the Exposure-Reduction approach to particulate matter in the UK. The impact of Exposure Reduction, and the options of combining the approach with the air quality objectives, are set out in Section 3.

The Exposure-Reduction Approach

2.2 The essential elements of an Exposure-Reduction approach were set out in the previous report. In summary, they are:

- the definition of the current annual average concentration for a fixed set of urban background sites. This would be defined as a running average, probably over 3 years. An option would be to define the urban increment by subtracting the current annual average concentration for a fixed set of rural sites;
- the definition of a target reduction in this average urban concentration by a given date;
- monitoring of progress towards the target on an annual basis using the fixed set of urban background sites.

Modelling vs Monitoring

2.3 The various advantages and disadvantages of defining exposure based on modelling were discussed in the previous report. For implementation within the UK, some of these disadvantages would no longer apply. For example, a UK approach towards a spatially disaggregated emissions inventory and associated air quality model has already been defined. However, there are still difficulties with defining exposure based solely on modelling that are considered sufficient to preclude its use for the Exposure-Reduction approach:

- the emissions inventory is continually updated and revised. Any changes in the methodology applied would require the baseline and target concentrations to be regularly re-evaluated;
- the modelling approach is also continually updated and improved. Once again, any changes would require the baseline and target to be re-evaluated.

2.4 It is concluded that the Exposure-Reduction approach is best defined using monitoring. Modelling will nevertheless play an important role in defining the scale of reduction to be achieved against the measured baseline. This is discussed in further detail in Section 3.

Types of Monitoring Stations

2.5 The types of monitoring stations that should be included in the calculation of the average exposure must also be taken into account. The UK networks currently include site types defined as 'Urban Background' and 'Urban Centre', and whilst these are expected to be broadly representative of exposure in the town or city centre, the original selection criteria[5] that were used to establish the urban network allowed sites relatively close to busy roads (up to 30,000 vehicles per day). For the purpose of Exposure Reduction, the previous report suggested that "monitoring sites should be no closer than 100 m to a very busy road (>40,000 vpd), 75 m of a busy road (20-40,000 vpd), 50 m to a fairly busy road (10-20,000 vpd) and 25 m from any other road. Where only one site represents an agglomeration it should be within the inner one-third of the radius of a circle representing the extent of the urban area". However, if these criteria were rigidly enforced they would exclude a number of existing background monitoring sites, and would potentially require significant re-configuration of the network.

2.6 The spatial variation in concentrations of PM with increasing distance from the kerbside has not been studied in any great detail. A study carried out alongside the M25 motorway, reported in the recent AQEG report[6], suggests that there is only evidence of a significant increase above the background within about 30 metres of the carriageway, and beyond 20 to 50 metres from the edge of the road, concentrations are likely to be indistinguishable from the background bearing in mind the measurement uncertainty and the high proportion of the background contribution to roadside concentrations.

2.7 Given a sufficient number of sites in the network, it is proposed that the previously suggested criteria could be relaxed for a small proportion of the monitoring stations, provided this does not exceed about 15% of the total (e.g. in a network of 20 sites, the relaxed criteria might be applied to up to 3 monitoring stations). The criteria should though be relaxed by no more than 50%, e.g. a site should be no closer than 50 m to a very busy road (>40,000 vpd) etc.

2.8 These suggestions for siting requirements are generally consistent with the macroscale siting criteria for urban and suburban monitoring stations described in Annex VIII of the proposed Directive[3].

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5 During the establishment of the urban network, the intent was to locate monitoring locations to be representative of the highest background concentrations in the area, rather than the general background.

6 AQEG (2005) Particulate Matter in the United Kingdom, Defra, UK.

Scale of Application

2.9 The Exposure-Reduction approach was initially developed for application at the UK and international levels. This report considers its application at a number of different levels,:

- ***UK:*** whereby just one target is developed and compliance is checked using a UK data set;
- ***Devolved Administrations:*** this would involve applying the Exposure-Reduction approach separately for England, Scotland, Wales and Northern Ireland, and possibly also for Greater London;
- ***Regional:*** this would involve applying the Exposure-Reduction approach at the regional (e.g. Government Office, EA region) level in England, in addition to the Devolved Administrations;
- ***Local Authorities:*** this would involve applying the Exposure-Reduction approach to individual local authorities, or groups of local authorities.

Each of these scenarios is considered in turn below. The focus at this stage is on application to PM_{10}. The issues associated with applying the approach to $PM_{2.5}$ are discussed in a subsequent section.

Implementation at the UK Level

2.10 The Exposure-Reduction approach was originally designed to be applied at the UK level. The practicalities of introducing the approach were discussed in some detail in the previous report, including recommendations on:

- the number of monitoring stations that might be required in agglomerations of varying sizes in order to provide a robust estimate of the average annual mean exposure to PM_{10};
- the types of monitoring stations that should be used;
- how the rural background component might be subtracted.

These issues are now considered in greater detail.

2.11 The aim is to define the average PM exposure of the urban population, but without explicit population weighting. This can be achieved by using monitoring sites in urban background locations, with the number of sites linked to the population[7]. It is also important to consider the uncertainty in the average UK exposure, which is dependant upon the number of sites used to determine this average concentration. An analysis of PM_{10} concentrations measured at urban background[8] sites across the UK has demonstrated that once there are more than about 20 sites, the UK average would be defined to within ± 5% (see Figure 1).

2.12 Agglomerations with over 250,000 people have been identified for the UK, under the requirements of the Framework Directive. There are 28 agglomerations, accounting for 43% of the UK population (about 24 million people). Agglomerations with an urban population of greater than 100,000 people have also been defined under the requirements of the Directive on the Assessment and Management of Environmental Noise. There are 40 agglomerations between 100,000 and 250,000 people, accounting for a further 10% of the population.

2.13 Exposure Reduction could be implemented at the level of the 250,000 or the 100,000 agglomerations. In either case, it would not be appropriate to assign a single monitoring station to every agglomeration. Some of the larger agglomerations would need to have more than one monitoring station, whilst the smaller agglomerations would need to be grouped together.

2.14 A strategy based on broadly 1 site per 1 million population applied to agglomerations over 250,000 could be a suitable approach, i.e. about 24 sites in total for the UK, and would provide a robust indicator of exposure. An assessment of potential agglomeration groupings and the numbers of monitoring sites based on this approach is provided in Table A1 (Appendix 1). In many cases it is possible to identify agglomerations that can be grouped sensibly on population size and geographic proximity (e.g. Bournemouth and Southampton), but in other cases (e.g. Belfast and Edinburgh) this has not proved possible.

2.15 Whilst about 20 sites would represent the minimum number of locations to provide a robust indicator, there are a number of reasons why inclusion of additional sites would be advantageous:

- there are more than 20 background PM_{10} monitoring sites in the UK agglomerations, and it would seem sensible to include as many sites as possible;

- there is the potential for sites to change, or even close. In addition, individual sites may need to be excluded in a particular year due to poor data capture. There is a justification for a larger rather than a smaller number of monitoring sites to minimise the impact of such events;

7 This gives an element of population weighting, but not explicitly.
8 Assumed to include Urban Background, Urban Centre and Suburban sites for this analysis

- the aim is to define exposure within a given proportion of the UK urban population by the measured concentration at a single monitoring location, e.g. with 24 sites the concentration measured at each monitoring station needs to broadly reflect the average exposure to 1 million people. It is therefore important to try to identify monitoring sites as close as possible to the population area that is being represented; this is particularly important for PM as annual mean concentrations vary significantly across the UK. For example, it is not appropriate to represent the exposure in Blackpool by a monitoring site in Southampton, even though the populations are similar. There is also the issue of public perception if population exposure within an agglomeration is determined by a monitoring site that is located some considerable distance away.

2.16 An alternative assessment of monitoring requirements, based on approximately 1 monitoring site per 750,000 population (equivalent to 32 sites), has also been carried out and is summarised in Table A2 (Appendix 1). Whilst the increased number of monitoring stations allows a better geographical grouping in most cases, there are still some difficulties e.g. it is difficult to group agglomerations such as Belfast and Southend in a logical manner as they are geographically remote.

2.17 It would also be possible to apply the monitoring requirements to agglomerations above 100,000. This does not have a significant advantage in defining the UK urban population (only 10% of the population live in agglomerations between 100,000 and 250,000) but it would allow different geographical groupings to be used. A proposed strategy is described in Table A3 (Appendix 1). The inclusion of the additional agglomerations allows some improvement to the geographical grouping, for example Bristol, Reading and Southend. However, groupings within Scotland, Wales and Northern Ireland remain less than ideal, due to the number and size of agglomerations in the Devolved Administrations.

Subtraction of the Rural Component

2.18 The advantages and disadvantages of subtracting a rural background were explored in detail in the previous report. At the EU level, a particular concern was equity amongst Member States with very different background concentrations. This would not be a concern for implementation at the UK level.

2.19 The minimum number of sites required to define a UK rural background with reasonable certainty is expected to be in the order of 10-15 sites for the UK. There are currently only 4 rural sites available that measure PM_{10} continuously.

2.20 There are still advantages to subtracting the rural background for implementation at the UK level as this would:

- give a PM concentration that more closely reflects that which is locally controllable;
- produce a higher figure for the percentage reduction, which may be more readily understandable by the public.

2.21 Against this there are some important disadvantages. Firstly, the uncertainty in the average UK exposure increases as the rural background is subtracted (see Figure 2). A greater number of urban background sites would therefore be required to define the UK average with a reasonable level of certainty. Secondly, a large number of rural monitoring stations would need to be established. In addition, the rural background was not subtracted from the original health studies used to derive the costs and benefits of the Exposure-Reduction target (see Section 3). On balance, it is concluded that the rural background should not be subtracted for implementation at the UK level.

Implementation by Devolved Administrations

2.22 The implementation of the approach at the level of the Devolved Administrations offers some potential advantages over implementation solely at the UK level. In particular, urban background PM concentrations vary significantly across the UK, generally declining from south to north. The highest urban background PM concentrations are measured in the south east of England, due to the influence of PM precursor emissions originating from Europe, and are the lowest in Scotland and Northern Ireland. It may therefore be more appropriate to set different Exposure-Reduction targets for different parts of the UK. In addition, it would also be possible to define different ratios of monitoring sites to the urban population, taking account of the number and size of agglomerations in each country[9].

2.23 There are only limited urban background PM_{10} monitoring data outside of London and the rest of England. A summary of monitoring sites operating in Scotland, Wales and Northern Ireland in 2003 is provided in Table A4 (Appendix 1). For completeness this table contains a list of all sites operating in 2003[10], including those in UK networks and the **netcen** 'Calibration Club', and also including locations outside of the identified agglomerations above 100,000 population. In terms of UK network sites there are only three stations in Scotland, two in Wales and three in Northern Ireland. Recently, four additional sites have been established in the Belfast agglomeration, but they are not currently part of the UK network.

[9] If the Exposure-Reduction approach is adopted by the EU, then it would still be possible to define a UK Exposure-Reduction network from the sites forming the individual networks within the Devolved Administrations.

[10] Derived from Site Pro Forma prepared for the AQEG report on Particulate Matter in the UK.

2.24 Trends in PM_{10} concentrations at urban background/urban centre sites have been investigated for England, Scotland, Wales and Northern Ireland, and are shown plotted in Fig 3. The data are presented as 3-year rolling means, after normalising annual mean data to 2001. Whilst trends in England, Wales and Northern Ireland are broadly similar, there is evidence of a different relationship in Scotland where average PM_{10} levels have remained relatively constant, or have slightly increased since 1999. However, it is important to note that this is based on measurements from only 3 sites in Scotland, and that the upward trend is driven by concentrations at one site (Edinburgh Centre) which may have been significantly affected by dust emissions from local construction works in 2001 and 2002. The site was subsequently relocated in 2004. It is therefore uncertain as to how well these data describe actual trends in Scotland.

2.25 An analysis of future trends in PM_{10} concentrations has also been carried out, based on the work carried out by **netcen**. Figure 4 describes the population-weighted baseline projections for PM_{10} up until 2020, based upon 2002 measurement data. The data have been normalised to the 2002 base year, to indicate trends in each country and London. The reduction in the population-weighted baseline over this period varies from 21% in 2020 for Greater London to 15% in Scotland. The trend line is significantly different for Northern Ireland, presumably due to the early introduction of controls on domestic solid-fuel combustion.

2.26 There are insufficient data available to assess the number of sites that would be required in each country in order to define the average exposure of the urban population. An analysis has been carried out for London (see Fig 5) that suggests about 8 sites would be sufficient to define the average concentration to within ±5%. For the Devolved Administrations, in the absence of any quantitative assessment, it is suggested that a minimum of 5 sites should be used, in order to avoid potential problems with data loss, site closure etc.

2.27 A further issue when using a smaller number of monitoring stations to define exposure is the potential for a very large reduction at a single site to distort the average. Theoretically, this could allow the Exposure-Reduction target to be achieved, but would not accurately reflect exposure reduction to the population. This was explored in the previous report, where it was concluded it would not be a problem with a large number of monitoring sites. The potential impact with only 5 sites has been investigated further (see Appendix 2). It is concluded that even with a smaller number of sites, the average concentration is unlikely to be significantly affected by atypical changes in concentration at a single site, however it is suggested that criteria could be applied to define the maximum possible reduction at a single site, before it is necessary to exclude the site from the Exposure-Reduction network.

2.28 Implementation could be at the 250,000 or 100,000 agglomeration level. For the Devolved Administrations, there is an advantage to implementation at the 100,000 agglomeration level, as this extends the geographical area of inclusion (e.g. in the case of Scotland, the agglomerations of Aberdeen, Dundee and Falkirk are included).

2.29 A potential monitoring strategy that could be applied to the Devolved Administrations and Greater London is described in Table A5 (Appendix 1). The assessment is based on agglomerations over 100,000 population, with the ratio of monitoring sites in each country adjusted to take account of local circumstances[11]:

- Greater London and the rest of England: 1 site per 1 million population;
- Scotland: 1 site per 400,000 population;
- Wales: 1 site per 140,000 population;
- Northern Ireland: 1 site per 100,000 population.

2.30 There are a number of disadvantages in implementing the Exposure-Reduction approach at the level of the Devolved Administrations:

- it would add complexity to the system, and would inevitably require additional expansion of the monitoring network, particularly within the Devolved Administrations;
- it would be less robust, as it would be based on a smaller number of monitoring sites.

2.31 Against this, there are a number of significant advantages:

- it would be possible to define better geographical groupings of agglomerations by adjusting the ratio of monitoring stations, which would be beneficial from both the political and public perception point of view;
- it would be possible to set different Exposure-Reduction targets to reflect the different PM background contributions and PM composition in each country, and the measures that are being introduced to control emissions.

[11] It would be possible to apply the approach to agglomerations >250,000 for England and Greater London.

2.32 Subtraction of the rural background would be even more problematic than at the UK level, and it is concluded that this would not be practicable.

Implementation at the Regional Level

2.33 It would also be possible to introduce the approach at a regional level, for example the Devolved Administrations and regions within England based on Government Office or Environment Agency boundaries. Trends in PM_{10} concentrations at urban background/urban centre sites have been investigated for regions of the UK, as well as the Devolved Administrations, and are shown plotted in Fig 6. The data are presented as 3-year rolling means, after normalising the annual mean concentrations to 2001. The main feature of Figure 5 is that with the exception of Scotland already discussed above, the general trends in PM_{10} reduction appear similar across the UK.

2.34 Given that introduction of the approach at the regional level would introduce even greater complexity than at the level of the Devolved Administrations, without offering any significant advantages, this option is not considered further.

Implementation by Local Authorities

2.35 The principal of applying the Exposure-Reduction approach at the local authority level is attractive. It is clearly beneficial in health terms to require all local authorities to take local measures to minimise exposure of their inhabitants to PM. Whilst the primary intent of LAQM has been to address local hotspots of poor air quality which are difficult to address in a cost-effective manner using UK policy instruments, it would also seem appropriate that the current requirements under the LAQM regime to pursue achievement of the objectives should not become divorced from a UK scheme that includes Exposure Reduction.

2.36 A detailed assessment of options to implement the Exposure-Reduction approach at the local authority level has been carried out (see Appendix 3). It is concluded that the approach would be difficult to implement in practice at the local authority level. The approach relies on a 'stable' measure of urban background exposure, which in turn requires the averaging of concentrations across a number of monitoring sites. It is not considered practical to require all local authorities to establish and maintain a stable set of high quality urban background monitoring stations over the long term. In addition, the measures that could be implemented at a local level are expected to only have a small (albeit still beneficial) impact at reducing population exposure to PM, and would be too low to accurately identify by monitoring. It is therefore not recommended that a formal Exposure-Reduction system be devolved down to the local authority level.

2.37 A half-way option that could work, would be to encourage, or possibly require, groups or clusters of urban authorities to apply the Exposure-Reduction approach. For instance it is possible to conceive of the system working for local authority groups in larger metropolitan areas, including London, the West Midlands, Manchester and Tyne and Wear. A potential route for this could be to encourage inclusion of the Exposure-Reduction approach into regional or sub-regional air quality strategies that a number of local authorities have prepared, or are currently preparing.

2.38 The concept of requiring local authorities to consider measures to reduce exposure to PM, when developing Regional Spatial Strategies and Local Development Frameworks; when evaluating planning applications; and when developing Local Transport Plans, is judged to be one worthy of further assessment. This is in recognition that local authorities can make contributions to PM Exposure Reduction above and beyond those introduced at a UK level, through such measures as low-emission zones, congestion charging etc. These ideas are not, however, developed further in this report, as such requirements fall outside the scope of a formal Exposure-Reduction system.

Application to PM_{10} and/or $PM_{2.5}$

2.39 The general approach that has been set out above could be applied equally to both PM_{10} and/or $PM_{2.5}$. The principal implications regarding implementation for $PM_{2.5}$ are:

- there is a paucity of $PM_{2.5}$ monitoring sites in the UK. Currently, there are only four continuous sites operating, only one of which is at an urban background location (London Bloomsbury). Application of the Exposure-Reduction approach to $PM_{2.5}$ would require a significant restructuring or expansion of the network;

- if the approach is based on a 3-year rolling mean, as suggested, it would not be possible to define the baseline until at least the end of 2009[12].

2.40 At this time, the precise implications for the UK monitoring network of the proposals within the CAFE Thematic Strategy to introduce both a cap and an Exposure-Reduction target for $PM_{2.5}$, are still being evaluated.

2.41 The proposals within the Thematic Strategy retain the existing PM_{10} limit value, and thus the Exposure-Reduction approach could be implemented at the UK level for PM_{10}. However, as proposals for both a $PM_{2.5}$ cap and Exposure-Reduction target are now included, then the Exposure-Reduction approach could be also be implemented at the UK level for $PM_{2.5}$. In any event, the UK networks would need to be restructured to measure $PM_{2.5}$.

[12] This assumes all new sites start operation in January 2006.

Implications of Revising the PM Monitoring Method

2.42 Current PM_{10} monitoring in the UK is largely founded on the TEOM analyser. Various studies have shown that the TEOM measures lower concentrations than the European reference sampler due to the loss of the semi-volatile component. TEOM concentrations measured in the UK networks are currently scaled using a factor of 1.3 to account for this loss.

2.43 The use of this scaling factor is an interim measure. A detailed study to investigate the equivalence of a number of different PM analysers with the European reference sampler is currently underway, although the full results of the project will not be available until mid-2006.

2.44 The future of the PM networks in the UK is therefore uncertain. As the PM_{10} limit value is to remain, it may prove necessary to replace the existing TEOM network with modified or different instrument types. This has significant implications for the timescale for the introduction of an Exposure-Reduction scheme.

2.45 If the proposals for a $PM_{2.5}$ cap and Exposure-Reduction target are introduced, this issue of modifying an existing network would not arise, as a suitable $PM_{2.5}$ network does not currently exist.

Practicalities of Implementation

2.46 This section addresses the various practicalities of implementing the Exposure-Reduction approach. Based on the assessment carried out above, implementation at either the UK or Devolved Administrations (including Greater London) levels would be practicable. However, the advantages of the Devolved Administrations approach (including Greater London) probably outweigh confining the approach to the UK level. The approach based on implementation at the level of the Devolved Administrations is therefore explored in greater detail.

2.47 Table A6 (Appendix 1) describes a proposed monitoring strategy based on the agglomeration groups previously identified in Table A5. The table describes the agglomerations greater than 100,000 population, the agglomerations within each group, the total population lying within that area, the proposed monitoring station(s) that would be used to define the exposure, and the distance of each site from the nearest major road. There are a number of issues arising from Table A6:

- issues regarding site type (see para 2.7) would be even more critical where the total number of sites is reduced. For the Devolved Administrations, where only 5 sites are proposed, the relaxed siting criteria should be applied to no more than 1 location;

- it would be necessary to carry out some restructuring of the networks. In particular, additional sites would need to be commissioned or affiliated in London, the Liverpool/Birkenhead area, and in all of the Devolved Administrations;

- in terms of existing sites, London Bloomsbury, Leeds Centre, Sheffield Centre, Newcastle Centre, and Glasgow Centre are considered to be too close to roads[13]. These sites would need to be relocated.

2.48 As discussed in detail within the previous report, it is recommended that the approach should be based on a 3-year running mean in order to account for variations in year-by-year meteorological conditions. Regardless of whether the approach is based on PM_{10} or $PM_{2.5}$, because of the issues set out in paragraphs 2.39 and 2.41 above, it is unlikely that the baseline could be established before 2009 at the earliest. A practical date for implementation of the approach would therefore be 2010 (baseline established at the end of 2010, based on annual mean concentrations measured in 2008, 2009 and 2010. It is suggested that an appropriate year for the target reduction would be the end of 2020, based on annual mean concentrations measured in 2018, 2019 and 2020. This is consistent with the proposals in the Thematic Strategy.

2.49 The issue regarding the potential impact of a very large reduction at a single site was discussed in paragraph 2.26. Where the approach is based on fewer than 10 sites, it is suggested that in cases where the reduction at any individual site exceeds twice the reduction measured across all sites, then the data should be carefully investigated (e.g. assuming the average concentration measured across all sites was 12%, the maximum permissible reduction at any individual site would be no more than 24%).

2.50 Issues related to defining the required Exposure-Reduction targets, and the impact of these in combination with the objectives, are discussed in Section 3.

[13] Data on distances of monitoring stations and road traffic flows have been determined from the Site Information Archive. It is recommended that the information is checked before any decisions on relocation are implemented.

3 Impact of Exposure Reduction

3.1 This section considers UK targets that could be set for Exposure Reduction, the potential implementation of the approach in combination with air quality objectives, and the potential impact of the approach in terms of both costs and benefits to health.

3.2 A detailed analysis of measures to reduce PM_{10} and $PM_{2.5}$ concentrations in the UK has been carried out by **netcen** in support of the revised Air Quality Strategy[14 15]. A range of scenarios related to the control of PM emissions has been examined[16]. These have been combined into two 'scenario packages' which are summarised in Table 1 below, and are described in detail in Appendix 4. These scenarios will be considered during the revision of the Air Quality Strategy, and should thus only be taken to be illustrative of possible packages that may be adopted.

Table 1: Summary of Scenario Packages

Scenario	Includes
Baseline	Current and agreed future policies.
Scenario 'P'	Incentives for early uptake of Euro V and VI standards plus reduction in emissions from small combustion plants.
Scenario 'Q'	Incentives for early uptake of Euro V and VI standards, plus incentives to increase penetration of low emission vehicles and reduction in emissions from small combustion plants..

3.3 The impact of these combined scenarios on PM_{10} and $PM_{2.5}$ concentrations in 2010 and 2020 has been used to quantify the expected health benefits, for input into a cost-benefit analysis.

3.4 For each scenario, the percentage reduction in population-weighted annual mean concentrations has been calculated in 2010, 2015 and 2020 for both PM_{10} and $PM_{2.5}$, with respect to a 2003 baseline. The results are shown plotted in Figures 7 to 11 for Greater London, the Rest of England and the Devolved Administrations, and are summarised for the 2020 scenario 'Q' in

[14] Grice S E, Bush T J, Stedman J R, Vincent K J, Kent A J and Targa J (2006) Baseline projections of air quality in the UK for the 2006 review of the Air Quality Strategy. AEA Technology, National Environmental Technology Centre. Report AEAT/ENV/R/1936.

[15] Stedman, J R, Grice, S E, Bush, T J, Murrells, T P and Hobson, M (2006) Projections of air quality in the UK for additional measures scenarios for the 2006 review of the Air Quality Strategy. AEA Technology, National Environmental Technology Centre. Report AEAT/ENV/R/1986.

[16] The measures considered do not focus specifically on local hotspots, as it would be impractical to do so at a UK level.

Table 2. The greatest reductions occur in Greater London, with a baseline (2020) reduction in PM_{10} concentration of 18% (compared with the 2003 baseline) increasing to a 24% reduction for the 2020 scenario 'Q'. The comparable reductions for $PM_{2.5}$ are greater, with a 26% reduction for the 2020 baseline (compared with the 2003 baseline) increasing to a 31% reduction for the 2020 scenario 'Q'. The lowest reductions occur in Scotland due, in part, to the smaller contribution of primary PM emissions.

Table 2: Percentage reduction in population-weighted annual mean concentrations in 2020 for scenario 'Q' compared with 2003 baseline

	PM_{10}	$PM_{2.5}$
Greater London	24.1%	31.0%
Rest of England	20.8%	28.2%
Scotland	16.9%	24.1%
Wales	18.9%	26.4%
Northern Ireland	18.2%	22.3%
UK	20.9%	28.2%

3.5 An analysis has also been carried out to identify the impact of each combined scenario package in 2020 compared with the 2020 baseline. A summary is provided in Table 3 which describes both the absolute (µg/m^3) reduction in population-weighted mean concentrations and the percentage reduction achievable. The reductions described are in addition to those that are expected to be achieved by current and agreed future measures. For scenario 'Q', the greatest reduction occurs in London (6.5% for PM_{10} and 6.7% for $PM_{2.5}$) and the lowest reduction in Northern Ireland (2.3% for PM_{10} and 3.3% for $PM_{2.5}$).

Table 3: Reductions in population-weighted annual mean PM_{10} and $PM_{2.5}$ concentrations ($\mu g/m^3$ gravimetric) for each combined scenario in 2020 compared with the 2020 baseline

Scenario	London		England		Scotland		NI		Wales		UK	
	Reduction ($\mu g\ m^{-3}$)	Reduction (%)	Reduction ($\mu g\ m^{-3}$)	Reduction (%)	Reduction ($\mu g\ m^{-3}$)	Reduction (%)	Reduction ($\mu g\ m^{-3}$)	Reduction (%)	Reduction ($\mu g\ m^{-3}$)	Reduction (%)	Reduction ($\mu g\ m^{-3}$)	Reduction (%)
'P' PM_{10}	1.29	6.1	0.76	4.1	0.51	3.5	0.36	2.2	0.53	3.1	0.78	4.2
'Q' PM_{10}	1.34	6.3	0.78	4.2	0.52	3.5	0.37	2.3	0.54	3.2	0.80	4.3
'P' $PM_{2.5}$	0.81	6.4	0.55	5.1	0.34	4.6	0.25	3.2	0.40	4.2	0.55	5.2
'Q' $PM_{2.5}$	0.84	6.7	0.57	5.3	0.35	4.7	0.26	3.3	0.42	4.4	0.57	5.3

Table 4: Reductions in population-weighted (100 K agglomerations) annual mean PM_{10} and $PM_{2.5}$ concentrations ($\mu g/m^3$ gravimetric) in 2020 for each combined scenario compared with 2010

	London		England		Scotland		NI		Wales		UK	
Scenario	Reduction		Reduction		Reduction		Reduction		Reduction		Reduction	
	ug/m^3	%	ug/m^3	%	ug/m^3	%	ug/m^3	%	ug/m^3	%	ug/m^3	%
'P' PM_{10}	2.79	12.3	2.16	10.3	1.38	8.4	1.19	6.5	1.86	9.4	2.24	10.7
'Q' PM_{10}	2.83	12.5	2.17	10.4	1.39	8.5	1.19	6.5	1.87	9.5	2.26	10.8
'P' $PM_{2.5}$	2.46	17.3	1.96	15.7	1.19	13.7	1.00	11.1	1.72	14.9	2.01	16.0
'Q' $PM_{2.5}$	2.49	17.4	1.97	15.8	1.20	13.7	1.01	11.1	1.73	15.0	2.02	16.1

Setting the E-R Target

3.6 Potential UK targets for Exposure Reduction have been considered by comparing the population-weighted annual mean concentrations in 2010 (the proposed baseline year for Exposure Reduction) with those predicted for 2020 (the proposed target year). Both PM_{10} and $PM_{2.5}$ have been considered. Predictions based on populations within the 100,000 agglomerations have been used, consistent with the proposed monitoring network for Exposure Reduction.

3.7 Table 4 describes both the absolute ($\mu g/m^3$) reduction in population-weighted mean concentration and the percentage reduction achievable for each combined scenario in 2020 compared with 2010. It should be noted that the 2010 values include the additional scenario measures that would be implemented in part prior to this date.

3.8 The projected reductions for Greater London, the Rest of England and the Devolved Administrations are summarised in Table 5 below for scenario 'Q', and could be used as the basis for setting the Exposure-Reduction targets for either PM_{10} or $PM_{2.5}$.

Table 5: Potential target reduction (2010 to 2020) for Exposure Reduction based on implementation of scenario 'Q' (based on percentage reduction in population-weighted means within 100K agglomerations)

	Target reduction compared with 2010	
	PM_{10}	**$PM_{2.5}$**
London	12.5	17.4
Rest of England	10.3	15.8
Scotland	8.4	13.7
Wales	9.4	15.0
Northern Ireland	6.5	11.1
UK	10.7	16.1

Analysis of Options

3.9 A 'threshold assessment' of the 2010 and 2020 Baseline and the combined scenario projections for both PM_{10} and $PM_{2.5}$ has been carried out by **netcen**[17]. This analysis identifies the exceedences of threshold concentrations for background locations (in terms of population

[17] All the analyses presented here are based on a 2003 base year.

exposure) and roadside locations (in terms of lengths of major urban roads). Threshold concentrations for both 'very few' and 'zero' exceedences have been calculated. Whilst a 'zero exceedence' analysis presents a worst case, it is believed that this threshold concentration is often influenced by industrial point sources.

3.10 A summary of the threshold concentrations for PM_{10} and $PM_{2.5}$ which would deliver both 'zero' and 'very few' exceedences at roadside locations for the scenario 'Q' package of measures is summarised in Table 6. A complete analysis is provided in Appendix 5. As an example, for the 2010 Baseline scenario, there would be no road links in Greater London with PM_{10} concentrations exceeding 41µg/m^3, and very few road links exceeding 37 µg/m^3.

Table 6: Threshold concentrations with 'very few' or zero exceedences of predicted annual mean roadside PM_{10} and $PM_{2.5}$ (µg/m^3 gravimetric) concentrations (2003 base year). Zero exceedences shown in parentheses.

	2010 Baseline	2020 Baseline	2010 s 'Q'	2020 s 'Q'
PM_{10}				
Greater London	37 [41]	33 [37]	36 [38]	27 [29]
Rest of England	34 [38]	31 [35]	33 [37]	28 [32]
Scotland	30 [37]	26 [31]	28 [34]	20 [22]
Wales	29 [31]	25 [27]	28 [30]	22 [24]
Northern Ireland	24 [25]	23 [24]	23 [24]	22 [22]
UK	37 [41]	33 [37]	36 [38]	28 [32]
$PM_{2.5}$				
Greater London	21 [23]	18 [20]	20 [22]	15 [16]
Rest of England	19 [21]	16 [17]	18 [20]	14 [16]
Scotland	15 [20]	14 [16]	16 [19]	11 [12]
Wales	16 [17]	14 [15]	16 [17]	12 [12]
Northern Ireland	12 [12]	11 [12]	12 [12]	10 [11]
UK	21 [23]	18 [20]	20 [22]	15 [16]

3.10 The following conclusions may be drawn from this analysis:

- based on 'very few' exceedences, the existing 2004 PM_{10} 24-hour objective, which is equivalent to an annual mean of 31.5 µg/m^3, is not met in 2010 in Greater London or the Rest of England with either the Baseline or scenario 'Q'. If a zero exceedence threshold is applied, this objective is not achieved in the Rest of England in 2020 with the scenario 'Q'[18].
- the 2010 annual mean objective for Scotland (18 µg/m^3) is not met in 2010 or 2020 for either the Baseline or scenario 'Q';
- the 2010 provisional objectives for the Rest of England, Wales and Northern Ireland (20 µg/m^3) are not met in 2010 or 2020 for either the Baseline or scenario 'Q';

[18] Exceedence of 24-mean objective assumed to be equivalent to an annual mean concentration of 31.5 µg/m^3

- the 2010 and 2015 provisional objectives for Greater London (23 µg/m^3 and 20 µg/m^3 respectively) are not met in 2010 or 2020 for either the Baseline or scenario ‘Q’.

3.11 A more detailed analysis of the threshold projections is provided in Figures 12 to 16 which describe the distribution of road lengths exceeding PM_{10} threshold concentrations (annual mean or annual mean equivalent) in 2020, assuming implementation of scenario ‘Q’. Forecast exceedences of 20 µg/m^3 PM_{10} in Scotland, Wales and Northern Ireland, and 25 µg/m^3 PM_{10} in Greater London and the Rest of England, are confined to small lengths of road.

3.12 Whilst the combined scenarios are insufficient to deliver the provisional 2010 objectives (and the 2010 objective in Scotland) at roadside locations, implementation of scenario ‘Q’ has a dramatic effect in reducing the population exposed to PM_{10} concentrations above 20 ug/m^3, as illustrated in Table 7. Populations exposed to PM_{10} concentrations above 20 µg/m^3 are reduced between 60% (London) and 99% (Northern Ireland) compared with the 2010 baseline.

Table 7: Populations in areas exceeding 20 µg/m^3 (gravimetric) PM_{10} concentrations for baseline and scenario ‘Q’ projections

	Total Population	Population exceeding 20 µg/m^3 gravimetric				%change of 2020 s ‘Q’ compared to 2010 baseline
		2010 baseline	2010s ‘Q’	2020 baseline	2020s ‘Q’	
London	7,730,326	7,727,768	7,727,768	6,919,180	3,151,906	-59.21%
Rest of England	41,011,137	20,904,147	19,503,573	8,313,678	3,652,434	-82.52%
Scotland	4,944,573	41,611	32,715	32,421	13,928	-66.53%
Wales	2,850,727	352,663	300,954	136,343	67,825	-80.77%
Northern Ireland	1,623,309	65,651	43,950	22,227	885	-98.65%
UK	58,160,071	29,091,840	27,608,959	15,423,848	6,886,978	-76.17%

Comparison of Objective and Exposure-Reduction Approaches

3.13 The analysis provided in Table 6 indicates that the provisional 2010 annual mean objectives for Greater London, the Rest of England, Wales and Northern Ireland, and the 2010 annual mean objective for Scotland, cannot be delivered even with implementation of the scenario ‘Q’ package of measures. At this stage, the health benefits of reducing PM_{10} concentrations to below 20 µg/m^3 (and below 18 µg/m^3 in Scotland) at roadside locations alone has not been quantified, but is not expected to be significant due to the relatively small numbers of people that are exposed.

3.14 Additional measures to reduce PM_{10} concentrations beyond the scenario ‘Q’ package may be implemented at the local level, for example via the LAQM regime, but in many cases these are unlikely to deliver the significant reductions required to meet the 2010 objectives unless dramatic actions are taken e.g. the closure of major urban roads. Such measures are expected to be disproportionate in terms of the costs incurred and the health benefits delivered.

3.15 Whilst the scenario 'Q' package does not deliver the 2010 objectives, the additional measures have a significant effect in reducing population exposure to PM_{10} (and $PM_{2.5}$) concentrations. The analysis of population-weighted mean concentrations has been used to estimate the health benefits, and together with the costs estimated for each of the scenario packages, combined to generate a cost-benefit analysis[19]. The benefits are based solely on the health effects e.g. the effect on life expectancy, and hospital admissions. No allowance has been made for non-health effects such as the costs to society associated with climate change, and ecosystem benefits. The total costs have been split by area based on emission projections and therefore the results for each individual area should be considered indicative. The results are summarised in Table 8 as estimates of annualised Net Present Value. Both 'Low' and 'High' estimates have been prepared[20].

Table 8: Summary of cost-benefit analysis for Scenarios 'P' and 'Q', Annualised Net Present Value (£ million)

	Scenario 'P'		Scenario 'Q'	
	Low	High	Low	High
Greater London	134	343	138	347
Rest of England	240	962	209	921
Scotland	8	66	3	60
Wales	5	39	2	36
Northern Ireland	-1	12	-3	11
UK	386	1,421	349	1,375

3.16 For both scenario 'P' and 'Q', the outcome for the UK is a net benefit (i.e. the benefits are greater than the costs) with both the 'Low' and 'High' assumptions. The combination of objectives and an Exposure-Reduction target will ensure a tight linkage between the regulatory objectives and public health outcomes, whilst also ensuring that a there is a minimum standard of air quality applied to the entire UK population. This combination is therefore likely to be a cost-beneficial approach to the control of a non-threshold pollutant such as PM. From the analyses provided in Table 6, a 2020 annual mean objective at the UK level of about 32 $\mu g/m^3$ (PM_{10}) or 16 $\mu g/m^3$

[19] 'An Economic Analysis to Inform the Air Quality Strategy Review Consultation*: Third Report of the Interdepartmental Group on Costs and* Benefits, Defra (2006). Available at http://www.defra.gov.uk/environment/airquality/strategy/igcb/index.htm

[20] The quantified benefits used in these estimates assume a 6% reduction in mortality rate per 10$\mu g/m^3$, based on a recent update by COMEAP ('Quantification of the Effects of Air Pollutants on Health in the UK. Interim Statement' (January 2006)). The Low and High estimates are based on differing assumptions regarding the lag time between changes in PM concentrations and chronic health impacts, different thresholds for ozone effects and differing values to be applied to the quantified health effects.

($PM_{2.5}$), in conjunction with Exposure-Reduction targets (2010 to 2020) for the UK and the Devolved Administrations ranging between 8 and 15%, could be adopted. The suggested new PM_{10} objective is effectively equivalent to the current 2004 24-hour PM_{10} objective, which is approximately equivalent to an annual mean of 31.5 $\mu g/m^3$.

3.17 Whilst it may be argued that the introduction of 2020 concentration objectives could alone deliver the benefits in reduction of population exposure (as they are based on the same measures within scenario 'Q'), the adoption of the Exposure-Reduction approach offers significant advantages:

- it may be possible to achieve the proposed 2020 objectives in part via local measures to reduce PM_{10} concentrations at hot spots, rather than the scenario 'Q' package. This would not deliver the reduction in population exposure, and associated health benefits that have been described;
- the Exposure-Reduction target provides a compliance mechanism by which the success of the proposed measures in terms of overall reduced population exposure may be monitored.

3.18 An analysis of four potential options for the introduction of the Exposure-Reduction approach in combination with air quality objectives is considered. Regardless of which option is adopted, it is assumed that the existing 2004 objective for PM_{10} would remain in place. The four options are:

- PM_{10} Exposure Reduction with a new PM_{10} annual mean objective
- PM_{10} Exposure Reduction with $PM_{2.5}$ objective
- $PM_{2.5}$ Exposure Reduction with a new PM_{10} annual mean objective
- $PM_{2.5}$ Exposure Reduction with $PM_{2.5}$ objective

3.19 A comparison of the various options for combinations of objectives and the Exposure-Reduction approach is set out in Table 9 below. The CAFE Thematic Strategy proposes a new $PM_{2.5}$ cap, together with an Exposure-Reduction target also based on $PM_{2.5}$. The adoption of a new $PM_{2.5}$ objective together with an Exposure-Reduction target also based on $PM_{2.5}$ would be consistent with the proposed EU approach.

3.20 Whilst a new objective and Exposure-Reduction approach based on PM_{10} would involve minimum restructuring of the existing network, this would not be consistent with the recommendations of the World Health Organisation regarding a standard based on $PM_{2.5}$.

3.21 It is concluded that an Exposure-Reduction approach based on $PM_{2.5}$, together with a new objective based upon either PM_{10} or $PM_{2.5}$ would be the most suitable combination.

3.22 It is important to bear in mind that there are risks involved in an early adoption of an Exposure-Reduction approach in advance of the formal adoption of such an approach by the EU. The UK system might in these circumstances be inconsistent with the EU approach, which would inevitably be confusing. The only way to avoid such a risk would be to await the final adoption of a new EU Directive, as changes might take place up until the last minute[21]. This is likely to require delaying a decision on a UK Exposure-Reduction system until some time in 2006 or 2007.

Table 9: Summary of Advantages and Disadvantages of Objective and Exposure-Reduction combinations

	Advantages	Disadvantages
New PM_{10} objective + PM_{10} E-R	Measurement of single pollutant. Would not require any significant changes to the existing network.	Inconsistent with the recommendations of WHO regarding the introduction of a $PM_{2.5}$ standard. Would require some realignment of existing PM_{10} network to meet the requirements for E-R.
New PM_{10} objective + $PM_{2.5}$ E-R	Provides control of PM_{coarse} emissions at hot spots (roadsides, construction sites) and is consistent with the recommendations of WHO regarding the introduction of a $PM_{2.5}$ standard.	Require a new $PM_{2.5}$ monitoring network to be established. If CAFÉ Thematic Strategy proposals are implemented, a new network would need to be established in any case.
$PM_{2.5}$ objective + PM_{10} E-R	Consistent with the recommendations of WHO regarding the introduction of a $PM_{2.5}$ standard.	Control of emissions at hot spots would be limited to the existing PM_{10} objective. Require both a new $PM_{2.5}$ network to be established and some realignment of existing PM_{10} network to meet the requirements for E-R.
$PM_{2.5}$ objective + $PM_{2.5}$ E-R	Measurement of single pollutant. Consistent with the recommendations of WHO regarding the introduction of a $PM_{2.5}$ standard. Based on current knowledge, this approach conforms with the proposals in the Thematic Strategy.	Control of emissions at hot spots would be limited to the existing PM_{10} objective. Require a new $PM_{2.5}$ monitoring network to be established.

21 A decision could be based on the proposals within the draft Directive, which is available. There would though still be an element of risk.

4 Application of Exposure Reduction to Other Pollutants

4.1 The first report specifically considered how an Exposure-Reduction approach might be applied to PM (either PM_{10} or $PM_{2.5}$), but recognised that the approach might equally be applied to other non-threshold pollutants. This section considers the potential for applying the Exposure-Reduction approach to other non-threshold pollutants such as benzene, 1,3-butadiene, ozone and PAH (benzo[a]pyrene).

Benzene

4.2 The Government and the Devolved Administrations have adopted a running annual mean concentration of 16.25 µg/m^3 for benzene as the objective to be achieved by 2003, with additional objectives of 5 µg/m^3 as an annual mean (England and Wales), and 3.25 µg/m^3 as a running annual mean (Scotland and Northern Ireland) to be achieved by 2010. The second Daughter Directive also sets a limit value for benzene of 5 µg/m^3 to be achieved by 2010.

4.3 Measured concentrations at all urban background and roadside sites remain significantly below the 2003 objective. Forecasts based on UK mapping suggest that the policy measures already in place will deliver both the 2010 objectives and the limit value at all urban background, and all roadside locations. There is the possibility of some remaining exceedences at locations in close proximity to petrol stations and industrial sites (petrochemical processes).

4.4 Health advice from EPAQS and the Department of Health's Committee on Carcinogenicity of Chemicals I Food, Consumer Products and the Environment (COC) is to reduce concentrations of benzene in air to as low a level as possible. The Exposure-Reduction approach could be implemented alongside the objectives and limit values.

4.5 At this stage however, there is no agreed exposure response function that would allow the health benefits of reducing urban background exposure to benzene to be estimated. It would therefore not be practical to set an Exposure-Reduction target, nor to quantify the benefits. Pending further development of an exposure response function for the UK, it is not recommended that the Exposure-Reduction approach is introduced for benzene at this time.

1,3-Butadiene

4.6 The Government and the Devolved Administrations have adopted a maximum running annual mean concentration of 2.25 µg/m^3 for 1,3-butadiene as the objective to be achieved by 2003.

Measurements of 1,3-butadiene are currently carried out at only a very limited number of sites, and only one urban background location (Cardiff). The measured concentrations in recent years have all been well below the objective.

4.7 Emissions of 1,3-butadiene continue to be dominated by the road transport sector, although levels have declined significantly following the introduction of catalytic converters. There is a justification to introduce the approach for 1,3-butadiene, but this needs to be considered in terms of the costs and benefits that would arise.

4.8 However, as in the case of benzene there is no agreed exposure response function that would allow the health benefits of reducing urban background exposure to 1,3-butadiene to be estimated. It would therefore not be practical to set an Exposure-Reduction target, nor to quantify the benefits. Pending further development of an exposure response function for the UK, it is not recommended that the Exposure-Reduction approach is introduced for 1,3-butadiene at this time.

PAH

4.9 The Government and the Devolved Administrations have adopted an annual mean concentration of 0.25 ng/m^3 for PAH (determined as B[a]P) as the objective to be achieved by 2010. The fourth Daughter Directive also sets a target value for B[a]P of 1.0 ng/m^3 as an annual mean by 2010.

4.10 The monitoring network for PAH has expanded in recent years, and now includes 17 urban background or urban industrial sites across the UK, together with additional monitoring sites located in the proximity of significant industrial emission sources. Monitoring results in 2003[22] indicate that the EU target value was met at all non-industrial sites. It was closely approached in Lisburn (0.95 ng/m^3), due to the contribution of local domestic emissions, and was exceeded in Scunthorpe (1.26 ng/m^3) due to industrial emissions. The UK objective was met at all urban background sites (with the exception of Lisburn) but was closely approached in several locations. Like 1,3-butadiene, there is a justification to introduce the approach for B[a]P, but this again needs to be considered in terms of the costs and benefits that would arise:

- The network of monitoring stations is still limited within the agglomerations, and some expansion would probably be required;

[22] AEA Technology (2004) Assessment of benzo[a]pyrene concentrations in the United Kingdom in 2003. A report prepared for Defra and the Devolved Administrations.

- The emissions inventory for PAH is poorly defined. The main sources within urban areas include a contribution from road traffic (approximately 8%) and significant contributions from the regional background and miscellaneous sources including uncontrolled fires. It would be extremely difficult to predict future concentrations against the baseline upon which an exposure reduction target could be set;

- The principal exceedences of the objective occur at isolated hot-spots influenced by very local industrial or domestic emissions. Controls are adequately exercised via IPC and the objectives;

- Reductions in PAH concentrations are likely to arise as a result of measures imposed to control PM. The Exposure-Reduction approach for PM would be expected to provide a reduction in PAH concentrations as well.

4.11 It is not recommended at this point in time that the Exposure-Reduction approach is introduced for PAH.

Ozone

4.12 The third Daughter Directive sets both long-term objectives and target values to be achieved where possible by 2010. The target values follow the Directive on National Emissions Ceilings. Defra and the Devolved Administrations have also set an air quality objective to be achieved by 2005. The objectives and targets are all based on short-term exposure (8-hour mean).

4.13 There is a wide network of ozone monitoring stations in the UK. Exceedences of the 2005 objective and the 2010 target value are common, but vary considerably from year to year depending upon the prevailing meteorological conditions.

4.14 At this stage, it is not certain that ozone is a non-threshold pollutant in terms of human health effects. There would be a number of difficulties with incorporating ozone into an Exposure-Reduction approach:

- The objectives and targets are based on exceedences of an 8-hour mean. It would be extremely difficult to set a baseline and exposure-reduction target based upon an 8-hour mean, as the number of exceedences will vary considerably from one year to another[23];

[23] A new measure that could possibly be utilised is the annual mean of daily maximum 8-hour concentrations. This is not explored further here.

- The highest concentrations of ozone, and the greatest numbers of exceedences, are measured outside of urban areas, generally in rural locations. Population exposure in rural areas is low (as population density is low);

- Annual mean concentrations in urban areas are predicted to increase in future years as emissions of NOx are reduced. It would be extremely difficult to meet an Exposure-Reduction target based on an annual mean.

4.15 It is concluded that the Exposure-Reduction approach is not well suited to ozone, and that controls are best exercised through the existing UK objectives, EU targets and objectives, and the National Emissions Ceiling.

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Appendix 1: Tables

Table A1: Analysis of Agglomeration Groups (Implementation at UK level, agglomerations greater than 250,000, 1 site per 1 million population)

Area	Individual agglomeration size	Population of agglomeration group	No.Sites
UK		24,619,964	24
London	7,650,944	7,650,944	8
West Midlands	2,296,180	2,296,180	2
Greater Manchester	2,277,330	2,277,330	2
West Yorkshire	1,445,981	2,079,343	2
Sheffield	633,362		
Tyneside	885,981	1,255,590	1
Teeside	369,609		
Liverpool	837,998	1,108,205	1
Birkenhead	270,207		
Potteries	367,976	981,702	1
Nottingham	613,726		
Leicester	416,601	747,849	1
Coventry	331,248		
Bristol	522,784	1,102,144	1
Cardiff	306,904		
Swansea	272,456		
Brighton	437,592	1,040,098	1
Southend	266,749		
Reading	335,757		
Portsmouth	409,341	1,044,414	1
Bournemouth	358,321		
Southampton	276,752		
Blackpool	261,355	828,402	1
Preston	256,411		
Hull	310,636		
Glasgow	1,315,544	1,315,544	1
Edinburgh	416,232	892,219	1
Belfast	475,987		

Table A2: Analysis of Agglomeration Groups (Implementation at UK level, agglomerations greater than 250,000, 1 site per 750,000 population)

Area	Individual agglomeration size	Population of agglomeration group	No.Sites
UK		24,619,964	31
London	7,650,944	7,650,944	9
West Midlands	2,296,180	2,296,180	3
Greater Manchester	2,277,330	2,277,330	3
West Yorkshire	1,445,981	1,445,981	2
Sheffield	633,362	633,362	1
Teeside	369,609	680,245	1
Hull	310,636		
Tyneside	885,981	885,981	1
Liverpool	837,998	837,998	1
Blackpool	261,355	787,973	1
Preston	256,411		
Birkenhead	270,207		
Potteries	367,976	981,702	1
Nottingham	613,726		
Leicester	416,601	747,849	1
Coventry	331,248		
Cardiff	306,904	579,360	1
Swansea	272,456		
Bristol	522,784	858,541	1
Reading	335,757		
Bournemouth	358,321	635,073	1
Southampton	276,752		
Portsmouth	409,341	1,113,682	1
Southend	266,749		
Brighton	437,592		
Glasgow	1,315,544	1,315,544	2
Edinburgh	416,232	892,219	1
Belfast	475,987		

Table A3: Analysis of Agglomeration Groups (Implementation at UK level, agglomerations greater than 100,000, 1 site per 1 million population)

Area	Individual agglomeration size	Population of agglomeration group	No.Sites
UK		24,619,964	29
London	7,650,944	7,650,944	8
West Midlands	2,296,180	2,296,180	2
Greater Manchester	2,277,330	2,277,330	2
West Yorkshire	1,445,981	2,079,343	2
Sheffield	633,362		
Tyneside	885,981	1,444,871	1
Sunderland	189,281		
Teeside	369,609		
Liverpool	837,998	1,108,205	1
Birkenhead	270,207		
Potteries	367,976	981,702	1
Nottingham	613,726		
Leicester	416,601	747,849	1
Coventry	331,248		
Brighton	437,592	846,933	1
Portsmouth	409,341		
Bristol	522,784	1,157,857	1
Bournemouth	358,321		
Southampton	276,752		
Blackpool	261,355	1,246,709	1
Preston	256,411		
Southport	116,315		
Wigan	174,406		
Blackburn	135,858		
Burnley	149,906		
Warrington	152,458		
Hull	310,636	911,996	1
York	124,609		
Grimsby	136,456		
Doncaster	128,847		
Barnsley	211,448		
Derby	223,836	1,071,607	1
Chesterfield	105,660		
Mansfield	154,966		
Nothampton	183,082		
Milton Keynes	156,148		
Cambridge	113,127		
Peterborough	134,788		

Area	Individual agglomeration size	Population of agglomeration group	No.Sites
Southend	266,749	1,147,529	1
Margate	116,745		
Gillingham	222,388		
Basildon	102,913		
Hastings	120,044		
Norwich	185,420		
Ipswich	133,270		
Reading	335,757	1,258,345	1
Slough	126,662		
Luton	221,337		
High Wycombe	116,361		
Farnborough	231,194		
Crawley	115,554		
St Albans	111,480		
Plymouth	245,295	960,024	1
Torquay	102,576		
Cheltenham	102,633		
Swindon	145,236		
Gloucester	126,149		
Telford	119,340		
Oxford	118,795		
Cardiff	306,904	694,882	1
Swansea	272,456		
Newport	115,522		
Glasgow	1,315,544	1,315,544	1
Edinburgh	416,232	888,135	1
Aberdeen	199,747		
Dundee	154,697		
Falkirk	117,459		
Belfast	475,987		

Table A4: Summary of PM_{10} monitoring sites in Scotland, Wales and Northern Ireland (Urban Background, Urban Centre and Suburban classifications)

Country	Site name	Site Type	Network Status[(c)]
Scotland	Aberdeen	Urban Background	AURN
	Edinburgh St Leonards	Urban Background	AURN
	Glasgow Centre[(a)]	Urban Background	AURN
Wales	Cwmbran[(b)]	Urban Background	AURN
	Port Talbot[(b)]	Urban Background	AURN
	Cardiff Centre	Urban Background	AURN
	Swansea	Urban Background	AURN
	Vale of Glamorgan[(b)]	Urban Background	Cal Club
Northern Ireland	Belfast Centre	Urban Background	AURN
	Belfast Clara St	Urban Background	AURN
	Carrickfergus	Urban Background	Cal Club
	Castlereagh	Urban Background	Cal Club
	Lisburn Dunmurray	Urban Background	Cal Club
	Lisburn Civic Centre	Urban Background	Cal Club
	Derry[(b)]	Urban Background	AURN
	Derry Brandywell[(b)]	Urban Background	Cal Club
	North Down Bangor[(b)]	Urban Background	Cal Club
	Strabane Springhill[(b)]	Urban Background	Cal Club
	Craigavon[(b)]	Urban Background	Cal Club
	Craigavon Lord Lurgan[(b)]	Urban Background	Cal Club
	Newry[(b)]	Urban Background	Cal Club
	Ards[(b)]	Urban Background	Cal Club

(a) There is some doubt as to whether this site is suitable for describing population exposure across the agglomeration.
(b) These sites do not lie within identified agglomerations >100,000.
(c) AURN – UK network; Cal Club – **netcen** calibration club.

Table A5: Analysis of Agglomeration Groups (Implementation at DA level, agglomerations greater than 100,000)

Area	Individual agglomeration size	Population of agglomeration group	No.Sites
Greater London	7,650,944	7,650,944	8
London	7,650,944	7,650,944	8
Rest of England		19,536,480	18
West Midlands	2,296,180	2,296,180	2
Greater Manchester	2,277,330	2,277,330	2
West Yorkshire	1,445,981	2,079,343	2
Sheffield	633,362		
Tyneside	885,981	1,444,871	1
Sunderland	189,281		
Teeside	369,609		
Liverpool	837,998	1,108,205	1
Birkenhead	270,207		
Potteries	367,976	981,702	1
Nottingham	613,726		
Leicester	416,601	747,849	1
Coventry	331,248		
Brighton	437,592	846,933	1
Portsmouth	409,341		
Bristol	522,784	1,157,857	1
Bournemouth	358,321		
Southampton	276,752		
Blackpool	261,355	1,246,709	1
Preston	256,411		
Southport	116,315		
Wigan	174,406		
Blackburn	135,858		
Burnley	149,906		
Warrington	152,458		
Hull	310,636	911,996	1
York	124,609		
Grimsby	136,456		
Doncaster	128,847		
Barnsley	211,448		
Derby	223,836	1,071,607	1
Chesterfield	105,660		
Mansfield	154,966		
Nothampton	183,082		
Milton Keynes	156,148		
Cambridge	113,127		
Peterborough	134,788		

Area	Individual agglomeration size	Population of agglomeration group	No.Sites
Southend	266,749	1,147,529	1
Margate	116,745		
Gillingham	222,388		
Basildon	102,913		
Hastings	120,044		
Norwich	185,420		
Ipswich	133,270		
Reading	335,757	1,258,345	1
Slough	126,662		
Luton	221,337		
High Wycombe	116,361		
Farnborough	231,194		
Crawley	115,554		
St Albans	111,480		
Plymouth	245,295	960,024	1
Torquay	102,576		
Cheltenham	102,633		
Swindon	145,236		
Gloucester	126,149		
Telford	119,340		
Oxford	118,795		
Scotland		**2,203,679**	**5**
Glasgow	1,315,544	1,315,544	1
Edinburgh	416,232	888,135	1
Aberdeen	199,747		
Dundee	154,697		
Falkirk	117,459		
Wales		**694,882**	**5**
Cardiff	306,904	694,882	1
Swansea	272,456		
Newport	115,522		
Northern Ireland		**475,987**	**5**
Belfast	475,987	475,987	5

Table A6: Proposed monitoring sites for Exposure-Reduction. Implementation at Devolved Administrations and Greater London

Greater London

Area	Individual agglomeration size	Population of agglomeration group	No. sites	Monitoring Site	Site type	Distance from major roads	Comments
Greater London	7,650,944	7,650,944	8	London Brent	U/B	30 metres from nearest road (8,000 vpd)	
				London Bloomsbury	U/C	35 metres from nearest road (35,000 vpd)	Site likely to be unsuitable due to proximity of busy road
				London Kensington	U/B	Surrounding area mainly residential	
				Croydon 3	Suburban	Surrounding area mainly residential	Affiliate from LAQN
				Greenwich 4 (Eltham)	U/B	65 metres from nearest road (15,000 vpd)	Affiliate from LAQN
				Tower Hamlets 1	U/B	70 metres from nearest busy road	Affiliate from LAQN
				Ealing 7 (Southall)	U/B	Surrounding area mainly residential	Affiliate from LAQN
				Harrow 1 (Stanmore)	U/B	100 metres from nearest road	Affiliate from LAQN

Rest of England

Area	Individual agglomeration size	Population of agglomeration group	No. sites	Monitoring Site	Site type	Distance from major roads	Comments
Rest of England		19,536,480	18				
West Midlands	2,296,180	2,296,180	2	Birmingham Tyburn Sandwell, West Bromwich	U/B U/C	In grounds of school. No main roads adjacent 100 metes from nearest main road	 No PM_{10} monitoring at present
Greater Manchester	2,277,330	2,277,330	2	Manchester Piccadilly Bolton	U/C U/B	Adjacent to pedestrianised areas and tramlines 170 metres from nearest main road	
West Yorkshire Sheffield	1,445,981 633,362	2,079,343	2	Leeds Centre Sheffield Centre	U/C U/C	30 metres from road with 21,500 vpd 20 metres from road with 20,000 vpd	Site likely to be unsuitable due to proximity of busy road Site likely to be unsuitable due to proximity of busy road
Tyneside Sunderland Teeside	885,981 189,281 369,609	1,444,871	1	Newcastle Centre	U/C	20 metres from busy road (20,000 vpd)	Site likely to be unsuitable due to proximity of busy road
Liverpool Birkenhead	837,998 270,207	1,108,205	1	None available			Liverpool Speke and Wirral Tranmere unsuitable. New site to be established
Nottingham The Potteries	613,726 367,976	981,702	1	Nottingham Centre	U/C	50 metres from road (24,000 vpd)	
Leicester Coventry	416,601 331,248	747,849	1	Leicester Centre	U/C	30 metres from road (14,000 vpd)	
Brighton Portsmouth	437,592 409,341	846,933	1	Portsmouth Centre	U/B	No main roads nearby	

Rest of England (continued)

Area	Individual agglomeration size	Population of agglomeration group	No. sites	Monitoring Site	Site type	Distance from major roads	Comments
Bristol	522,784	1,157,857	1	Bristol Centre	U/C	NA	Site due to be relocated in 2005
Bournemouth	358,321						
Southampton	276,752						
Blackpool	261,355	1,246,709	1	Preston Centre	U/B	No main roads nearby	
Preston	256,411						
Southport	116,315						
Wigan	174,406						
Blackburn	135,858						
Burnley	149,906						
Warrington	152,458						
Hull	310,636	911,996	1	Hull Freetown	U/C	50 metres from road (20,000 vpd)	
York	124,609						
Grimsby	136,456						
Doncaster	128,847						
Barnsley	211,448						
Derby	223,836	1,081,607	1	Northampton	U/B	45 metres from road (12,000 vpd)	
Chesterfield	105,660						
Mansfield	154,966						
Northampton	183,082						
Milton Keynes	156,148						
Cambridge	113,127						
Peterborough	134,788						
Southend	266,749	1,147,529	1	Norwich Centre	U/C	No main roads close by	
Margate	116,745						
Gillingham	222,388						
Basildon	102,913						
Hastings	120,044						
Norwich	185,420						
Ipswich	133.270						

Rest of England (continued)

Area	Individual agglomeration size	Population of agglomeration group	No. sites	Monitoring Site	Site type	Distance from major roads	Comments
Reading	335,757	1,258,345	1	Reading Centre	U/B	100 metres from nearest roads (38,000 vpd)	
Slough	126,662						
Luton	221,337						
High Wycombe	116,361						
Farnborough	231,194						
Crawley	115,554						
St Albans	111,480						
Plymouth	245,295	960,024	1	Plymouth Centre	U/C	200 metres from nearest road	
Torquay	102,576						
Cheltenham	102,633						
Swindon	145,236						
Gloucester	126,149						
Oxford	118,795						
Telford	119,340						

Northern Ireland

Area	Individual agglomeration size	Population of agglomeration group	No. sites	Monitoring Site	Site type	Distance from major roads	Comments
Northern Ireland		475,987	5				
Belfast	475,987	475,987	5	Belfast Centre	U/C	16 m from a minor road (1500 vpd)	
				Belfast Clara St	U/B	No main roads nearby	
				Carrickfergus	U/B	185 metres from nearest road	
				Castlereagh	U/B	80 m from nearest road (37,000 vpd)	
				Lisburn Dunmurray	U/B	500 m from nearest road	

Scotland

Area	Individual agglomeration size	Population of agglomeration group	No. sites	Monitoring Site	Site type	Distance from major roads	Comments
Scotland		2,203,679	5				
Glasgow	1,315,544	1,315,544	3	Glasgow Centre	U/C	20 metres from road with 20,000 vpd	Site likely to be unsuitable due to proximity of busy road. 1 new site needed.
Edinburgh	416,232	416,232	1	Edinburgh St Leonards	U/B	50 metres from nearest road	
Aberdeen Falkirk Dundee	199,747 117,459 154,697	471,903	1	Aberdeen Centre	U/B	80 metres from nearest road with 24,000 vpd	

Wales

Area	Individual agglomeration size	Population of agglomeration group	No. sites	Monitoring Site	Site type	Distance from major roads	Comments
Wales		694,882	5				
Cardiff	306,904	306,904	2	Cardiff Centre	U/C	200 m from nearest road	1 additional site needed
Swansea	272,456	272,456	2	Swansea Centre	U/C	40 metres from busy dual carriageway	1 additional site needed
Newport	115,522	115,522	1	N/A			1 new site required

Appendix 2

Assessment of Reduction Scenarios at Individual Sites on the Calculated Annual Mean

An Exposure-Reduction approach based on the average exposure concentration across all sites represents a much simpler approach than one based on individual sites. This approach does however require that there would be a broadly consistent reduction in PM concentrations across all monitoring sites. There is the potential that the Exposure-Reduction target could be achieved by a very large reduction at a single, or very few sites, with no reduction at others. This would then not accurately represent exposure reduction to the population.

An assessment of the likelihood of this occurring was initially carried out based on 43 sites across the UK network. The assessment has been re-evaluated based on 5 monitoring stations. Due to the lack of suitable data in the Devolved Administrations, the analysis has been carried out using data collected within Greater London (London Bexley, London Brent, London Eltham, London Hillingdon and London North Kensington). As a base case a 5% reduction in average PM_{10} concentrations was assumed. Two scenarios were considered:

- A single site was selected at random. Concentrations at all other sites were then assumed to reduce by progressively 1, 2, 3 and then 4%, and the required reduction at the single selected site calculated, such that the overall reduction would be 5%. Even assuming a 3% reduction at all other sites, the necessary reduction at the single site would be over 13% in order to reach the overall 5% target;

- A 15% reduction was applied to an increasing number of sites selected at random, with concentrations at all other sites remaining unchanged. It was necessary to apply a 20% reduction to 2 sites in order to achieve the required overall 5% reduction.

It may be concluded that given a sufficiently large number of sites, the average concentration is not significantly influenced by even large changes to a small number of the monitoring locations.

Appendix 3

Options for implementation of the Exposure-Reduction Approach within Local Air Quality Management

1. Introduction

1.1 This appendix considers in detail the potential options for the implementation of the Exposure-Reduction approach within the LAQM regime that applies to all UK local authorities. It also assesses the practicalities and likely costs of implementation, and the expected benefits in terms of reduced population exposure to PM that could be delivered from local measures implemented via LAQM.

1.2 For the purpose of this appendix, it is assumed that implementation of the Exposure-Reduction approach would be for $PM_{2.5}$.

2. Practicalities of Implementation

Number of monitoring stations

2.1 For implementation of the E-R approach at the UK or Devolved Administration and Greater London Authority (GLA) level, it is necessary to include a sufficient number of urban background monitoring stations in order to define the average PM exposure to the urban population without the need for explicit population weighting. Detailed consideration has been given to this within the main report. It was concluded that between 20 and 30 urban background sites for the UK would be sufficient (equivalent to about 1 site per 1 million population in agglomerations). For implementation at the Devolved Administration and GLA level, additional monitoring would be required to ensure a minimum of 5 sites within each DA.

2.2 It would clearly be impractical to require individual local authorities to operate 5 monitoring stations for $PM_{2.5}$ over the long term. However, implementation at the reduced scale of a local authority may preclude the necessity to have more than a single site (although more than one site would be beneficial) *provided that the monitoring location is chosen carefully*.

2.3 At the local authority level, the geographic scale is much smaller. Whilst it is unlikely that a single monitoring station would accurately represent the average population exposure to $PM_{2.5}$ across the local authority area, concentrations measured at a single site could be representative of the *reduction* in $PM_{2.5}$ levels between the baseline and target years. For the E-R approach, it is more relevant to measure the reduction in exposure rather than the absolute exposure.

2.4 As an example, it is assumed that there are 2 urban background monitoring stations within a local authority. $PM_{2.5}$ concentrations in 2010 are 18 µg/m^3 at Station A, and 24 µg/m^3 at Station B. It is clearly not possible to accurately define the average population exposure based on data from only one station. Due to the implementation of both national and local measures, it is assumed that by 2020 concentrations have declined across the local authority area by 2 µg/m^3, resulting in measured levels of 16 µg/m^3 at Station A (an 11% reduction) and 22 µg/m^3 at Station B (a 9% reduction). Whilst the absolute exposure is not well represented, provided the monitoring station **reflects the average $PM_{2.5}$ reduction across the area**, concentrations measured at either monitoring station would reflect the Exposure Reduction.

Scale of implementation

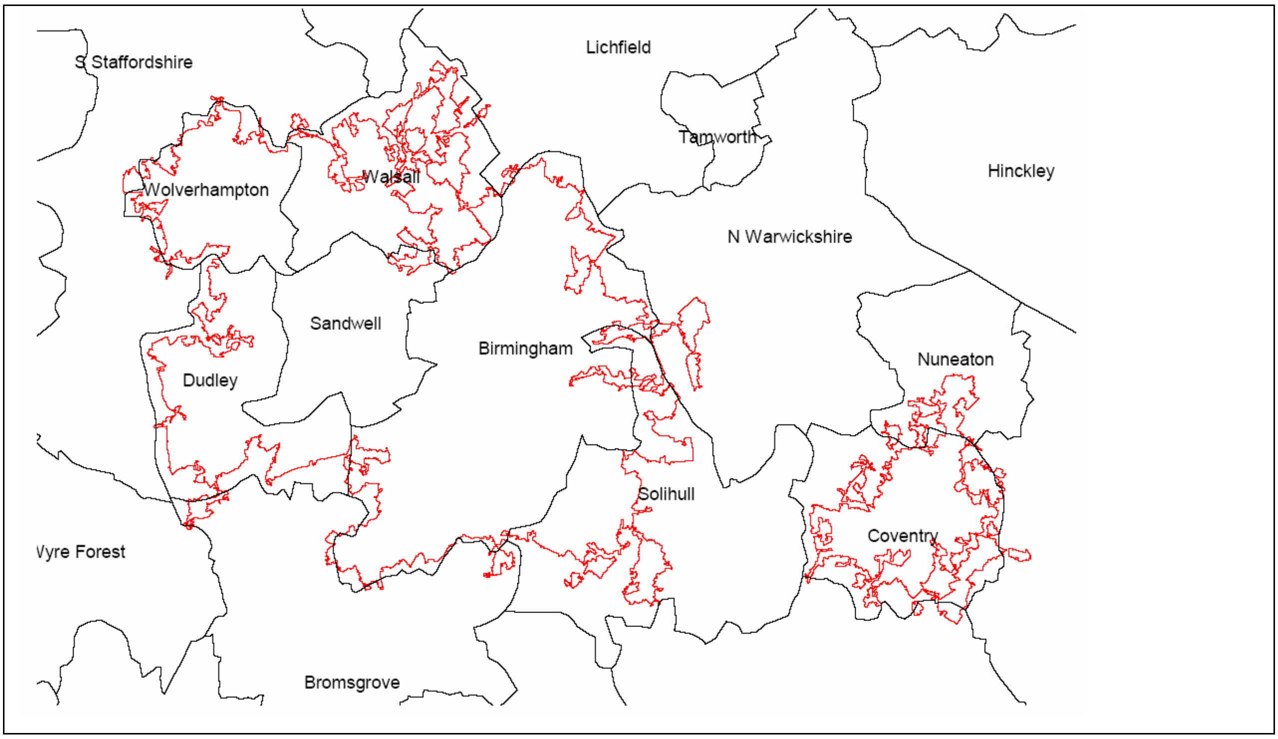
2.5 The scheme could be implemented into the LAQM regime for those local authorities within the 250K agglomerations. However, the boundaries of the agglomerations are not consistent with either local authority or ward boundaries (see Figure 1). Some local authorities lie wholly within an agglomeration, whilst others only have a proportion of their area within the agglomeration boundary. A small number of local authorities in the UK lie within 2 agglomerations.

2.6 An analysis of the local authority boundaries coinciding with the 250K agglomerations has been carried out and is summarised in Table 1. This table describes the agglomerations, the local authorities that have boundaries within all or a part of the agglomeration, and the 'agglomeration population' within each local authority boundary[24]. The 29 UK agglomerations (above 250K) include all or parts of 194[25] local authorities.

[24] The 'agglomeration population' in each authority area has been estimated from the proportional area of the agglomeration in each authority. The analysis is subject to additional uncertainty for agglomerations with coastal or river boundaries as these are not defined in the shape files provided. The data for the Belfast agglomeration were provided by DoE(NI).

[25] 5 local authorities have 2 agglomerations within their boundaries

Figure 1: Boundaries of the West Midland and Coventry & Bedworth agglomerations (in red) compared with local authority boundaries



2.7 This analysis identifies a large number of authorities with only a very small area of the agglomeration within their boundaries. Clearly, it would not be sensible to implement the E-R approach within LAQM for these authorities. A threshold of 100K 'agglomeration population' has therefore been applied to all local authorities outside of the GLA boundary[26]. The results are summarised as follows:

- Table 2: Greater London Agglomeration (authorities within the GLA boundary)
- Table 3: Greater London Agglomeration (authorities outside the GLA boundary)
- Table 4: All other agglomerations.

2.8 Within the Greater London Agglomeration there are 33 authorities within the GLA boundary, and a further 7 authorities outside of the GLA. For the rest of the UK there are 62 authorities that meet this criterion. With this approach there are therefore a total of 102 authorities for the UK as a whole, for which it would be appropriate to integrate Exposure Reduction into the LAQM responsibilities.

[26] To allow for the potential uncertainty in the method that has been used to estimate the agglomeration population, a threshold of 95,000 has been used.

Implications for monitoring

2.9 There are currently only a limited number of $PM_{2.5}$ monitoring sites in the UK, and only a proportion of these are within the local authority areas described in Tables 2, 3 and 4. Summary information on these monitoring sites is provided in Table 5 below.

Table 5: Summary of existing $PM_{2.5}$ monitoring sites in the UK

Local Authority	Site Name	Status	Site Type
LB Bexley	Belvedere Thamesmead	LAQN LAQN	Suburban Suburban
LB Camden	London Bloomsbury	AURN	Urban Centre
LB Ealing	Acton TH	LAQN	Roadside
LB Greenwich	Bexley 6	LAQN	Roadside
LB Hackney	Hackney 4	LAQN	Urban Background
LB Kensington & Chelsea	North Kensington	Defra Research	Urban Background
LB Westminster	Marylebone Road	AURN	Kerbside
Glasgow CC	Glasgow Centre	Defra Research	Urban Background
Manchester CC	Manchester Piccadilly	Defra Research	Urban Background
Birmingham CC	Birmingham Centre Hodge Hill Birmingham West	Defra Research LA LA	Urban Background Urban Background Urban Background
Belfast CC	Belfast Centre	Defra Research	Urban Background

Source: Site Pro-Forma prepared for AQEG report on Particulate Matter in the UK. This includes both TEOM and filter-based gravimetric samplers.

2.10 Of those sites listed in Table 5, several are at roadside locations and would not be suitable for the Exposure-Reduction approach. Whilst in some cases it may be feasible to relocate sites or $PM_{2.5}$ monitoring equipment, it would not be acceptable to move others, such as Marylebone Road.

2.11 However, if the Exposure-Reduction approach is implemented at the level of the Devolved Administrations and the GLA, it would be necessary for the national governments to establish additional $PM_{2.5}$ monitoring sites (as set out in Table A6 in the main report). Considering only new sites within those local authorities identified in Tables 2, 3 and 4 of this document, it is estimated that application at the DA level would provide about 20 monitoring sites. In total, $PM_{2.5}$ monitoring might be expected to be available at up to 25 sites[27] across the UK.

2.12 Additional monitoring for $PM_{2.5}$ would therefore need to be established in about 70 local authority areas. At this stage, it is not possible to define the preferred method of monitoring, but it is

[27] This includes 20 new sites from Table A6, and 5 sites from Table 5, avoiding duplication.

assumed that this would be based on a continuous analyser. A capital cost of approximately £1.5 to 1.8 million would be incurred[28]. There would be additional annual costs for operating the equipment, including site servicing and QA/QC, estimated to be approximately £0.5 million per annum.

Types of monitoring stations

2.13 Consideration has previously been given to the types of monitoring stations that should be used to define average PM exposure. An original set of criteria was developed suggesting that 'monitoring sites should be no closer than 100m to a very busy road (>40,000 vpd), 75m of a busy road (20-40,000 vpd), 50m to a fairly busy road (10-20,000 vpd) and 25m from any road'.

2.14 Whilst consideration was given to relaxing these criteria at a small percentage of sites for implementation at the UK level, it is not considered that this would be appropriate for implementation at the local authority level. As described in para 2.4 above, an important concept is that $PM_{2.5}$ concentrations measured at a single site would represent the reduction of exposure across the agglomeration population. Site selection would therefore be critical, and it is recommended that independent audits be carried out and system of national approval of sites be instituted.

3. Impact of E-R at the local authority level

3.1 To date, local authority measures to improve air quality have been largely focused on the control of pollution at hot spots, and in most cases specifically targeted towards a reduction in NOx emissions. The aim of introducing the E-R approach to LAQM would be to change this focus, and for the local authorities to include local measures that would reduce population exposure to $PM_{2.5}$.

3.2 An assessment of the source contribution to population-weighted mean PM_{10} concentrations in 2010 has been carried out by **netcen**, and the results are shown summarised in Table 6[29]. The contribution of road traffic emissions in 2010 is estimated to be within the range of about 1 to 2 $\mu g/m^3$ for most of the UK, but slightly higher for London. Local measures would be expected to have very limited impact of on domestic or industrial sources. Other area sources include quarries, construction etc, for which only limited controls can be applied. Almost 80% of the contribution is derived from secondary sources or the residual component, over which local authorities have very little control over concentrations in their areas. The likely *upper range* of

[28] Assumed cost for FDMS system with requirements for additional housings and infrastructure at some sites
[29] The analysis has not been carried out for $PM_{2.5}$, but it is not expected that the general pattern would be any different.

$PM_{2.5}$ reduction that could possibly be attained by local measures is therefore between 1 and 2 µg/m^3. For agglomerations outside of London, it would be unlikely to exceed about 1 µg/m^3.

Table 6: Source contribution to population-weighted mean PM_{10} concentrations in 2010 (µg/m^3 gravimetric)

	road traffic	domestic	industry	waste + agric	other area	secondary	residual
Scotland	1.784	0.312	0.731	0.122	0.429	4.425	8.775
Wales	1.724	0.311	1.289	0.171	0.536	7.146	8.775
Northern Ireland	1.331	2.667	0.686	0.210	0.567	4.215	8.775
Inner London	3.317	0.277	0.643	0.151	0.612	9.797	8.775
Outer London	2.541	0.201	0.745	0.115	0.547	9.822	8.775
Rest of England	1.967	0.266	1.400	0.149	0.487	8.027	8.775
UK	2.157	0.298	1.156	0.143	0.506	8.132	8.775
%age of total	10.2%	1.4%	5.5%	0.7%	2.4%	38.4%	41.5%

3.3 Local authorities have a variety of powers available to them to control air quality at a local level. These include measures related to transport and land-use planning, and are summarised in Table 7.

Table 7: Summary of principal action plan measures

Transport	Traffic regulation, including restriction of vehicles or types of vehicle Low Emission Zones Re-allocation of road space (Bus lanes, HOV etc) Parking Controls Bus Quality Partnerships Park and Ride schemes Travel Plans Promotion of modal shift to walking and cycling
Land Use Planning	Development Control, including mitigation of impacts from road traffic related to new developments

3.4 It is almost impossible to quantify the impact of many of these local measures on $PM_{2.5}$ exposure reduction across a large urban population. The measures are generally localised and targeted at specific road links or areas of the city, or are focused towards encouraging a modal shift away from the use of the private car. Whilst all of these measures will contribute to a reduction in PM emissions, in terms of average exposure the impact is likely to be very small.

3.5 Measures that could impact significantly at a much wider scale are limited. These include the implementation of LEZs. The analysis conducted by **netcen** to support the revision to the Air Quality Strategy examined the impact of LEZs in seven urban areas outside of London. The conclusion was that implementation of the LEZs would lead to a slightly smaller exposure reduction between 2010 and 2020 than would be achieved with implantation of the baseline scenario[30]. This is because the LEZ would have some effect in 2010, but none in 2020.

3.6 Whilst beneficial, it is therefore expected that the measures that are likely to be introduced at a local level will only have a small impact in reducing population exposure. The expected level of reduction over a 10 year period (between 2010 and 2020) would be too low to accurately identify by monitoring. Any Exposure-Reduction targets would need to be consistent with those implemented at the UK or the DA level.

[30] This relates to the population-weighted exposure reduction for the UK. The implementation of an LEZ would provide a greater change in PM concentration relative to the baseline for the population within the LEZ area itself.

Table 1: Summary of local authorities with boundaries coinciding with 250K agglomerations, and estimated 'agglomeration population'

Agglomeration	Local Authority	Population of agglomeration	Estimated Agglomeration Population in LA
Belfast Urban Area	Belfast	579,276	276,705
	Carrickfergus		32,259
	Castlereagh		61,200
	Lisburn		72,759
	Newtownabbey		62,022
	North Down		74,331
Birkenhead Urban Area	Ellesmere	270,207	500
	Wirral		264,350
Blackpool Urban Area	Blackpool	261,355	116,625
	Fylde		58,073
	Wyre		83,529
Bournemouth Urban Area	Bournemouth	358,321	127,459
	Christchurch		38,596
	E Dorset		3,154
	New Forest		41,398
	Poole		142,114
	Purbeck		3,098
Brighton/Worthing/Littlehampton	Adur	437,592	75,571
	Arun		78,086
	Brighton		179,657
	Lewes		3,487
	Worthing		99,007
Bristol Urban Area	Bath	522,784	4,003
	Bristol		330,749
	N Somerset		3,580
	S Gloucestershire		183,175
Cardiff Urban Area	Cardiff	306,904	268,754
	Glamorgan		30,810
	Newport		66
	Rhondda		499
Coventry/Bedworth	Coventry	331,248	285,922
	Nuneaton		33,654
	Rugby		5,115
	Warwick		6,556
Edinburgh Urban Area	E Lothian	416,232	22,777
	Edinburgh		378,084
	MidLothian		5,176
Glasgow Urban Area	E Dunbartonshire	1,315,544	137,850
	E Renfrewshire		60,276
	Glasgow		585,455
	N Lanarkshire		192,664
	Renfrewshire		194,355
	S Lanarkshire		92,744
	W Dunbartonshire		46,951

Table 1 (continued)

Agglomeration	Local Authority	Population of agglomeration	Estimated Agglomeration Population in LA
Greater London Urban Area	Barking	7,650,944	133,647
	Barnet		321,700
	Bexley		240,633
	Bracknell		5,052
	Brent		226,242
	Brentwood		15
	Bromley		360,201
	Broxbourne		90,716
	Camden		101,095
	Chiltern		171
	Corp of London		12,767
	Croydon		337,726
	Dacorum		107,998
	Dartford		60,659
	E Hertfordshire		3,783
	Ealing		238,446
	Elmbridge		198,027
	Enfield		261,390
	Epping		109,559
	Epsom		82,769
	Greenwich		242,900
	Guildford		5,047
	Hackney		94,015
	Hammersmith		74,931
	Haringey		140,440
	Harrow		195,225
	Havering		249,608
	Hertsmere		27,760
	Hillingdon		373,759
	Hounslow		314,073
	Islington		61,722
	Kensington		51,964
	Kingston		154,701
	Lambeth		127,125
	Lewisham		140,706
	Merton		172,354
	Mole Valley		75,347
	Newham		156,730
	Redbridge		206,688
	Reigate		73,188
	Richmond		262,283
	Runnymede		97,216
	S Bucks		1,453
	Sevenoaks		60
	Southwark		143,317

Table 1 (continued)

Agglomeration	Local Authority	Population of agglomeration	Estimated Agglomeration Population in LA
Greater London Urban Area	Spelthorne		113,026
(continued)	St Albans		4,608
	Surrey		16,486
	Sutton		188,580
	Tandridge		58,070
	Three Rivers		112,401
	Tower Hamlets		86,111
	Waltham Forest		177,229
	Wandsworth		180,947
	Watford		79,814
	Westminster		102,799
	Windsor		39,594
	Woking		119,423
Greater Manchester Urban Area	Bolton	2,277,330	211,059
	Bury		170,945
	Chorley		44
	Macclesfield		87,526
	Manchester		435,734
	Oldham		171,090
	Rochdale		186,544
	Rossendale		4,711
	Salford		228,462
	Stockport		265,193
	Tameside		186,326
	Trafford		235,429
	Warrington		848
	Wigan		93,421
Kingston upon Hull	E Yorkshire	310,636	66,751
	Kingston-upon-Hull		243,629
Leicester Urban Area	Blaby	416,601	52,422
	Charnwood		31,442
	Harborough		8,310
	Hinckley		9,910
	Leicester		253,797
	Oadby		60,720
Liverpool Urban Area	Halton	837,998	4,172
	Knowsley		90,258
	Liverpool		476,836
	Sefton		119,591
	St Helens		143,681
	Warrington		354
Nottingham Urban Area	Amber Valley	613,726	45,706
	Ashfield		27,808
	Broxtowe		113,202
	Erewash		43,420

Table 1 (continued)

Agglomeration	Local Authority	Population of agglomeration	Estimated Agglomeration Population in LA
Nottingham Urban Area	Gedling		83,800
(continued)	Nottingham		257,116
	Rushcliffe		42,675
Portsmouth Urban Area	E Hampshire	409,341	27,479
	Fareham		70,034
	Gosport		69,419
	Havant		102,483
	Portsmouth		128,146
	Winchester		2,093
Preston Urban Area	Chorley	256,411	58,174
	Preston		101,354
	S Ribble		96,201
Reading/Wokingham Urban Area	Bracknell	335,757	67,417
	Reading		113,479
	S Oxfordshire		220
	W Berkshire		21,509
	Wokingham		133,131
Sheffield Urban Area	Barnsley	633,362	11
	NE Derbyshire		6,528
	Rotherham		159,386
	Sheffield		467,437
Southampton Urban Area	Eastleigh	276,752	92,000
	Southampton		166,739
	Test Valley		10,653
	Winchester		950
Southend Urban Area	Basildon	266,749	99
	Castle Point		57,549
	Rochford		69,238
	Southend		139,625
Swansea Urban Area	Port Talbot	272,456	103,811
	Swansea		162,516
Teesside Urban Area	Hartlepool	369,609	77
	Middlesborough		109,307
	Redcar		112,632
	Stockton		139,724
The Potteries	Congleton	367,976	8,961
	Newcastle-under-Lyme		81,065
	Stafford		5,980
	Staffordshire		18,362
	Stoke		253,609
Tyneside	Castle Morpeth	885,981	207
	Chester-Le-Street		26,066
	Easington		5,364

Table 1 (continued)

Agglomeration	Local Authority	Population of agglomeration	Estimated Agglomeration Population in LA
Tyneside (continued)	Gateshead		190,530
	N Tyneside		160,798
	Newcastle		256,908
	S Tyneside		137,567
	Sunderland		93,722
West Midlands Urban Area	Birmingham	2,296,180	921,324
	Bromsgrove		16,223
	Dudley		309,079
	Lichfield		2,768
	N Warwickshire		20,128
	S Staffordshire		9,572
	Sandwell		317,810
	Solihull		202,879
	Walsall		256,728
	Warwick		8
	Wolverhampton		239,416
	Wyre Forest		245
West Yorkshire Urban Area	Bradford	1,445,981	342,584
	Calderdale		34,340
	Kirklees		363,607
	Leeds		569,524
	Wakefield		135,927

Table 2: Summary of local authorities (agglomeration populations >100K) within the Greater London Agglomeration and within the GLA boundary

Agglomeration	Local Authority	Population of agglomeration	Estimated Agglomeration Population in LA
Greater London Urban Area	Barking	7,650,944	133,647
	Barnet		321,700
	Bexley		240,633
	Brent		226,242
	Bromley		360,201
	Camden		101,095
	Corp of London		12,767
	Croydon		337,726
	Ealing		238,446
	Enfield		261,390
	Greenwich		242,900
	Hackney		94,015
	Hammersmith		74,931
	Haringey		140,440
	Harrow		195,225
	Havering		249,608
	Hillingdon		373,759
	Hounslow		314,073
	Islington		61,722
	Kensington & Chelsea		51,964
	Kingston		154,701
	Lambeth		127,125
	Lewisham		140,706
	Merton		172,354
	Newham		156,730
	Redbridge		206,688
	Richmond		262,283
	Southwark		143,317
	Sutton		188,580
	Tower Hamlets		86,111
	Waltham Forest		177,229
	Wandsworth		180,947
	Westminster		102,799

Table 3: Summary of local authorities (agglomeration populations > 100k) within the Greater London Agglomerations but outside of the GLA boundary

Agglomeration	Local Authority	Population of agglomeration	Estimated Population in LA
Greater London Urban Area	Dacorum	7,650,944	107,998
	Elmbridge		198,027
	Epping		109,559
	Runnymede		97,216
	Spelthorne		113,026
	Three Rivers		112,401
	Woking		119,423

Table 4: Summary of local authorities within agglomeration boundaries and 'agglomeration populations > 100,000

Agglomeration	Local Authority	Population of agglomeration	Estimated Agglomeration Population in LA
Belfast Urban Area	Belfast	579,276	276,705
Birkenhead Urban Area	Wirral	270,207	264,350
Blackpool Urban Area	Blackpool	261,355	116,625
Bournemouth Urban Area	Bournemouth	358,321	127,459
	Poole		142,114
Brighton/Worthing/Littlehampton	Brighton		179,657
	Worthing		99,007
Bristol Urban Area	Bristol	522,784	330,749
	S Gloucestershire		183,175
Cardiff Urban Area	Cardiff	306,904	268,754
Coventry/Bedworth	Coventry	331,248	285,922
Edinburgh Urban Area	Edinburgh	416,232	378,084
Glasgow Urban Area	E Dunbartonshire	1,315,544	137,850
	Glasgow		585,455
	N Lanarkshire		192,664
	Renfrewshire		194,355
Greater Manchester Urban Area	Bolton	2,277,330	211,059
	Bury		170,945
	Manchester		435,734
	Oldham		171,090
	Rochdale		186,544
	Salford		228,462
	Stockport		265,193
	Tameside		186,326
	Trafford		235,429
Kingston upon Hull	Kingston-upon-Hull	310,636	243,629
Leicester Urban Area	Leicester	416,601	253,797
Liverpool Urban Area	Liverpool	837,998	476,836
	Sefton		119,591
	St Helens		143,681
Nottingham Urban Area	Broxtowe	613,726	113,202
	Nottingham		257,116
Portsmouth Urban Area	Havant	409,341	102,483
	Portsmouth		128,146
Preston Urban Area	Preston	256,411	101,354
	S Ribble		96,201
Reading/Wokingham Urban Area	Reading	335,757	113,479
	Wokingham		133,131
Sheffield Urban Area	Rotherham	633,362	159,386
	Sheffield		467,437
Southampton Urban Area	Southampton	276,752	166,739
Southend Urban Area	Southend	266,749	139,625

Table 4 (continued)

Agglomeration	Local Authority	Population of agglomeration	Estimated Agglomeration Population in LA
Swansea Urban Area	Port Talbot	272,456	103,811
	Swansea		162,516
Teesside Urban Area	Middlesborough	369,609	109,307
	Redcar		112,632
	Stockton		139,724
The Potteries	Stoke	367,976	253,609
Tyneside	Gateshead	885,981	190,530
	N Tyneside		160,798
	Newcastle		256,908
	S Tyneside		137,567
West Midlands Urban Area	Birmingham	2,296,180	921,324
	Dudley		309,079
	Sandwell		317,810
	Solihull		202,879
	Walsall		256,728
	Wolverhampton		239,416
West Yorkshire Urban Area	Bradford	1,445,981	342,584
	Kirklees		363,607
	Leeds		569,524
	Wakefield		135,927

Appendix 4

Description of PM reduction scenarios

Scenario	Description
A	New Euro Standard V/VI Low intensity
B	New Euro Standard V/VI High intensity
C	Incentives for early uptake of Euro V and VI Standards (LOW)
D	Incentives to phase out most polluting vehicles (pre-Euro)
E	Incentives to increase penetration of low emission vehicles
F	Impact of all road user charging schemes
G	Extend London LEZ to London and 7 largest urban areas
H	Retrofit (diesel particulate filters) on HDV and captive fleets
I	Domestic combustion: switch from coal to natural gas or oil
J	Domestic combustion: Product standards for gas fired appliances which require tighter NOx emission standards
K	Large combustion plant measure.
L	Small combustion plant measure
M	Reduce national VOC emissions by ~9%
N	Shipping measures through IMO
O	Combined measures C + E
P	Combined measures C + L
Q	Combined measures C + E + L

Appendix 5

Threshold analysis for baseline and scenario 'P' projections for PM_{10} and $PM_{2.5}$

Table 1a: Threshold concentrations with very few or *zero* exceedences: background PM_{10} 2003 base year in terms of population exposure (μg m^{-3}, gravimetric)

	2010 Baseline		2020 Baseline		2010 s27		2020 s27	
London	27	*27*	25	*26*	26	*27*	23	*25*
Rest of England	29	*33*	29	*34*	29	*33*	28	*33*
Scotland	22	*28*	21	*27*	21	*28*	20	*27*
Wales	24	*26*	23	*26*	24	*26*	22	*25*
Northern Ireland	21	*22*	22	*22*	21	*22*	21	*22*
UK	29	*33*	29	*34*	29	*33*	28	*33*

Table 1b: Threshold concentrations with very few or *zero* exceedences: roadside PM_{10} 2003 base year in terms of major road length (μg m^{-3}, gravimetric)

	2010 Baseline		2020 Baseline		2010 s27		2020 s27	
London	37	*41*	33	*37*	36	38	28	*30*
Rest of England	34	*38*	31	*35*	33	*37*	28	*32*
Scotland	30	*37*	26	*31*	28	*34*	21	*22*
Wales	29	*31*	25	*27*	28	*30*	22	*24*
Northern Ireland	24	*25*	23	*24*	23	*24*	22	*22*
UK	37	*41*	33	*37*	36	*38*	28	*32*

Table 2a: Threshold concentrations with very few or *zero* exceedences: background $PM_{2.5}$ 2003 base year in terms of population exposure (μg m^{-3}, gravimetric)

	2010 Baseline		2020 Baseline		2010 s27		2020 s27	
London	16	*17*	14	*14*	16	*16*	13	*14*
Rest of England	16	*18*	14	*17*	16	*18*	13	*17*
Scotland	12	*16*	11	*15*	12	*16*	10	*15*
Wales	14	*16*	12	*15*	13	*16*	12	*15*
Northern Ireland	11	*11*	10	*11*	10	*11*	10	*11*
UK	16	*18*	14	*17*	16	*18*	13	*17*

Table 2b: Threshold concentrations with very few or *zero* exceedences: roadside $PM_{2.5}$ 2003 base year in terms of major road length (μg m^{-3}, gravimetric)

	2010 Baseline		2020 Baseline		2010 s27		2020 s27	
London	21	*23*	18	*20*	21	*22*	16	*17*
Rest of England	19	*21*	16	*17*	18	*20*	14	*16*
Scotland	15	*20*	14	*16*	16	*19*	11	*12*
Wales	16	*17*	14	*15*	16	*17*	12	*12*
Northern Ireland	12	*12*	11	*12*	12	*12*	10	*11*
UK	21	*23*	18	*20*	21	*22*	16	*17*

Threshold analysis for baseline and scenario 'Q' projections for PM_{10} and $PM_{2.5}$

Table 1a: Threshold concentrations with very few or *zero* exceedences: background PM_{10} 2003 base year in terms of population exposure (mg m^{-3}, gravimetric)

	2010 Baseline		2020 Baseline		2010 s25		2020 s25	
London	27	*27*	25	*26*	26	*27*	23	*25*
Rest of England	29	*33*	29	*34*	29	*33*	28	*33*
Scotland	22	*28*	21	*27*	21	*28*	20	*27*
Wales	24	*26*	23	*26*	24	*26*	22	*25*
Northern Ireland	21	*22*	22	*22*	21	*22*	21	*22*
UK	29	*33*	29	*34*	29	*33*	28	*33*

Table 1b: Threshold concentrations with very few or *zero* exceedences: roadside PM_{10} 2003 base year in terms of major road length (mg m^{-3}, gravimetric)

	2010 Baseline		2020 Baseline		2010 s25		2020 s25	
London	37	*41*	33	*37*	36	38	27	*29*
Rest of England	34	*38*	31	*35*	33	*37*	28	*32*
Scotland	30	*37*	26	*31*	28	*34*	20	*22*
Wales	29	*31*	25	*27*	28	*30*	22	*24*
Northern Ireland	24	*25*	23	*24*	23	*24*	22	*22*
UK	37	*41*	33	*37*	36	*38*	28	*32*

Table 2a: Threshold concentrations with very few or *zero* exceedences: background $PM_{2.5}$ 2003 base year in terms of population exposure (mg m^{-3}, gravimetric)

	2010 Baseline		2020 Baseline		2010 s25		2020 s25	
London	16	*17*	14	*14*	16	*16*	13	*14*
Rest of England	16	*18*	14	*17*	16	*18*	13	*17*
Scotland	12	*16*	11	*15*	12	*16*	10	*15*
Wales	14	*16*	12	*15*	13	*16*	12	*15*
Northern Ireland	11	*11*	10	*11*	10	*11*	10	*11*
UK	16	*18*	14	*17*	16	*18*	13	*17*

Table 2b: Threshold concentrations with very few or *zero* exceedences: roadside $PM_{2.5}$ 2003 base year in terms of major road length (mg m^{-3}, gravimetric)

	2010 Baseline		2020 Baseline		2010 s25		2020 s25	
London	21	*23*	18	*20*	20	*22*	15	*16*
Rest of England	19	*21*	16	*17*	18	*20*	14	*16*
Scotland	15	*20*	14	*16*	16	*19*	11	*12*
Wales	16	*17*	14	*15*	16	*17*	12	*12*
Northern Ireland	12	*12*	11	*12*	12	*12*	10	*11*
UK	21	*23*	18	*20*	20	*22*	15	*16*

Notes: This note presents an analysis of the projected PM_{10} and $PM_{2.5}$ concentrations calculated within the 2005 AQS review in terms of threshold concentrations above which there are predicted to be very few or no exceedences.

The analysis has been carried out for the baseline and combined scenarios 'P' and 'Q' for background and roadside concentrations. The exceedence of threshold concentrations for background locations has been assessed in terms of population exposure and for roadside locations in terms of the length of urban major roads exceeding.

The analysis has been carried out for PM_{10} concentrations derived from base years of 2003 and 2002. The analysis has been carried out for separate GIS-based mapping assessments of $PM_{2.5}$ concentrations derived from gravimetric monitoring data.

The frequency distributions of concentrations predicted for 2010 and 2020 have been examined and the concentrations have been rounded up to the nearest integer so that each bin represents the population or road length between this integer and one $\mu g\ m^{-3}$ less than this integer. (So the bin labelled 28 has all predicted concentrations between 27 and 28).

The highest background and in some instances roadside concentrations are associated with emissions from industrial point sources, for which the dispersion modelling may include additional uncertainty. Threshold concentrations have therefore been identified for the predictions with very few (in plain text) or zero (*in italics*) exceedences. The zero exceedence threshold is often determined by concentrations influenced by industrial point sources. The 'very few' exceedences threshold have been identified as follows:

- **Background, Rest of England, population exceeding less than 100,000**
- **Background, all other areas, population exceeding less than 20,000**
- **Roadside, Rest of England, road length exceeding less than 50 km**
- **Background, all other areas, road length exceeding less than 10 km**

Figures

Figure 1 Deviation from Overall Average PM_{10} for UK Urban Background, Suburban and Urban Centre Sites in 2002.

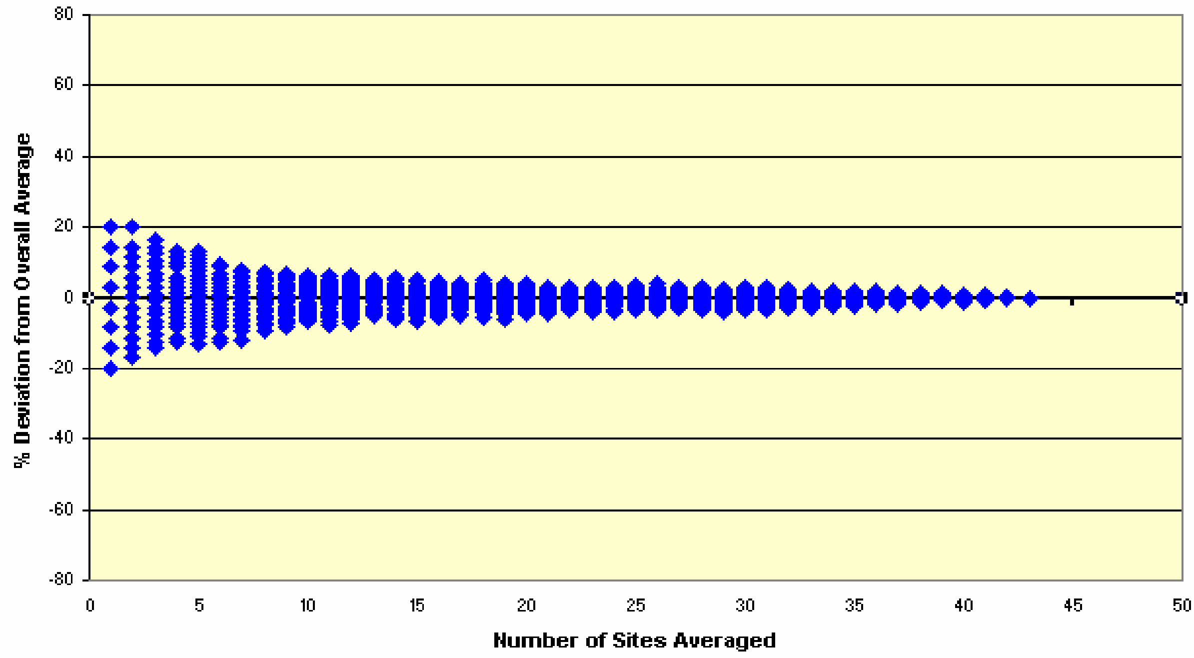


Figure 2 Deviation from Overall Average PM_{10} for UK Urban Background, Suburban and Urban Centre Sites in 2002 Minus a Rural Background Value of 15 $\mu g/m^3$.

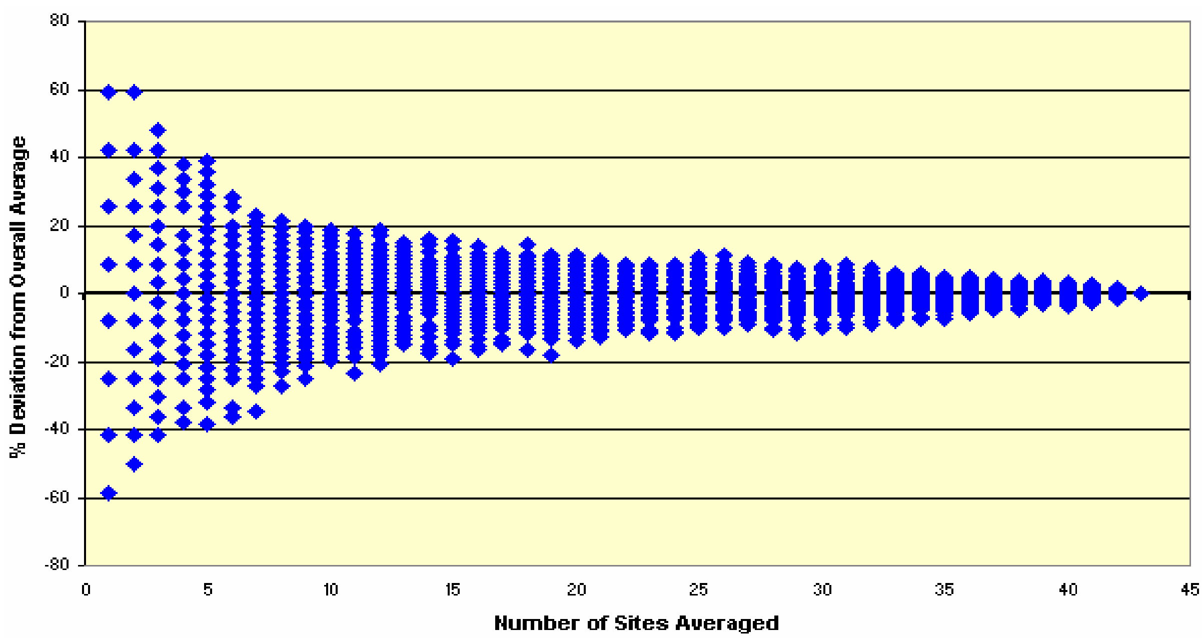


Figure 3: Normalised (2000) 3-year rolling annual mean PM_{10} concentrations by Country (The results for Scotland should be treated with caution – see text para 2.24)

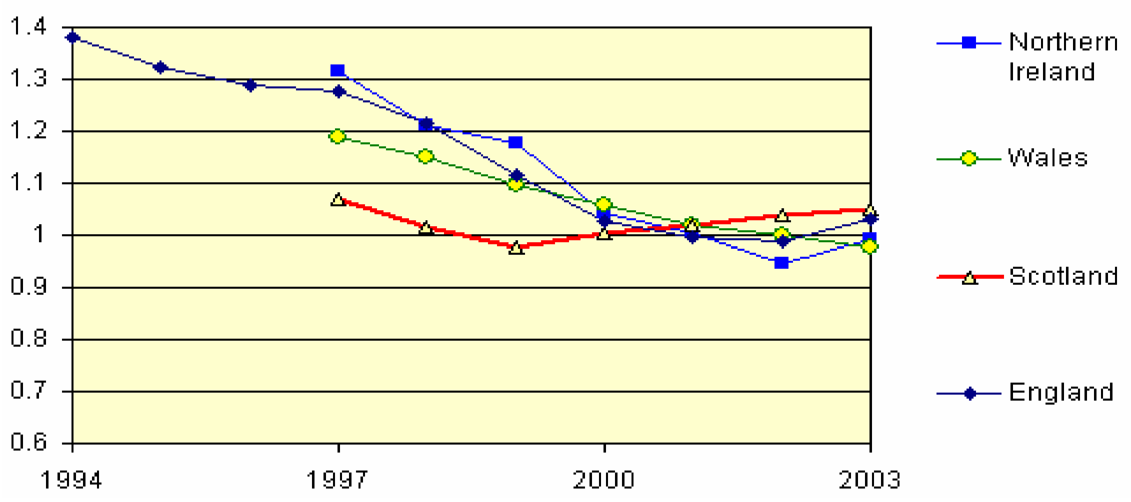


Figure 4: Normalised Population-Weighted Baseline Projections for PM_{10} by Country (Base year 2002)

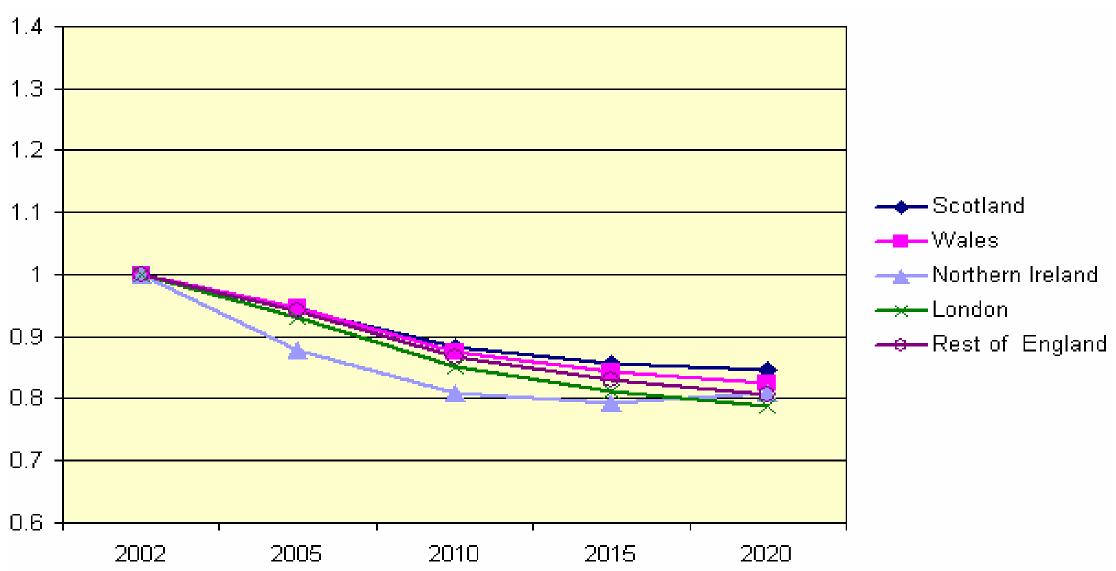


Figure 5: Deviation from Overall Average PM_{10} for London Urban Background and Suburban Sites in 2002.

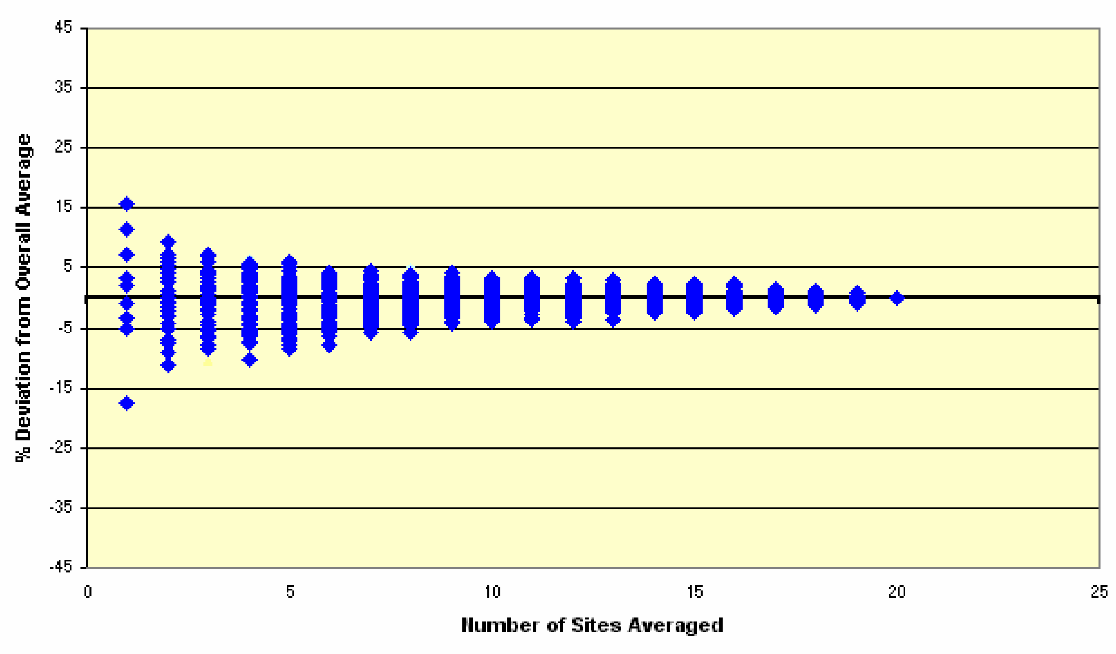


Figure 6: Normalised (2000) 3-year rolling annual mean PM_{10} concentrations by Region (Results from AURN stations)

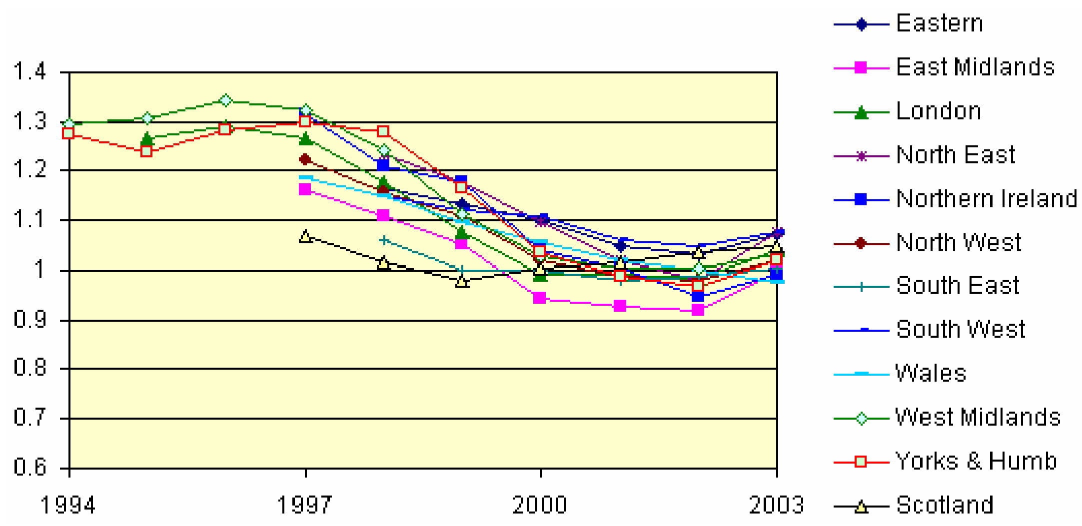


Figure 7: Percentage reduction in population-weighted mean PM_{10} and $PM_{2.5}$ concentrations in Scotland (μg m^{-3} gravimetric), normalised to 2003 base.

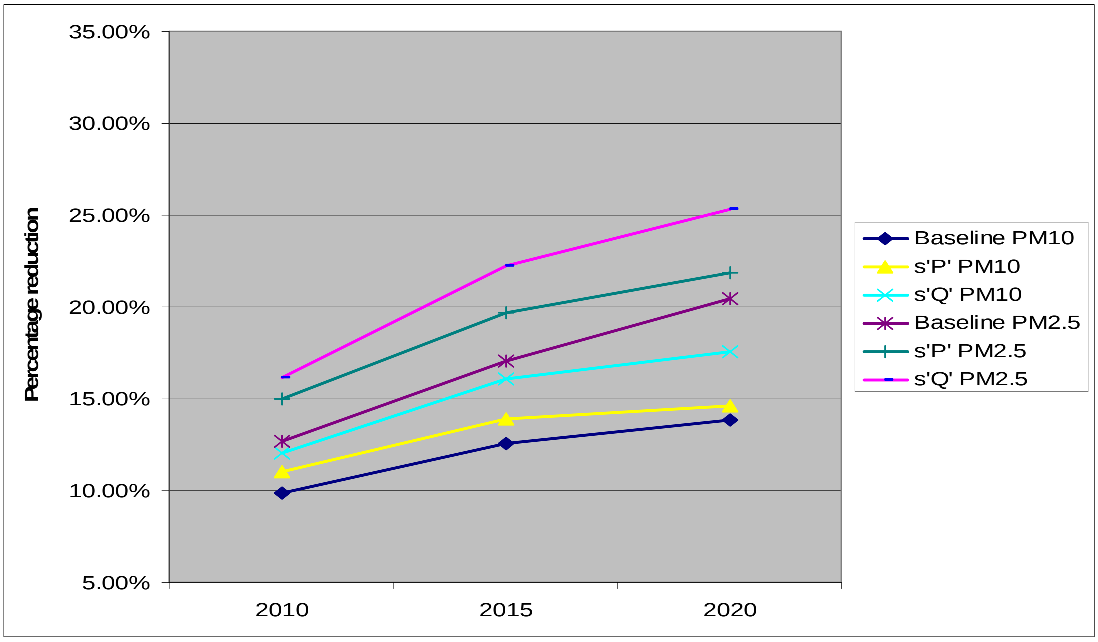


Figure 8: Percentage reduction in population-weighted mean PM_{10} and $PM_{2.5}$ annual mean concentrations in Northern Ireland (μg m^{-3} gravimetric), normalised to 2003 base.

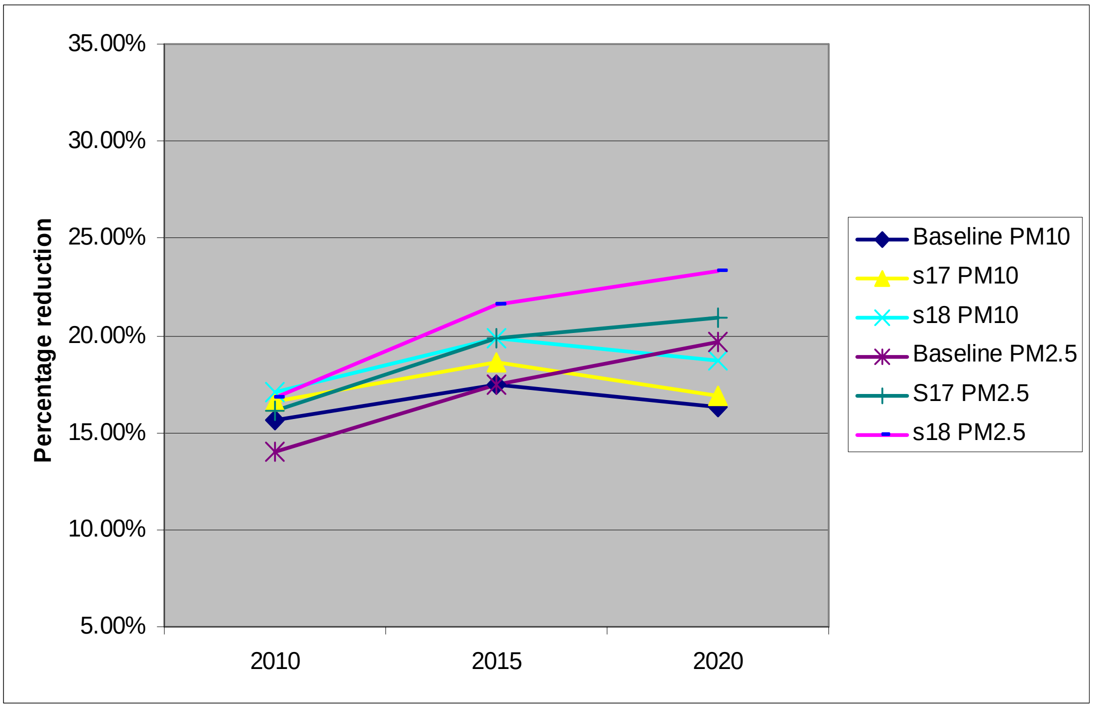


Figure 9: **Percentage reduction in population-weighted mean PM_{10} and $PM_{2.5}$ concentrations in Wales (µg m^{-3} gravimetric), normalised to 2003 base.**

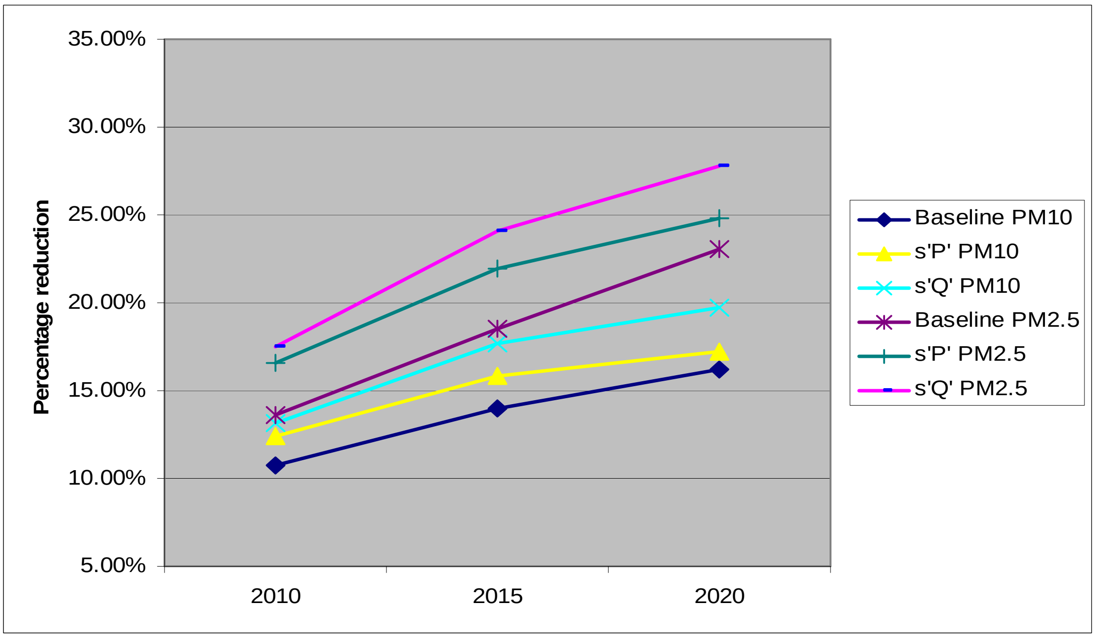


Fig 10: **Percentage reduction in population-weighted mean PM10 and PM2.5 concentrations in Greater London (µg m-3 gravimetric), normalised to 2003 base.**

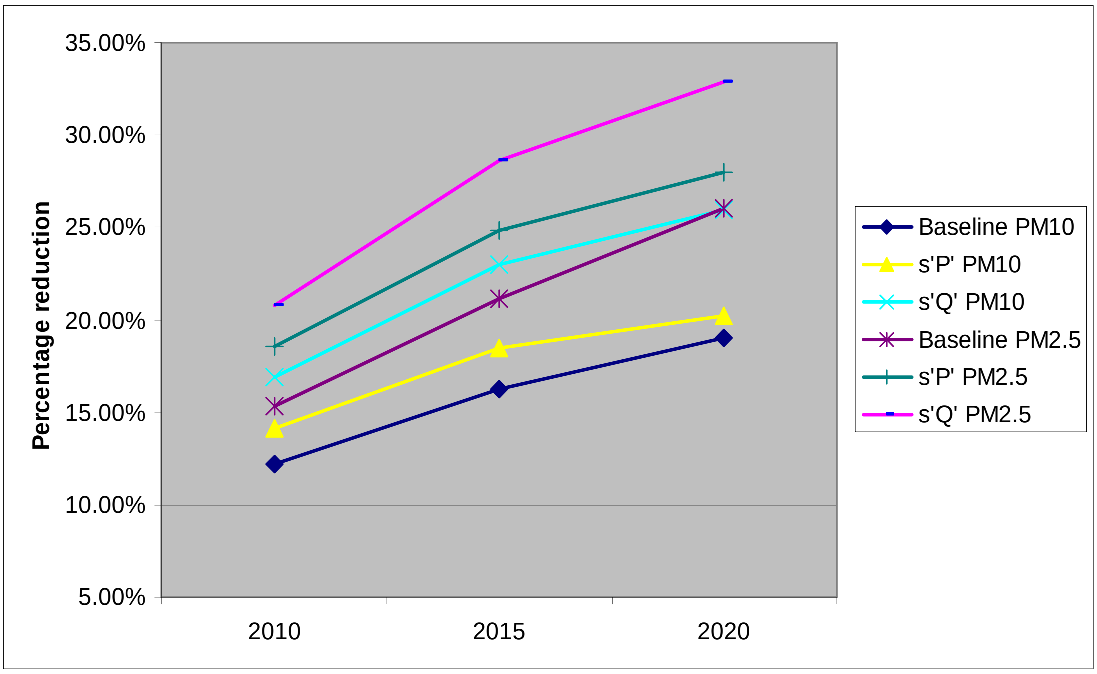


Figure 11: Percentage reduction in population-weighted mean PM_{10} and $PM_{2.5}$ concentrations in England (excluding Greater London) (µg m^{-3} gravimetric), normalised to 2003 base.

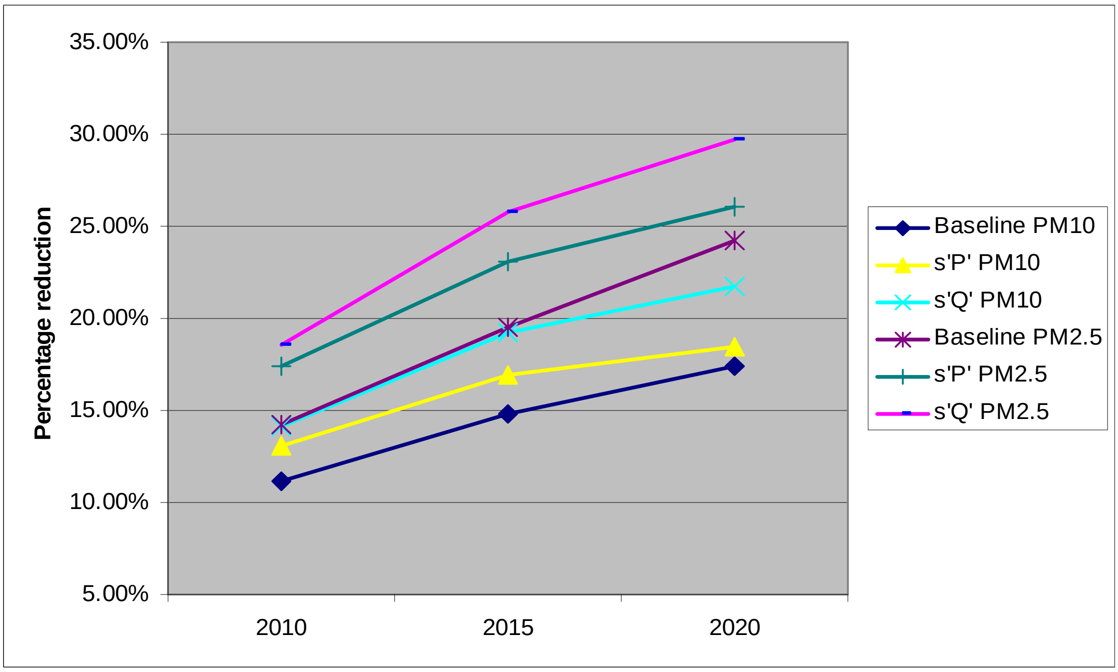


Figure 12: Incremental road lengths in Greater London exceeding threshold PM_{10} concentrations in 2020 with scenario 'Q' (base year 2003)

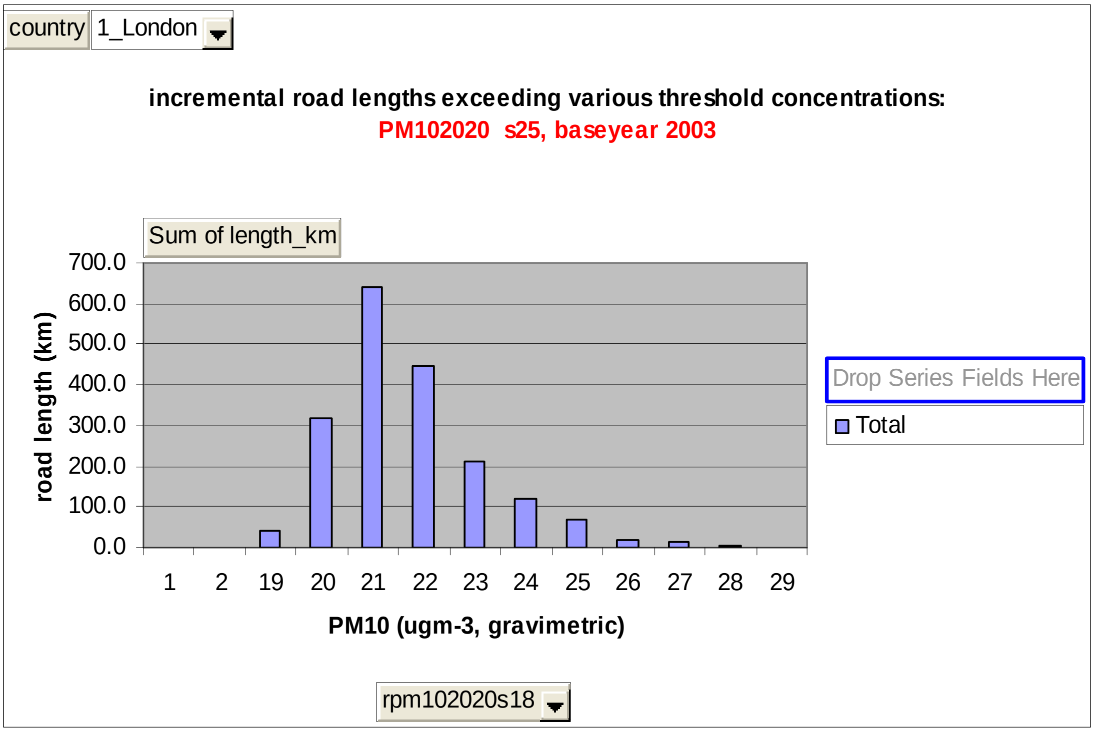


Figure 13: Incremental road lengths in Rest of England exceeding threshold PM10 concentrations in 2020 with scenario 'Q' (base year 2003)

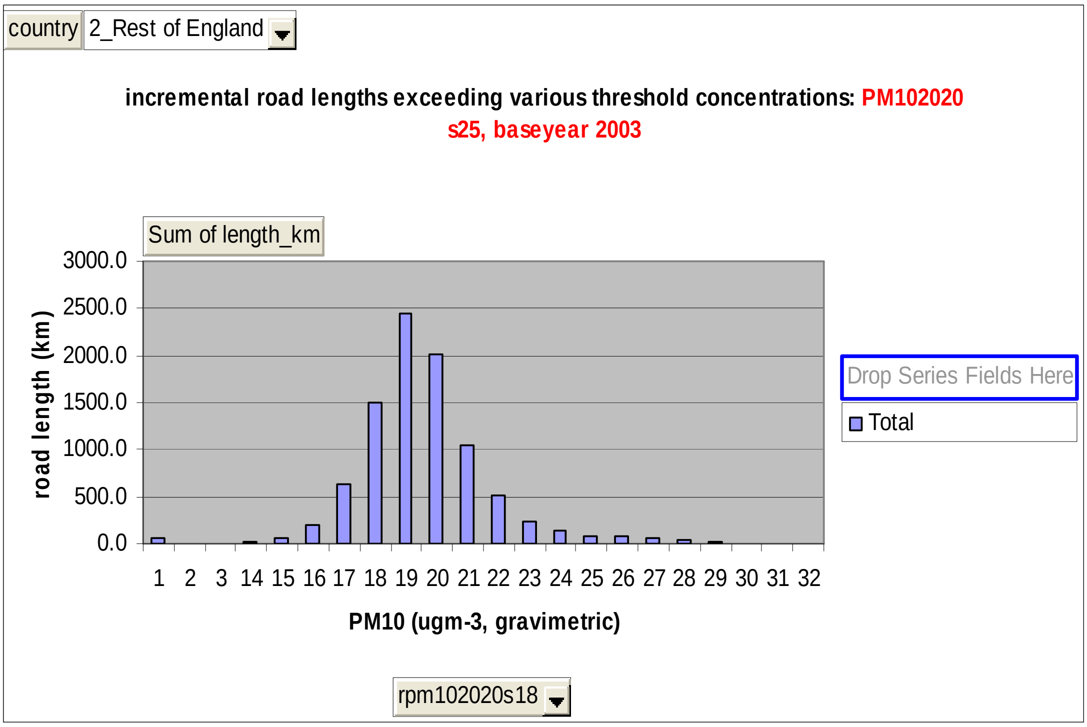


Figure 14: Incremental road lengths in Scotland exceeding threshold PM_{10} concentrations in 2020 with scenario 'Q' (base year 2003)

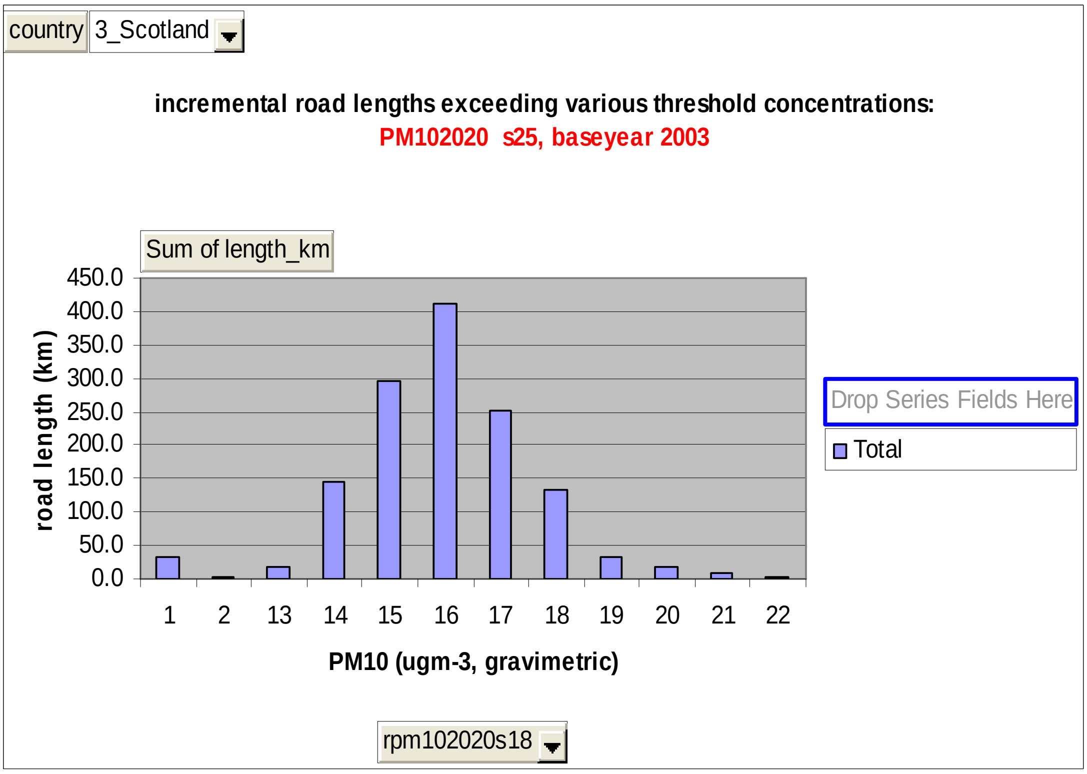


Figure 15: Incremental road lengths in Wales exceeding threshold PM_{10} concentrations in 2020 with scenario 'Q' (base year 2003)

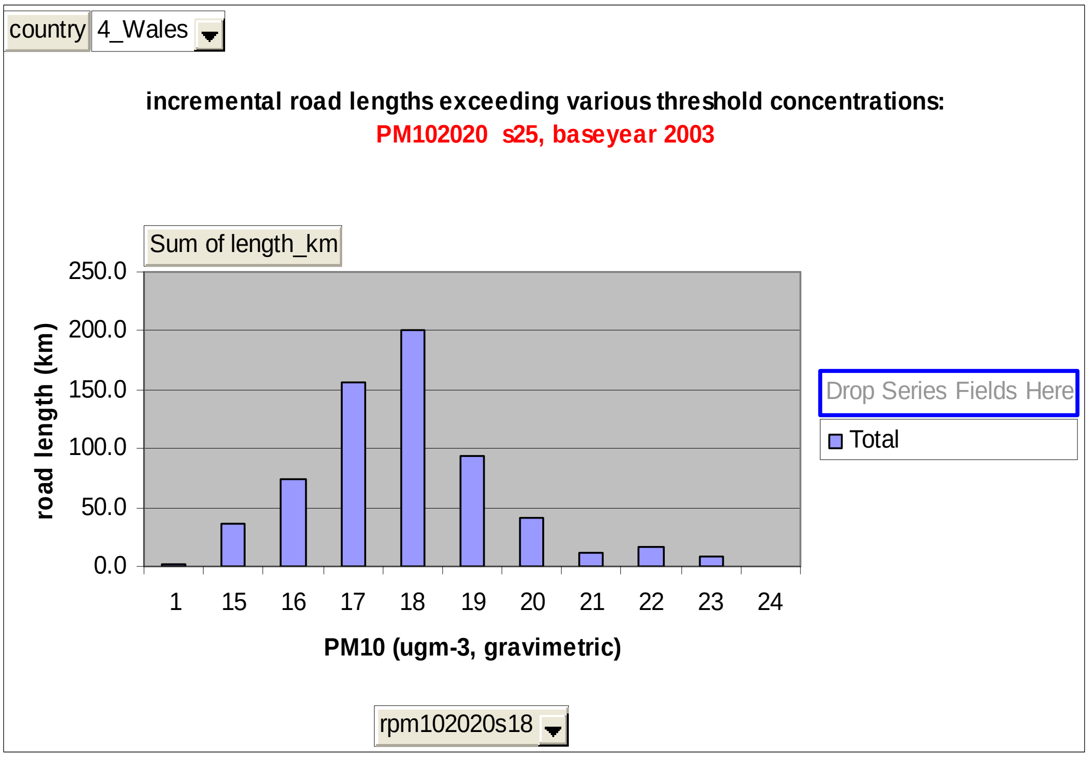


Figure 16: Incremental road lengths in Northern Ireland exceeding threshold PM_{10} concentrations in 2020 with scenario 'Q' (base year 2003)