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REVIEW OF CUMULATIVE AIR IMPACT ASSESSMENT METHODOLOGIES FOR NSW
FINAL REPORT

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EXECUTIVE SUMMARY

Introduction

Proponents of new or modified emission sources in NSW are required to demonstrate compliance with the impact assessment outlined in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (the Approved Methods) (NSW EPA, 2005). The Approved Methods requires that both incremental and cumulative impacts need to be presented in an air quality impact assessment.

The Environment Protection Authority (EPA) has commissioned ENVIRON Australia (ENVIRON) to review and evaluate approaches to cumulative air impact assessment and recommend suitable assessment methodologies for implementation in NSW.

Notwithstanding the complexity of cumulative air impact assessment in general, there are a number of specific challenges faced in NSW, including:

- Spatial and temporal gaps in background data.
- Evaluation of short-term cumulative impacts.
- Climate effects and the influence of inter-annual variability on background particulate matter (PM).
- NO_x conversion.
- Dealing with elevated background concentrations.
- Inclusion of local and distant emissions sources in cumulative assessment.

Study approach

The purpose and scope for the study are defined by the Terms of Reference (ToR), summarised in the following key steps.

- Literature review to review existing methodological approaches in NSW and other Australian and international jurisdictions
- Summarise key features from the review and evaluate the conservatism and potential for broad application for each methodology.
- Preliminary evaluation of the relative conservatism and potential for broad application for each identified method.
- Recommend a broad cumulative impact assessment framework and present further evaluation for specific recommendations.

Review and evaluation

The review of methodologies is based on recent air quality impact assessments, guidance documentation and regulatory frameworks for air quality management in other jurisdictions. In addition, a questionnaire was distributed to senior personnel in ENVIRON's global air practice to gather local perspective on cumulative assessment and seek feedback on how challenges faced in NSW have been addressed elsewhere.

The methodologies that seek to address challenges faced in NSW are qualitatively evaluated in a matrix, based on criteria including broad application, objectiveness, conservativeness, consistency and suitability for implementation in NSW.

One of the outcomes of the review identified that challenges faced in NSW are common to many other jurisdictions, and have not necessarily been resolved. Nevertheless, common themes were identified in the jurisdictional review, some of which have been used to develop a proposed framework for cumulative air impact assessment in NSW.

Recommendations

The proposed framework for cumulative impact assessment includes the classification of airshed management areas where requirements for cumulative assessment are more detailed. Also introduced is the concept of screening for significance, which can be used, outside of airshed management areas, to screen new emissions sources for risk. Screening for significance is particularly useful for situations where background monitoring data are unavailable for cumulative assessment and detailed cumulative modelling is not warranted due to low project risk.

RECOMMENDATION

Framework for cumulative impact assessment
A framework for cumulative impact assessment is recommended which incorporates:

- The concept of airshed management, identified based on attainment or nonattainment of air quality goals.
- A preliminary impact determination to screen for significance and determine the need for cumulative impact assessment.
- A tiered cumulative impact assessment process for sources identified as significant or located within an airshed management area.

For new emissions sources that are shown to be significant (or located in airshed management areas) cumulative impact assessment would be required.

Depending on the level of complexity and/or risk, cumulative impact assessment should consider a combination of the following aspects:

- Direct change caused by a proposed action or emissions source.
- Other local sources of emissions.
- Existing background or baseline from other sources.
- Reasonably foreseeable future emission sources.
- Potential indirect or induced effects that might flow on from the proposed action.

A tiered approach for cumulative assessment is outlined, whereby an initial "*tier 1*" cumulative assessment would add the project contribution to a suitable representative existing background. The requirement for more detailed cumulative assessment (i.e. "*tier 2*") might trigger, for example, when the *tier 1* cumulative assessment results are greater than 70% of the goal (for annual averages).

Tier 2 or detailed cumulative assessment would include modelling of other local sources, estimating emissions for reasonably foreseeable future development, estimating regional background from non-modelled sources and inclusion of indirect or induced effects, if relevant.

Specific recommendations for detailed cumulative air impact assessment are summarised below, based on additional evaluation completed as part of this study.

Recommendations for future work are also made, if the recommended methodologies are considered for implementation in NSW.

RECOMMENDATIONS

Incorporating background

- Historical data are, in most cases, likely to be conservative for describing a future background. It is recommended that multiple years of data (3-5) are used to describe background in cumulative assessment, to account for inter-annual variation due to climate effects (particularly for particulate matter (PM)).
- For detailed cumulative assessment (tier 2), where other significant local sources are modelled, it is recommended that a suitable 'distant' background site is selected to describe regional background for other non-modelled sources. This is to avoid double counting of existing sources within local (i.e. industry operated) air quality monitoring data.
- For tier 1 cumulative assessment, where other local sources are not explicitly modelled, the background site should be the closest upwind and / or the most representative background site. The selection of background (local or distant sites) should attempt to eliminate or reduce the source-oriented impacts from nearby sources to avoid potential double counting.
- For detailed cumulative assessment (tier 2), future air quality should be considered by including reasonably foreseeable or committed development in modelling or adjusting background based on a percentage change per year, derived from long term analysis of historical trends.
- To demonstrate that a site is representative, analysis of spatial variation should be presented as well as comparison of influencing factors such as land use, local emissions sources, population density etc.
- Where a background year is significantly influenced by bushfire events or dust storms, the median value may be a better statistical descriptor than the mean for describing background. Alternatively a quantitative analysis of the background data should be used to justifiably remove these events from background data.

Cumulative assessment for short term averaging periods

- Assuming that the "additional exceedance" test is the critical factor when assessing compliance with the short term impact assessment criteria, a probabilistic risk based approach is recommended.

Modelling other sources

- The Area of Impact (AOI) methodology may be appropriate if significance screening and Significant Impact Levels (SILs) are adopted for NSW. Consideration of other methodologies, such as the ratio of emissions to distance method (Q/D method) could be used if an AOI approach is ruled out. It is noted that the AOI approach is contingency on where the SIL is applied (receptor or beyond boundary), which has direct implications on the magnitude of the SIL value.

RECOMMENDATIONS

Future work

- Detailed analysis of OEH monitoring data for the previous 5 years to evaluate the suitability of acceptance criteria for defining attainment and nonattainment areas.
- Additional consideration is required to establish suitable SILs for NSW. Also, further investigation of the area of impact methodology for inclusion of other sources is recommended if significance screening and SILs are adopted for NSW.
- The trend and correlation analysis presented in this report should be extended for industry monitoring data, which would be particularly useful for rural NSW.
- A longer term recommendation is made to develop background maps for NSW, based on regional emissions inventories and dispersion modelling.

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1. INTRODUCTION

The New South Wales (NSW) Environment Protection Authority (EPA) has commissioned Ramboll Environ Australia Pty Ltd (previously ENVIRON Australia Pty Ltd) to review and evaluate approaches to cumulative air impact assessment and recommend a suitable assessment methodology for inclusion in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (the Approved Methods) (NSW EPA, 2005).

The recommended methodology would aim to provide an objective, accurate, consistent and repeatable approach which would overcome some of the common challenges encountered in cumulative air impact assessment in NSW.

1.1 Background and context

Proponents are required to demonstrate that new or modified development is able to comply with the impact assessment outlined in the Approved Methods. For criteria[1] pollutants the Approved Methods requires that both incremental and cumulative impacts need to be presented in an air quality impact assessment.

While cumulative air impact assessment is applicable to all criteria pollutants, some pollutants present more significant challenges in NSW. The most commonly assessed criteria air pollutants in NSW, include particulate matter (PM) as PM_{10} and $PM_{2.5}$[2], nitrogen dioxide (NO_2) and sulphur dioxide (SO_2).

PM_{10} concentrations in NSW are generally below the ambient air quality standards and although concentrations occasionally exceed the national 24-hour average standards, this is generally a result of bush fires and dust storms (DSEWPC, 2011).

In rural areas such as Wagga Wagga and in the Upper and Lower Hunter, exceedances of the national 24-hour average standards are more frequent (see **Appendix 1**). Although long term trends in PM_{10} at a number of Office of Environment and Heritage (OEH) monitoring sites are suggestive of a slight downward trend, as evidenced by the trend plots shown in **Appendix 2**, PM_{10} remains a significant pollutant of concern in NSW. There is strong evidence of adverse effects on human health and a lack of evidence for a concentration threshold below which health effects do not occur. This means that there are likely to be adverse health effects due to population exposure to concentrations currently experienced, even where these are below the current standards and goals (NEPC, 2014).

Similarly, $PM_{2.5}$ is a significant pollutant of concern in NSW. A growing body of research points towards the $PM_{2.5}$ fraction as being the most significant in relation to health outcomes (NEPC, 2014). At a number of OEH monitoring sites, the long term trend in $PM_{2.5}$ is suggestive of a slight upward trend, as evidenced by the trend plots shown in **Appendix 2**.

The main sources of NO_2 emissions are motor vehicle exhaust, electricity generation and other combustion sources. NO_2 concentrations in NSW are generally less than a half to one third of the national standards and have been steadily declining over the last decade (DSEWPC, 2011). This is also evidenced in the trend plots shown in **Appendix 2**.

The main sources of SO_2 are electricity generation from coal, oil or gas and processing of metal and mineral ores that contain sulfur. SO_2 concentrations are low in urban areas across NSW with peak levels were generally less than one-third of the standard, but can be elevated near industrial sources, for example smelting operations (DSEWPC, 2011).

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[1] Criteria pollutant is a term used to describe air pollutants that are commonly regulated and typically used as indicators for air quality. In the Approved Methods the criteria pollutants are TSP, PM_{10}, NO_2, SO_2, CO, ozone (O_3), deposition dust, hydrogen fluoride and lead.

[2] Particu late matter with an aerodynamic diameter of less than 10 μm and 2.5 μm

Unlike other pollutants, ozone concentrations in Sydney are not decreasing and although natural sources such as bushfires do contribute to exceedances of the national standard, emissions from anthropogenic sources are often sufficient to alone cause regular exceedances (NSW EPA, 2012). Cumulative impact assessment for ozone is particularly important for the NSW Greater Metropolitan Region (GMR), however methodologies for estimating ground level ozone impacts are described elsewhere (ENVIRON, 2011) and are not considered as part of this review.

Other criteria pollutants such as carbon monoxide (CO), hydrogen fluoride and lead are less of a challenge cumulatively, due to the relative low background concentrations in NSW, and not specifically considered as part of this review. Emissions of hydrogen fluoride are limited to a few specific industries, while elevated concentrations of CO are typically only encountered very near roadways, in areas of high traffic density and poor dispersion (NSW EPA, 2012). Since the phasing out of lead in petrol, the primary source of lead in regional air has been eliminated (NSW EPA, 2012), and ambient lead concentrations are low enough not to be a significant concern for cumulative air impact assessment. For 'air toxic' or 'odorous air pollutants', the Approved Methods requires that only incremental increases in concentrations are presented and are also not considered as part of this review.

1.2 Definitions of cumulative air quality effects

The Approved Methods does not define cumulative air quality effects, however it does require that background air quality is considered to assess "total" impact of a proposal. The Approved Methods also requires that cumulative impacts of emissions from several facilities needs to be considered. Implied in this is that cumulative air assessment needs to consider both background/baseline and other existing sources of local emissions.

A broad definition of cumulative impact is provided in the US National Environmental Protection Act (NEPA) regulation (40 CFR[3] 1508.7) as:

> *Cumulative impact is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.*

Of note, the NEPA definition introduces the concept of "*reasonably foreseeable*" future actions, which is not specifically mentioned in the Approved Methods. The inclusion of future actions and reasonably foreseeable development in cumulative assessment is inconsistent in current approaches (see **Section 3**).

Future actions are also considered in the Government of Canada's definition of cumulative effects[4], as follows:

> *Cumulative effects are changes to the environment that are caused by and action in combination with other past, present and future human actions. (CEAA, 1999)*

Direct and indirect effects, as they related to cumulative assessment, are defined in 40 CFR 1508.8, as follows:

> *Direct effects, which are caused by the action and occur at the same time and place.*
>
> *Indirect effects, which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of*

[3] Code of Federal Regulations

[4] Cumulative effects and cumulative impacts are synonymous and both terms are used interchangeably in this report

land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems.

A definition for cumulative impacts is also provided in the Cumulative Impacts Good Practice Guide for the Australian coal mining industry, as follows:

Cumulative impacts are the successive, incremental and combined impacts of one, or more, activities on society, the economy and the environment. Cumulative impacts result from the aggregation and interaction of impacts on a receptor and may be the product of past, present or future activities. (Franks et al, 2010).

Based on the definitions presented above, cumulative air impact assessment should consider all or a combination of the following aspects:

- the proposed direct change caused by a proposed action or emissions source.
- other local sources of emissions.
- the existing background or baseline from other sources.
- reasonably foreseeable future emission sources.
- potential indirect or induced effects that might flow on from the proposed action.

These aspects come together to form a conceptual model for cumulative impact, as shown in **Figure 1-1**.

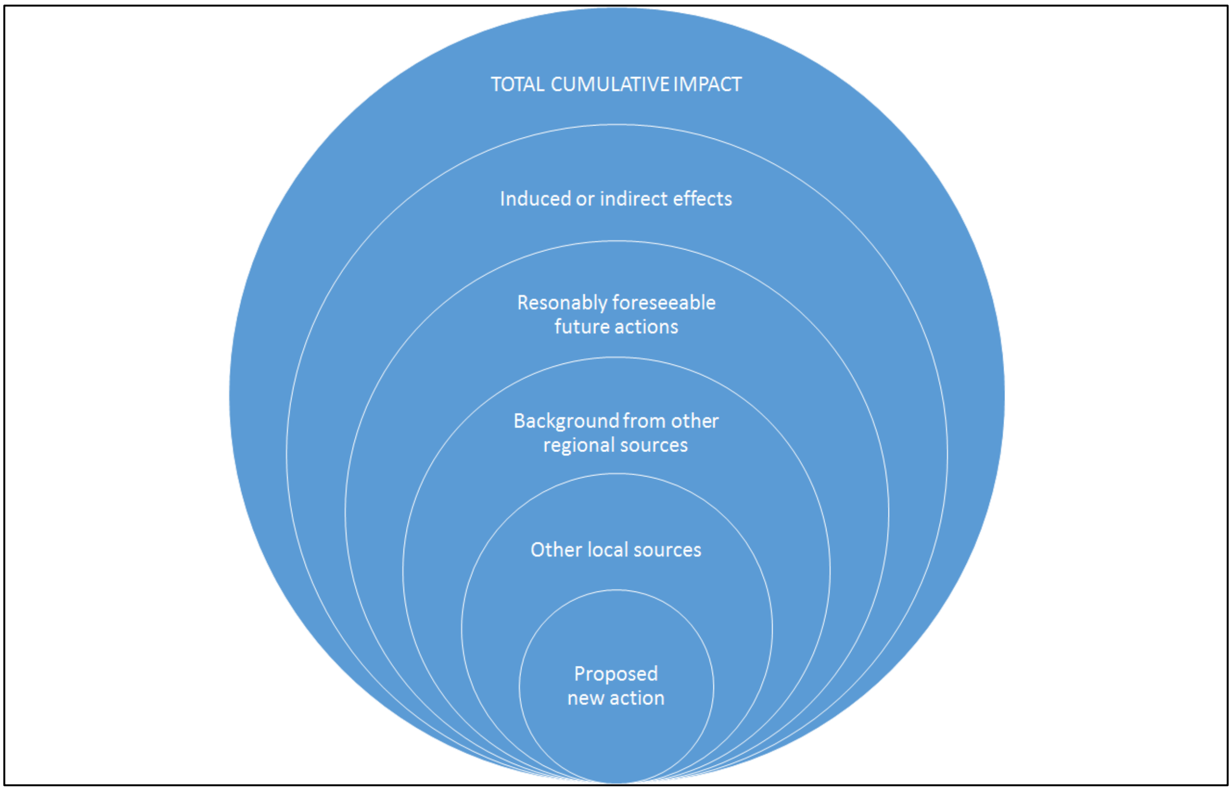

Figure 1-1: Conceptual model for total cumulative impact

2. STUDY APPROACH

The study approach is based on the Terms of Reference (ToR) for the study, as outlined in Schedule 2 (technical specification) of Part B – General Conditions of Contract for Cumulative Air Impact Assessment Methodology Review (agreement number EPA-86-2014).

The purpose of the study, as defined by the ToR, is to evaluate methods for cumulative air impact assessment, as follows:

- Review and summarise existing approaches to cumulative air impact assessment for common air pollutants (including PM_{10}, NO_2 and SO_2) both within NSW and other jurisdictions.
- Identify data and methodological gaps and provide recommendations on additional data and procedures to adequately quantify background/baseline concentrations for air impact assessments.
- Recommend preferred methodology(ies) to incorporate background concentration data in a cumulative impact assessment.
- Demonstrate the validity of the preferred approaches.

The scope for the study, as defined by the ToR, includes the following tasks:

- Summarise and compare existing methodological approaches in NSW with other local and international jurisdictions with particular reference to NO_2, SO_2 and PM.
- Identify and consider any other feasible cumulative assessment methods to those currently utilised within NSW and other jurisdictions.
- Evaluate the relative conservatism and potential for broad application for each identified method.
- Recommend the preferred method(s) to incorporate background concentrations in cumulative impact assessments within a tiered assessment framework.
- Detail procedures for evaluating cumulative impact assessment modelling results.

2.1 Scope of work

The scope of work for the study involves the following steps.

Step 1: Literature review of existing approaches

Existing approaches to cumulative air impact assessment within NSW are identified by reviewing recent air quality impact assessment (AQIA). AQIA are reviewed for a number of different regions of NSW, a range of different air quality practitioners and a variety of major projects with varying sources of emissions.

The international jurisdictional review focused on a number of key regions, where established regulatory frameworks for air quality management include requirements for cumulative air impacts. A series of questions related to challenges faced in NSW was distributed to senior personnel in Ramboll Environ's global air practice. The objective of the questionnaire was to gather local perspective on cumulative assessment and seek feedback on how challenges faced in NSW have been addressed elsewhere. Cumulative assessment approaches applied in other states of Australia are summarised based on published guidance, legislatives framework, case studies which demonstrate the application of the approach and feedback from ENVIRON personnel on the questionnaire. The following jurisdictions were included in the review:

- Australia (NSW, Western Australia, South Australia, Victoria, Queensland) and New Zealand.
- U.S - federal permitting and NEPA approvals.
- Canada - Alberta, British Columbia and Ontario.
- EU – United Kingdom, France, Italy and Netherlands.
- Hong Kong.

Step 2: Summarise key features

A summary of the literature review is provided for each jurisdiction and key features were identified for evaluation.

Step 3: Preliminary evaluation

A preliminary evaluation of key features is presented based on the objectives outlined in the ToR. The approaches that seek to address the challenges faced in NSW are qualitatively evaluated in a matrix, based on criteria including broad application, objectiveness, conservativeness, consistency and suitability for implementation in NSW.

Step 4: Further evaluation of key features

Additional evaluation is presented to inform recommendations for short term impact assessment, incorporating background concentration data and other inclusion of other sources in modelling for cumulative air impact assessment.

Step 5: Recommendations for implementation

Based on the literature review and evaluation, recommendations are presented for potential cumulative assessment methodologies for NSW. The recommendations are used to develop a proposed framework for cumulative air impact assessment in NSW.

3. GUIDANCE AND CHALLENGES FOR CUMULATIVE AIR IMPACT ASSESSMENT IN NSW

3.1 Introduction

The NSW Environmental Planning and Assessment Act (1979) is the principal piece of legislation used in NSW for the approval of new development. Under the Act, environmental assessment is required for new or modified development applications. Where an activity involves emissions to air, typically an air quality impact assessment (AQIA) is required as part of an environmental assessment (EA) or environmental impact statement (EIS).

The Act does not specifically prescribe requirements for cumulative effects analysis (other than for designated fishery activity), however requirements for impact assessment are outlined in the Secretary's Environmental Assessment Requirements (SEARs), issued by the Department of Planning and Environment (DPE) with input from the relevant state regulators. The EPA provides advice to the DPE on the requirements for AQIA, and these requirements typically reference the Approved Methods, which include provisions for cumulative impact assessment (see **Section 3.2**).

Air emissions from existing facilities in NSW are regulated under the Protection of the Environment Operations Act 1997 (POEO Act), supported by the Protection of the Environment Operations (Clean Air) Regulation 2010 (POEO Clean Air Regulation (PCO, 2011a)). The EPA is responsible for regulating air emissions under the POEO Act, primarily through the licensing of scheduled industrial activities. The POEO Act is primarily aimed at regularly individual facilities and does not consider cumulative effects.

3.2 Cumulative assessment guidance in the Approved Methods

Section 5.1 of the Approved Methods describes the requirements for background air quality and introduces the concept of 'total' impact (the addition of new emissions on existing air quality). A tiered assessment approach is described, as follows:

- Level 1 assessment, whereby the maximum background concentration is added to the 100^{th} percentile dispersion model prediction at the maximum exposed receptor, to obtain the total impact for each averaging period.
- Level 2 assessment, whereby hourly dispersion model predictions are paired with contemporaneous hourly background concentrations to obtain predictions of total impact for each hour. At each receptor, the 100^{th} percentile total impact is determined from the hourly concentrations for each averaging period.

Guidance is provided on how much background data are required (one year of continuous measurements) and on suitable sources of ambient monitoring data. For areas where existing exceedances of the impact assessment criteria already occur, a proponent is required to demonstrate that no additional exceedance would occur as a result of the proposal.

Section 7 describes how dispersion modelling results are to be interpreted against the prescribed impact assessment criteria. For "criteria" pollutants both the increment impact and total impact (increment plus background) must be reported.

Section 7 also describes how the cumulative impact of emissions from several facilities needs to be considered. However it is noted that no guidance is provided on how "other facilities" are considered, for example whether emissions from other facilities are considered in dispersion modelling or existing monitoring data.

The Approved Methods outlines a three tiered approach to dealing with NO_x conversion (the oxidation of NO to NO_2) and cumulative NO_2 assessment. Method 1 assumes full conversion of NO_x to NO_2 and can be applied in a Level 1 or Level 2 assessment. Method 1 requires background NO_2 statistics (for Level 1) or hourly averages (for Level 2).

Method 2 applies the U.S. EPA Ozone Limiting Method and can be applied in a Level 1 or Level 2 assessment. Method 2 requires NO_2 and ozone statistics (for Level 1) or hourly averages (for Level 2). Method 3 describes an empirical relationship between NO_2 and NO_x, based on distance downwind, ozone concentration and wind speed.

For major sources of NO_x and VOCs, the Approved Methods recommends a more detailed approach, based on the use of photochemical grid models (PGMs). Major sources have be subsequently defined in the ozone assessment framework for NSW (ENVIRON, 2011).

The NSW EPA has commissioned a separate consultancy to provide recommendations for NOx conversion and this is not considered further in this report.

3.3 Planning and industry guidance

Assessment of cumulative air impacts in NSW is of particular significance for the coal mining industry. The NSW Department of Urban Affairs and Planning published EIS guidelines for coal mines and associated infrastructure (DUAP, 2000) which included specific guidelines for cumulative assessment, including air quality. The guidelines require a consideration of background air quality as well as "*other existing or proposed activities in the same area with similar environmental impacts*".

Cumulative impacts for mining are also referenced in the State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) Amendment (Resource Significance) 2013. The Mining SEPP defines a "cumulative air quality level" and requires that mining development does not result in a cumulative annual average level greater than 30 µg/m^3 of PM_{10} for private dwellings.

Challenges faced by the coal mining industry in assessing and managing cumulative impacts have led to the development of a *Cumulative Impact Good Practice Guide*, specifically for the Australian coal mining industry. The guide covers broad cumulative impacts and does not provide specific guidance for cumulative air impact assessment.

3.4 Challenges in cumulative air impact assessment

Notwithstanding the complexity of cumulative air impact assessment in general, there are a number of specific challenges faced in NSW, some of which are discussed below.

3.4.1 Spatial and temporal coverage of background data

The Office of Environment and Heritage (OEH) operate and manage 43 active air quality monitoring stations across NSW, with the majority (36 sites) located within Greater Metropolitan Region (GMR). Coverage is good in the Sydney Region (15 sites) and in industrial areas such as the Upper Hunter Valley (14 sites[5]) and the Lower Hunter / Newcastle area (6 sites).

The concentration of monitoring stations within the GMR reflects the area where the majority of people reside (approximately 75% of the population in 2008 (NSW EPA, 2012a) and therefore where population exposure to air pollution is greatest.

Rural NSW has limited coverage of OEH monitoring stations. Current monitoring sites include Tamworth, Bathurst, Wagga Wagga and Albury, however significant areas of Western NSW are un-represented. Rural monitoring sites may be expanded under the NSW Government's *New England North West Strategic Regional Land Use Plan* which included a commitment to the establishment of an air quality monitoring network in the region. The spatial coverage of OEH monitoring stations in rural areas compared with the GMR is shown in **Appendix 3**.

Not all OEH monitoring stations measure all criteria pollutants and in areas with good spatial coverage, such as the Upper Hunter Air Quality Monitoring Network (UHAQMN), monitoring data may not be available for all pollutants of interest. For example, of the 14 UHAQMN sites, only two

[5] Merriwa, Wybong and Aberdeen lie outside the GMR but form part of the UHAQMN.

measure NO_x and SO_2 and only three measure $PM_{2.5}$. The pollutants measured at each site are summarised in **Appendix 3**.

Temporal coverage also varies across the OEH monitoring stations. The OEH monitoring network continues to grow and while some sites have long term data records, others, such as the UHAQMN, the Newcastle Local sites and the Central Coast site were established in recent years.

In rural areas outside the GMR there is a reliance on industry operated sites for baseline data. Industry operated sites are often established for compliance purposes and therefore the pollutants measured are specific to the monitoring requirements for that industry, or as required by an approval and/or Environment Protection Licence (EPL).

Industry monitoring for PM_{10} and $PM_{2.5}$ is more widespread than any other pollutants, for example, baseline / background PM data are available in mining areas such as the Gloucester Valley, the Gunnedah Basin, and areas around Mudgee, Orange, West Wyalong and Broken Hill.

Temporal coverage varies between sites and industry operated sites have also historically employed High Volume Air Samplers, resulting in non-continuous data in most areas.

3.4.2 Climate effects

Climate effects such as climate change and El Niño Southern Oscillation (ENSO) add another level of temporal uncertainty for the consideration of background data. Variation in annual rainfall related to ENSO cycles may influence background PM_{10} concentrations, particularly in rural areas of NSW, where dryer conditions can result in increased fugitive dust, which in turn can dominate ambient concentrations of PM_{10}.

An example of how climate cycles influence PM_{10} concentrations is illustrated in **Figure 3-1**, showing the cyclical pattern in PM_{10} concentration at Tamworth over a period of 14 years. **Appendix 2** presents the long term monthly trends for other OEH monitoring sites and pollutants in NSW.

Between 2010 and 2012 a dip in PM_{10} concentrations is evident in the higher percentile trend lines, corresponding to development of La Nina conditions and above average rainfall in 2010 and 2011. In 2013 PM_{10} concentrations increase again, corresponding to period of low rainfall and the warmest year on record for NSW. The pattern is clear in the higher percentile value but almost non-existent in the lower percentiles, showing a potentially stronger climate influence on peak concentrations, indicative of the influence of fugitive dust in dryer conditions and greater numbers of dust storms and bushfires. There is a slight pattern evident in the median (50^{th} percentile) trend.

Annual variability in background PM_{10} at Tamworth (climate influenced or otherwise) is clear and the selection of a single year for cumulative assessment in this case may not necessarily result in a representative value for background, for peak concentrations.

The Approved Methods currently requires *at least* one year of background monitoring data but doesn't specify a preferred number of years for analysis. Recommendations for other jurisdictions range from 3-5 years (refer **Section 5**). Currently in NSW, air quality impact assessment would generally describe background using a single year of data, matched period selected for modelling.

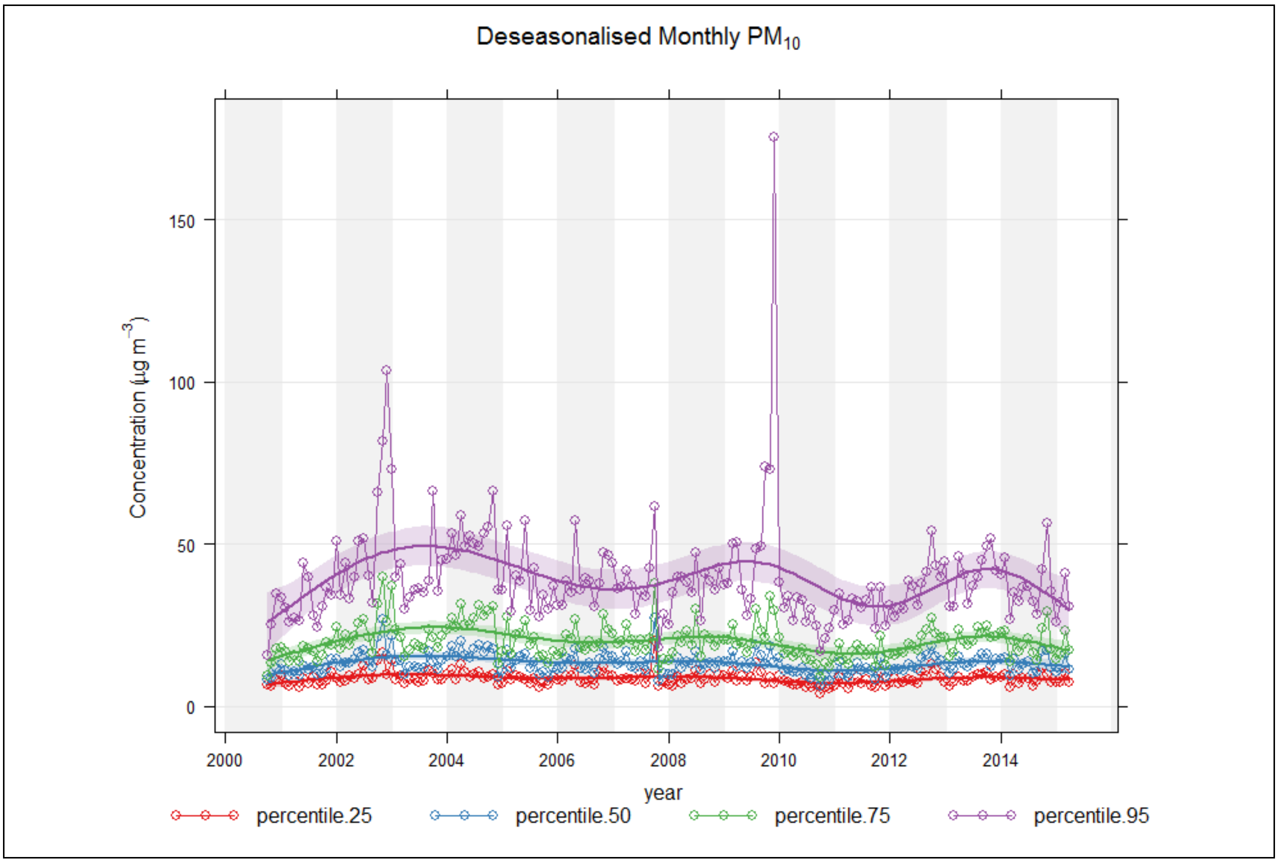

Figure 3-1: Monthly mean PM_{10} concentration at Tamworth with 95% confidence limits

3.4.3 Evaluation of short-term impacts

Cumulative assessment for short term averaging periods (such as 24-hour PM_{10} and $PM_{2.5}$, 1-hour NO_x) are typically more challenging than for long term averages. While issues related to availability of data, spatial and temporal variability, high background, etc. are applicable to both long term and short term averages, the uncertainly in short-term impact assessment can amplify some of these challenges.

The existing methodologies prescribed in the Approved Methods do not overcome these challenges. The Level 1 assessment methodology falls over for elevated background or existing exceedances. Baseline PM data often have existing exceedances and the treatment of these exceedances can be inconsistent and somewhat subjective, with no prescribed guidance to follow.

The Level 2 assessment methodology is challenging when insufficient data are available, for example the wrong period, where the data are not continuous or where gaps are present.

Adhering to the Level 2 assessment methodology can also force a less appropriate dataset being used for cumulative assessment, if for example, it is solely selected on the basis that the data are continuous. The Level 2 assessment methodology does not take into account inter-annual variability.

For both the Level 1 and the Level 2 approach, high background paired with very small project increment can result in an exceedance of impact assessment criteria. In some circumstances a precautionary approach such as this may be warranted, however in other circumstances this might place undue restriction on low risk development while other existing industry continues to operate with higher risk of air quality impact.

3.4.4 NO_x conversion

Proposed methods for NO_x conversion in the Approved Methods require background data, either in the form of statistics (Level 1 approach) or continuous hourly data (Level 2 approach). For peak short-term concentrations, the application of Level 1 assessment (for Method 1 or OLM) is often too conservative, resulting in non-compliance with 1-hour goals. Regardless, the Level 1 approach needs at least an indication of background (in the form of average and maximum statistics), and as shown in **Appendix 3**, not many monitoring sites, particularly outside the GMR, have suitable data. This is compounded in the application of the Level 2 approach, which requires continuous hourly NO_2 data, and in the case of OLM, hourly ozone data.

Another common challenge is the modelling of intermittent peak NO_x emission sources (such as blast fume in mining or back up diesel generators) and how these sources are assessed cumulatively with continuous NO_x emissions sources (such as mining plant) and background. In most cases, a Level 1 assessment approach, using maximum predictions, is likely to be too conservative. The NSW EPA has commissioned a separate study to evaluate methodologies for NO_x conversion and this is therefore not considered further for cumulative assessment.

3.4.5 Elevated background

The Approved Methods provides guidance on dealing with elevated background and requires proponents to demonstrate that no additional exceedances would occur as a result of proposed activity, and to implement best practice management to minimise emissions as far as practical. A worked example of the Level 2 assessment approach is presented in the Approved Methods showing cumulative results for the highest background days with corresponding increment and the highest increment days with corresponding background.

The no additional exceedance test is suitable where elevated background is a result of natural events (dust storms and bushfires) and the maximum project increment typically does not correspond to the same day as the elevated background[6]. In this way, relatively minor emissions sources would be demonstrated as having minimal impact on the airshed.

For an airshed that is influenced by existing anthropogenic sources, it is more challenging to demonstrate that no additional exceedances would occur. For example, in the Upper Hunter Valley mining area, modifications to existing mines need to account for the contribution of existing activities to measured concentrations (and existing exceedances). The no additional exceedance test needs to consider that the background for cumulative assessment includes activities that may have contributed to existing exceedances but will be replaced or modified into the future.

The implementation of best practice management to minimise emissions for new sources may be more important in situations where constrained airsheds are a result of anthropogenic activity, rather than situations where elevated background is caused by uncontrollable natural events. This is reflected in the EPA's "dust stop" pollution reduction programme, which is currently focused on the coal mining industry.

Challenges also arise in situations where the existing background concentration is elevated but not necessarily resulting in existing exceedances. A new emissions source might have minimal incremental risk (i.e. less than 1% of the standard) and yet still result in an exceedance when added to background using the Level 1 or Level 2 methodologies. If this predicted exceedance is seen as unacceptable, it may then require emission reduction requirements on the new emissions source, disproportionate to other existing contributing sources and for very little air quality benefit. An example of this is seen in PEL (2014a) whereby a relatively small increment in 24-hour PM_{10} added to an elevated background for that day resulted in additional exceedances of the impact assessment criteria. The facility (a cotton gin) was proposing cyclones for PM emissions control, generally considered to be best practice for cotton ginning facilities. Due to the relatively remote location of the project with very little population exposure to emissions from the facility, any additional controls may have had little or no air quality benefit.

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[6] Exceedances of air quality goals in NSW are typically limited to PM and ozone.

3.4.6 Subjective data selection for background

The Level 2 assessment approach does not require treatment of ambient PM monitoring data to remove the influence of natural events, as the no additional exceedance rule can be applied. However, in some cases the treatment of background data to remove certain events may be warranted.

For example, in 2009, the high frequency and intensity of dust storm events significantly influenced the annual mean PM_{10} concentration, and in this case the median concentration in 2009 would provide a better representation of average background (see **Figure 3-2**).

There is currently no guidance for the treatment of background data, such as the removal of natural events or the most appropriate statistical descriptors to use, which can result in an inconsistent and subjective approach in air quality impact assessment.

3.4.7 Inclusion of local and distant emissions sources in cumulative assessment

The inclusion or exclusion of "other" sources in modelling for cumulative impacts presents a significant challenge for cumulative assessment. There is limited guidance on what local sources should be included in modelling, what are considered 'distant' sources and therefore included in the added background. The lack on guidance results in a rather subjective selection process, both for modelling other sources and selection of background for cumulative assessment.

Potential future actions include emissions sources that are approved or are proposed for development in the future (i.e. publically listed on the NSW Department of Planning and Environment assessments register). Existing cumulative air assessments in NSW are generally limited to including those developments that are already approved. This is particularly challenging in areas such as the Upper Hunter Valley, where approval can be granted for a mine based on approved development at the time, only for a subsequent modification at another mine to change what was previously defined for the future airshed.

3.4.8 Background creep

New emissions sources are currently assessed against cumulative impact assessment criteria, which in most cases mirrors the national ambient air quality standards. The assessment of cumulative impacts against these cumulative standards alone theoretically allows for air quality to deteriorate right up to the standard, without any control on the allowable increments. The U.S. permitting process aims to avoid this by assessing new emissions sources against an allowable increment[7] and also cumulatively against the national ambient air quality standards (NAAQS). The aim of the allowable increment is to prevent air quality in clean areas from deteriorating to the level set by the NAAQS, thereby avoiding or slowing background creep.

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[7] Prevention of significant deterioration (PSD) increment.

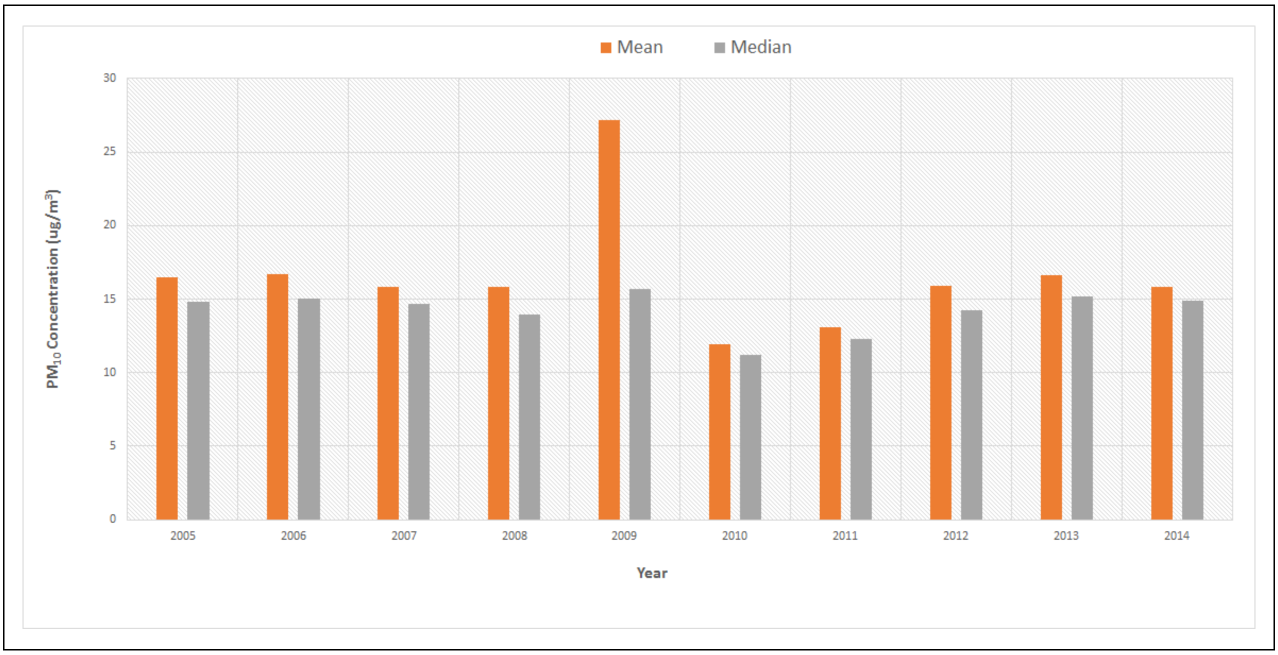

Figure 3-2: Annual mean and median PM_{10} for Tamworth

4. REVIEW OF CUMULATIVE ASSESSMENT APPROACHES IN AIR QUALITY IMPACT ASSESSMENT

A summary of current approaches to cumulative air assessment in NSW is presented by reviewing the various approaches applied in recent air quality impact assessment (AQIA). The AQIAs are taken from the DPE major project register for Environmental Assessments of State Significant Development (SSD) and Part 4a applications. By reviewing AQIAs, the challenges faced in NSW are further highlighted and the reasons for commissioning this review are reinforced.

AQIA is reviewed for a number of different regions, including constrained airsheds with multiple emissions sources, rural areas with limited background data and urban areas with extensive background data. Reports produced by a range of different air quality practitioners are selected for review to capture variations in approach. In general, major projects have been selected as they are more likely to have considered cumulative effects.

4.1 Upper Hunter Valley coal mining region

A comparison between two recent AQIAs is presented as a case study of cumulative assessment challenges in a constrained airshed with multiple emissions sources. Both AQIAs were completed for modifications to existing mining operations.

The cumulative assessment approach for the Mount Owen Continued Operations AQIA (PEL, 2014b) and Mount Thorley Operations AQIA (TAS, 2014a) are compared in **Table 4-1**. Some of the challenges and issues faced in these studies are discussed as follows:

- Committed or Future Development. Both assessments modelled other mining sources and the radius for inclusion of other sources was very similar. PEL (2014b) included approved development only, with the exception of the not yet approved Liddell Coal Mine Modification which was also included. TAS (2014a) assumed all mines would continue to operate, regardless of when their existing approvals lapsed. This approach could be argued as including *reasonably foreseeable future development*. There was an exception to this in that TAS (2014a) did not include Integra, which is currently in care and maintenance.
- Background. The approach for deriving background PM_{10} results in very different values reported in the assessments (13.2 µg/m³ and 6.9 µg/m³). While the approach is different, an additional "model calibration" step in PEL (2014b) would probably result in the background that is applied close to mining sources being more comparable between the assessments. However, on the surface and to the non-technical reader, this difference in background might seem unreasonable and be questioned.
- Short term averaging periods. Different approaches are applied for short-term impact assessment. PEL (2014b) presents a probabilistic estimate of the risk of additional exceedances, using monte-carlo techniques (described in **Section 4.5**). TAS (2014a) uses the Approved Methods Level 2 assessment approach (paired in time background and model predictions).
- Double counting: Both assessments avoid '*double counting'* by modelling existing operations and removing the predicted contribution from the monitoring data.
- Subjective selection of data. For background $PM_{2.5}$ TAS (2014a) adopts a different approach to PM_{10}. A nominal background value is selected based on the assumption that local concentrations would be lower than the concentrations measured at Singleton. For the assessment of 24-hour $PM_{2.5}$ impacts, the 70th percentile is used.

Table 4-1: A comparison of recent approaches to cumulative assessment for mining operations in the Hunter Valley

Mount Owen (Pacific Environment)	Mount Thorley (Todoroski Air Sciences)
Treatment of 'other' local emission sources	
• Emissions from "*neighbouring mines*" were included in the dispersion model. The process for selecting which mines was not described. • 9 mines within a radius of ~17kms were included in the modelling. • Mines that are operating or have approval to operate were included. • Where a mine is scheduled to cease operating or approval lapses, it is not included in the future year scenarios. • Integra (in care and maintenance) was assumed to be operational and included. • Although not approved, the Liddell Coal Mine modification was included.	• Emissions from "other mining operations" were included in the dispersion model. The process for selecting which mines was not described. • 5 mines within a radius of ~17kms were included in the modelling. • Mines that are operating or have approval to operate were included. • All mines are assumed to continue to operate for all future year scenarios (regardless of whether approval or not). • Integra (in care and maintenance) was not included. • Although not approved the Rix's Creek Continuation of Mining Project was included.
Treatment of background from other sources - long term averages	
• Annual average background PM_{10} derived based on measurements from the OEH monitoring stations at Merriwa, Wybong and Jerrys Plains. These sites are chosen as they are less likely to be influenced by mining activity due to their location (both in terms of distance from mining and being out of the dominant prevailing wind direction). Median value selected (to remove the influence of bushfires in the data). • Annual average background $PM_{2.5}$ derived based on measurements from the OEH monitoring station at Camberwell. Median value selected (to remove the influence of bushfires in the data). • Annual average background TSP derived from PM_{10} concentration based on a PM_{10}/TSP ratio measured around the mine site. • The adopted background for other non-mining sources is: • PM_{10} = 13.2 µg/m³ • $PM_{2.5}$ = 7.1 µg/m³. • TSP = 37.7 µg/m³. • Dust = 2 g/m²/month • While these background values are added to model predictions across the entire modelling grid, an additional adjustment is made to the modelling to account for model over prediction, particularly close to mining sources. Dispersion model predictions for the existing 9 mines discussed above were compared to the measured concentrations at monitoring stations. The ratio of measured to modelled is then used to develop a spatially varying "model calibration grid" which is combined with the cumulative predictions. .	• The annual average background PM_{10}, TSP, from other is derived by modelling existing mining operations (for the 5 local mines described above) and comparing model predictions to the measured concentrations at monitoring stations. Background (from all other sources) is taken as the average difference between measured and predicted PM_{10}, TSP and dust concentration. • Annual average $PM_{2.5}$ concentrations are taken as 5 µg/m³, based on the assumption that levels at the site would be lower than at Singleton (which was measured as approximately 8 µg/m³. • The adopted background for sources not included in the modelling and is: • PM_{10} = 6.9 µg/m³. • $PM_{2.5}$ = 5 µg/m³. • TSP = 23.1 µg/m³. • Dust = 1.7 g/m2/month
Cumulative 24-hour PM_{10} and $PM_{2.5}$	
• Cumulative 24-hour impacts are assessed using a statistical approach (Monte Carlo modelling technique). The approach randomly adds modelled increments to measured background for an assessment of total impact. Background is derived based on the TEOM measurements surrounding the site, but with the contribution from the existing Mount Owen mine removed. The contribution from the existing Mount Owen mine is removed by modelling existing operations and then subtracting the model predictions from the measured concentrations for each corresponding day.	• The approach taken for cumulative 24-hour PM_{10} impacts is based on the Level 2 contemporaneous approach outlined in the approved methods. Background concentrations are derived based on TEOM measurements surrounding the site but with the contribution from the existing mine removed. The contribution from the existing mine is removed by modelling existing operations and then subtracting the model predictions from the measured concentrations for each corresponding day. The resultant concentration is added to model predictions for an assessment of total impact. Unlike the approach for annual average, the modelling done for Mt Thorley and Warkworth only (not the other 5 mines). • The approach taken for cumulative 24-hour $PM_{2.5}$ impacts is to add the 70th percentile of the measured data from Singleton site to the modelling predictions.

Cumulative assessment methodologies for three other mining operations near Muswellbrook were reviewed by ENVIRON on behalf of the (then) Department of Planning and Infrastructure (ENVIRON, 2013). The review included the Mount Arthur Coal Open Cut Modification (prepared by Pacific Environment), the Bengalla Continuation Project (prepared by Todoroski Air Sciences) and the Mangoola Coal Modification (prepared by Todoroski Air Sciences).

Modelling other sources: All three assessments were reasonably consistent in their inclusion of neighbouring mines in the dispersion model. The Mt Arthur AQA (PAE, 2013) models four neighbouring mines (Bengalla, Drayton, Mangoola and Mt Pleasant). The Bengalla AQA (TAS, 2012) models five neighbouring mines (Mt Arthur, Drayton, Mangoola, Muswellbrook, Mount Pleasant) and the Mangoola AQIA (TAS, 2013) models three neighbouring mines (Bengalla, Mt Arthur, Mount Pleasant). Generally, only approved mines are modelled in each assessment. For example, Bengalla is included up to 2016 but the continuation of mining due to the proposed Bengalla modification is not included in the other modelling assessments. Similarly, the proposed Drayton South modification is discussed but not quantified for assessment. Emissions from the approved Mt Pleasant mine are included in all three assessments, but not based on the latest modification, which was not yet approved.

Background from other sources: The Bengalla AQA and Mangoola AQIA adds a constant background across the modelling domain for long term averages (in the case of PM_{10} a value of 5 µg/m^3 is applied in both assessments). This background is derived by modelling an existing scenario (all local mines) and subtracting from the existing monitoring data immediately surrounding the site. A similar approach is used for 24-hour average PM_{10}, except only the project contribution is modelled for existing operations (i.e. not the neighbouring mines). A Level 2 cumulative assessment is then completed.

The Mt Arthur AQA models an existing scenario (all local mines) and derives a spatially varying annual average background by comparing to all available monitoring data in the model domain. Cumulative 24-hour PM_{10} concentrations are assessed by presenting the combined concentrations from the project and local mining operations, however background from other sources is not included.

Background and cumulative $PM_{2.5}$: The Mangoola AQIA (TAS, 2013) adopts a nominal annual average $PM_{2.5}$ concentration of 4 µg/m^3 for background, based on the assumptions that higher $PM_{2.5}$ levels recorded in Muswellbrook during winter (due to domestic wood burning) and other urban sources should be excluded from background. For 24-hour $PM_{2.5}$, the 70th percentile of the "winter excluded" 24-hour average $PM_{2.5}$ concentrations was selected. The Bengalla AQA, also completed by Todoroski Air Sciences, does not characterise a background $PM_{2.5}$ and does not present cumulative $PM_{2.5}$ impacts (TAS, 2012).

The Mt Arthur AQA adopts an annual average $PM_{2.5}$ concentration of 5 µg/m^3 for background, derived from the PM_{10} measurements around the site and a $PM_{2.5}$:PM_{10} ratio of 0.38 (which is derived from co-located monitors in Muswellbrook). Cumulative 24-hour $PM_{2.5}$ impacts are not presented.

A summary of the challenges for AQIA in the Upper Hunter Valley are:

- Subjective selection of "background" results in very different values applied in different assessments for the same area.
- Future emissions sources included for approved development but not for *reasonably foreseeable future development* in most cases.
- Inconsistency in the approach for cumulative short term impact assessment.

4.2 Lower Hunter /Newcastle Port area

The AQIA for the Port Warratah Coal Services (PWCS) T4 project used a combination of existing monitoring data and modelling of future sources for assessment of cumulative impacts (ENVIRON, 2012). All existing sources of emissions for the region were assumed to be accounted for in the background, which was based on all the available local monitoring data. All approved future sources were explicitly modelled, using emissions estimates presented in their respective air quality impacts assessments. The modelled future sources were added to existing monitoring data to derive a "*future baseline*" for cumulative assessment.

Spatial variation in background was accounted for using the most representative background monitoring station for each receptor location. This was made possible by a relatively extensive network of monitoring sites (for example data from nine PM_{10} monitoring sites was used). The extensive network of monitoring sites also provides confidence that existing sources of emissions were accounted for in the background data.

When combined with the future source modelling predictions, a future baseline is defined specific to each location. For example, the cumulative background annual average PM_{10} ranged from 17.4 µg/m³ to 19.4 µg/m³. For 24-hour PM impacts, a Level 2 assessment approach was followed, using the daily varying future baseline (combination of background and modelled future sources) and the number of predicted additional exceedances was presented.

4.3 Rural locations

The air quality assessment for the Atlas-Campaspe Minerals Sands Project (Katestone, 2013) is an example of a relatively isolated project where little or no long term background monitoring data are available. The AQIA completed a review of the National Pollution Inventory (NPI) to identify existing sources of emission to air that might result in cumulative air effects with the project. No nearby emissions sources were identified and on that basis, background concentrations of gaseous pollutants (i.e. NO_2, SO_2, CO) were assumed to be negligible. Future committed development were considered, but deemed to be too remote to warrant quantitative assessment.

Katestone (2013) describes background PM based on distant monitoring data, both industry operated at Broken Hill (located 270km away) and an OEH operated site at Wagga Wagga (located 400 km away). An analysis of community monitoring data (Dust Watch data) were also presented but not used in the quantification of background. The background data chosen for cumulative assessment was the OEH Wagga Wagga site, although the Broken Hill data are described as being more representative for the project site. The reason for selecting Wagga Wagga above Broken Hill was due to the availability of continuous data to enable a Level 2 assessment. Missing data were filled in using the average of the daily concentration immediately preceding and following the missing data point and existing exceedances in the background dataset were retained. Background TSP data were not available and were derived from the PM_{10} data using the assumption that 50% of TSP is PM_{10}. Background $PM_{2.5}$ data were also derived from the PM_{10} data using the assumption that 20% of PM_{10} is $PM_{2.5}$. Predictions of PM from onsite power generation were not combined with fugitive dust from mining for cumulative assessment.

The approach in Katestone (2013) demonstrates some of the challenges in cumulative assessment in remote (data sparse) areas, resulting in the subjective data selection process for background. Monitoring data collected 400 km from the site were selected for assessment to satisfy the Level 2 assessment approach despite a more representative dataset being available in Broken Hill (although also remote from the site). The selection of background data for $PM_{2.5}$ was based on the assumption of a $PM_{2.5}$:PM_{10} ratio of 0.2. Justification for such a low ratio is based on US EPA recommended $PM_{2.5}$:PM_{10} ratios for emissions at source (not ambient ratios) for sources such as unpaved roads and wind erosion. Measured ambient $PM_{2.5}$:PM_{10} ratios at Wagga Wagga were not referenced, although Wagga Wagga PM_{10} data were used. The AQIA was also unable to match $PM_{2.5}$ monitoring at Wagga Wagga with the PM_{10} data because 2007 was selected as the meteorological modelling period, and

$PM_{2.5}$ data were not available for this period, although $PM_{2.5}$:PM_{10} ratios are available for a different monitoring period.

The availability of site specific background data allowed for a more representative Level 2 approach for the Cobbora Coal Project (ENVIRON, 2012). Site specific PM_{10} collected for the project were compared with other regional data and found to correlate strongly. No other local emission sources were identified within 40 km of the site, based on a review of the National Pollution Inventory (NPI) for existing sources and the major project register for approved future sources. By adopting the Level 2 approach, it was necessary to supplement the onsite data (75% complete) with data from an OEH station 140 km away. While not ideal, the approach was demonstrated as suitable based on a detailed comparison in regional PM_{10} which were found to correlate well (R^2 ranging from 0.68 to 0.91). The regional comparison was also useful to demonstrate that spatial variation in 24-hour PM_{10} was not significant and that the adoption of a single background for cumulative assessment across the domain was appropriate. There were no $PM_{2.5}$ or TSP data available and typical TSP:PM_{10} and PM_{10}:$PM_{2.5}$ ratios were applied to the PM_{10} data to derive background for other size metrics. No background were available for other products of combustion.

An unconventional approach to cumulative air impact assessment is presented for the Austen Quarry Stage 2 Extension project (Benbow Environmental, 2014). The approach adopted by Benbow was based on the fact that the quarry was the only source of PM emissions within a radius of 15km and therefore background for each PM size fraction was taken as zero. This assumption was based solely on observations made during a site visit, which found no visible plumes of dust from other sources or activities in the area. Agricultural activity was identified as a possible source, but this was assumed to be short-lived and local to a few metres from source. Finally, the approach of not using background was deemed appropriate due to the conservative nature of the modelling assessment. It is noted that significant incremental 24-hour PM_{10} concentrations were predicted at the closest sensitive receptors (i.e. 48.4 µg/m³). Cumulative results were also presented, however these were identical in magnitude to the incremental results (due to the assumed zero background).

As previously discussed in **Section 3.4.5**, in some circumstances the pairing of background and modelled predictions using Level 1 or Level 2 methodologies can result in a new emission source with minimal incremental risk resulting in an exceedance of short-term impact assessment criterion. A dispersion modelling assessment for a proposed cotton gin in rural NSW (PEL, 2014a) used PM_{10} monitoring data from Albury, in the absence of available local data to describe background. When modelled concentrations were added to the Albury data using the Level 2 approach, additional exceedances of the impact assessment criteria were predicted. In each case, the exceedance occurred as a result of a relatively small increase in 24-hour PM_{10} added to an already elevated background. This Level 2 approach was not necessarily suited to a facility such as a cotton gin, whose operation is seasonal. The additional exceedances occurred outside the cotton ginning season, when the facility would not be operational, thereby highlighting some of the challenges in applying the Level 2 approach.

4.4 Urban area (Southwest Sydney)

The Boral Brickworks Bringelly Air Quality Assessment (Wilkinson Murray, 2014) is reviewed as an example of a site with an extensive site representative background dataset. Background data for PM_{10}, NO_2, SO_2 were described based on the OEH monitoring site at Bringelly, located 3.5 km away.

The approach to cumulative assessment was to add background to modelling predictions based on the Level 2 approach, although only cumulative results are presented for PM_{10}, TSP and dust deposition. There is no cumulative assessment presented for NO_2, arguably a key pollutant for which good quality and continuous background data were available.

In adopting the Level 2 assessment approach, only a single year of background data were used, matching the meteorological modelling year, despite the Bringelly OEH site having over 10 years of available data.

Other local sources of emissions were not identified and therefore assumed to be contained in the measured background. No other future committed development were included.

Background data for HCl, HF and CO were not available and assumed to be negligible based on the surrounding land use. Background TSP data were not available and were derived from the PM_{10} data using the assumption that 40% of TSP is PM_{10}.

Background dust deposition was assumed to be equivalent (in scale) to the TSP and derived from the ratio of the respective criteria. The assumption that a relationship exists between the TSP criteria of 90 µg/m³ and the dust deposition criteria of 4 g/m²/month is an unconventional approach, considering that dust deposition monitoring data were available for the site and the measured data, averaged across all sites, was effectively the same as the derived background of 1.9 g/m²/month.

4.5 Short-term cumulative assessment in NSW

To overcome some of the challenges in the cumulative assessment for short term periods, recent air quality impact assessments have applied probabilistic estimates of the risk of additional exceedances (PEL, 2014; ENVIRON, 2015). Recent SEARs issued for the Mount Owen Continued Operations project specifically required that cumulative 24-hour PM_{10} was to be evaluated using an "*appropriate probabilistic methodology*".

For assessments in NSW, PEL typically use a Monte Carlo type simulation which combines a randomly selected percentile from the background dataset with a randomly selected percentile from the predicted (modelled) dataset. PEL typically present the results as the predicted number of days that cumulative 24-hour PM_{10} concentration would exceed certain 24-hour PM_{10} concentrations at selected residence locations.

The ENVIRON probabilistic approach differs in that a frequency distribution of cumulative impact is presented by showing every possible combination of predicted incremental (modelled) and background concentration. In other words, every modelling prediction is added to all available background values. The number of combinations would depend on the number of background values chosen. For example, if five years of continuous background data are available and paired with one year of dispersion modelling predictions, the frequency distribution is based on a total of 666,125 combinations. The main difference in this approach is that a modelled concentration cannot be added to the same background concentration more than once, whereas for the Monte Carlo simulation, it is possible (likely) to draw the same background more than once.

An alternative probabilistic approach is described in Wiebe (2011) using a convolution technique to combine a distribution of predicted concentrations with the distribution of observed background concentrations. The resultant distribution takes into account all possible combinations of predicted and observed, weighted by the probability of occurrence.

The convolution is defined in Wiebe (2011) as:

$$[B * P](c) \equiv \int_0^c B(\tau)P(c-\tau)d\tau$$

Where B(c) is the probability of observing a background concentration c and P(c) is the probability of predicting concentration c. The convolution formula is the sum of distributions P(τ) shifted by c and weighted by B(c).

The convolution technique was applied by Katestone Scientific in the Wandoan Caol Project, with the number of exceedances determined by summing the convolved probabilities above 50 µg/m³ (the air quality objective) and multiplying by the length of the data set (365 days), (Wiebe, 2011).

5. CUMULATIVE ASSESSMENT APPROACHES IN OTHER AUSTRALIAN JURISDICTIONS

5.1 Victoria

Air quality management in Victoria is guided by State Environment Protection Policies (SEPPs), made under the Environment Protection Act (1970). The SEPP (Ambient Air Quality) (AAQ) outlines air quality objectives and goals for the state and incorporates the National Environment Protection Measure (NEPM) standards, goals and monitoring and reporting protocols. The SEPP (Air Quality Management) (AQM) sets the framework for managing emissions to air and includes requirements for cumulative assessment of new emissions sources in Works Approval submissions.

5.1.1 SEPP (AQM)

Cumulative impact is a major consideration for Air Quality Control Regions. Special provisions for air quality management are outlined for Air Quality Control Regions, including Air Quality Improvement Plans and requiring new stationary sources to achieve a higher degree of emission control than general requirements under the policy. In some cases, a Works Approval (permit) for a new large emissions source may be refused unless emissions reductions for other sources are able to offset emission increases and impacts. For very large emissions sources in or around air quality control regions, a cumulative regional impact assessment is required. In the guideline for works approval applications (Vic EPA, 2015), very large emissions sources are defined for the Port Phillip region, based on being approximately 1% of the total regional emissions, as follows:

- >1,000 tonnes of NO_x
- 2,000 tonnes of VOCs
- >200 tonnes of PM

The requirements for cumulative assessment are outlined in the SEPP (AQM). Design criteria for Class 1, 2 and 3 indicators are set for the purpose of assessing new emission sources or modifications to existing sources. The design criteria are set at a different level and form to ambient air quality objectives (outlined in the SEPP (AAQ)).

The SEPP (AQM) also sets intervention levels, used to assess local air quality monitoring data to determine if the beneficial uses are being protected and are set higher than design criteria and ambient air quality objectives. For Class 1 indicators intervention levels are set at 20% above the ambient air quality objectives.

Schedule C of SEPP (AQM) provides guidance for modelling and cumulative assessment of new emissions sources. Cumulative assessment requires consideration of background concentrations and other sources of emissions. Guidance for what other existing sources to include is limited and there is no provisions for including future committed development.

Specific regulatory modelling guidance is provided for AERMOD (EPA Victoria, 2013a; EPA Victoria, 2013b). The guidance is mostly technical and not related to cumulative assessment, however it does specify that 5 years of recent meteorological data should be modelled, with predicted air quality compliance demonstrated for each of the 5 years.

Where appropriate hourly background data are not available, the 70th percentile of one year of observed hourly concentrations can be added as a constant background to the maximum concentration from the model. The predicted maximum concentration from the model is taken as the 99.9th percentile for averaging times of 1-hour and the 100th percentile for longer averaging times.

Where exceedances of the design criteria are predicted, a risk assessment is required to demonstrate no adverse impact.

5.1.2 PEM for mining and extractive industries

Specific requirements for cumulative assessment in the mining and extractive industries are outlined in the Protocol for Environmental Management (PEM) for Mining and extractive industries (EPA Victoria, 2007).

For mines and quarries with a proposed production less than 50,000 tonnes per annum, no modelling is required but emissions should be controlled through the application of best practice. For mines with a proposed production greater than 50,000 tonnes per annum, a three tiered assessment approach is followed, depending on the scale or size of the operation and where it is located in relation to sensitive receptors, for example:

- Level 1 assessment is required for medium to large mines/quarries in urban areas or large mines/quarries in rural areas where residences are nearby (i.e. 500m from boundary).
- Level 2 assessment is required for large mines/quarries in rural areas where residences are not nearby or for medium mines/quarries in rural areas where residences are nearby.
- Level 3 assessment is required for medium mines/quarries in rural areas where residences are not nearby or for small mines rural areas where residences are nearby.

The PEM provides assessment criteria specific to the assessment of mining and extractive industry that differ from the SEPP (AQM) design criteria and in some cases (i.e. PM_{10}) reflect the magnitude and form of intervention levels, which are 20% higher than the ambient air quality objectives. The assessment criteria are used to assess the total cumulative impact of the new emissions source, plus background.

The PEM acknowledges that under certain circumstances, the assessment criteria may not be achievable at the closest sensitive location to the operation. In these circumstances, where the predicted impact extends into urban areas or townships, the PEM allows for an assessment of impact at locations representative of the general population (i.e. town centre) against the more stringent SEPP (AAQ) objectives.

For Level 1 assessments, a complete year of site specific continuous background PM_{10} and $PM_{2.5}$ data is required to characterise background. Time varying daily background is added to modelling predictions for assessment of cumulative impacts. For indicators such as NO_2 and CO, the 70^{th} percentile of the 1-hour average data can be added as a constant value, although if justifiable, background for these indicators does not have to be included.

For Level 2 assessments a full year of continuous data is also required but *site representative* data can be used. Representative time varying daily background is added to modelling predictions for assessment of cumulative impacts. Allowance is made for the use of the 70^{th} percentile as a constant background value, as a screening level assessment. Inclusion of background for NO_2 and CO is not required for Level 2 assessments. For Level 3 assessment, no monitoring data is required and cumulative impacts do not need to be assessed.

VICTORIA

Summary / key features for evaluation

- Airshed management in the form of Air Quality Control Regions where cumulative air impact is a major consideration. Regional air impacts are considered for very large emission sources in Air Quality Control Regions (>1% of total regional emissions).
- Design criteria for new emissions sources set at a different level to ambient air quality objectives.
- Use of 70th percentile for background in the absence of suitable hourly data.
- Use of 99.9th percentile in modelling 1-hour impacts to screen out the highest hourly predictions.
- Modelling other 'local' sources required for cumulative assessment.
- Tiered assessment approach under the PEM for mining and extractive industries, depending on the scale and location of new emissions sources. Cumulative assessment is not required for low risk activity (i.e. small mines/quarries located distant from sensitive receptors).
- Requirements for risk assessment where exceedances of design criteria are predicted.
- Regulatory modelling should include 5 years of meteorological data with compliance demonstrated for each year.

5.2 Queensland

Air quality management in Queensland (QLD) is primarily governed by the Environmental Protection Act 1994 (EP Act), the Environmental Protection Regulation (2008) (the Regulation) and the Environmental Protection (Air) Policy 2008 (EPP (Air)). Guidelines issued under the EP Act outline the requirements for assessing activities with an impact to air (DEHP, 2002).

The guidelines do not specifically outline methodologies for cumulative assessment, however in cases where air dispersion modelling is required, existing sources and background concentrations should be considered, as follows:

> "*Dispersion modelling should predict maximum ground level concentrations for contaminants of interest, including contributions from the proposed activity and all existing sources."*

Cumulative impacts are assessed by comparing the results of modelling, plus background, against the applicable EPP (Air) air quality objectives, NEPM standards or other relevant criteria such as the Victorian design criteria or NSW impact assessment criteria.

The QLD EPA has accepted the use of the 95th percentile to describe short-term background air quality for cumulative assessment (Redland City Council, 2012; Katestone, 2009).

5.2.1 Brisbane City Council Air Quality Planning Scheme Policy

Published under the Brisbane City Plan 2014, the Air quality planning scheme policy provides guidance for air quality reports prepared for development applications[8]. Cumulative impacts need to be considered for sensitive areas by adding the predicted site impacts to either the representative background air quality monitoring data or to modelled impacts from other sources of air pollutants. Background data should be obtained from the nearest or most representative air quality monitoring station and at least 3 years of data should be used. No specific guidance is provided for determining the representativeness of background data.

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[8] http://eplan.brisbane.qld.gov.au/?doc=AirQualityPSP

For short term cumulative impact assessment, the 70th percentile of the hourly background data can be applied as a constant background value. For 8-hour average or 24-hour average impacts, either concurrent time-varying background concentrations are added to modelling predictions or the 70th percentile is applied as a constant value for the relevant averaging period.

Where existing exceedances occur in background data, these data are required to be presented on a time series plot, with the incremental contribution from the development and total cumulative impact. This analysis is accompanied by a discussion of the elevated concentrations and implications for air quality management.

Other existing sources in the vicinity of the development are required to be included in dispersion modelling. No guidance is provided for the selection of these other sources, with the exception of guidance for cumulative odour impacts (known sources within 1km of the development).

Cumulative modelling may also be required where monitoring data is inadequate, for example where the development is proposed adjacent to a busy road that is not represented in monitoring data. An average daily traffic threshold of greater than 20,000 vehicles is used to define a busy or major road for the purposes of cumulative assessment. Future (approved) sources are also required to be considered in the air quality assessment. No guidance is provided on sources of data for emissions inventories, future sources etc.

For averaging periods of 1-hour or less, the 99.9th percentile concentration of total cumulative impact is presented for comparison against air quality objectives. For averaging periods of 1-hour or greater, the maximum concentration of total cumulative impact is presented for comparison against air quality objectives.

CASE STUDY

Air Quality Assessment for North Galilee Basin Rail Project (GHD, 2013)
Accounting for background was a particular challenge for this project, which comprises of a 300 km rail corridor, running from relatively remote areas of central QLD to the coast at Abbott Point. For the purposes of characterising background air quality, the study area was separated into inland and coastal regions. For the inland regions, background was characterised for particulate matter only, using a representative greenfield monitoring site. For 24-hour average PM_{10} and $PM_{2.5}$ the 70th percentile of the dataset was selected as the constant background for cumulative assessment. For annual $PM_{2.5}$, the median was selected in lieu of the annual mean, which was skewed by a small number of high values from dust storm events. For gaseous pollutants, background was assumed to be zero for inland regions.

For the coastal region, a representative monitoring site was selected on the basis that it would be conservative (expected higher concentrations than the study area). For 24-hour average PM_{10} the 75th percentile of the dataset was selected as a constant background for cumulative assessment. $PM_{2.5}$ was derived from a $PM_{10}/PM_{2.5}$ ratio (measured elsewhere) and a different ratio was applied for 24-hour and annual average periods. The 90th percentile of the daily peak NO_2 was selected for hourly average background, as this was the only percentile reported for the data. Annual mean NO_2 was not known and was derived from the 1-hour value (which was actually the 90th percentile of the daily peak), using a power law adjustment. For SO_2 the 75th percentile of the dataset was selected as the background for 1-hour and 24-hour averaging periods. The derived background values were added to modelling predictions for cumulative assessment in the inland and coastal regions.

QUEENSLAND

Summary / key features for evaluation

- Use of 95th or 70th percentile to describe short-term background.
- Use of a significant source threshold for inclusion of busy roads in cumulative modelling (20,000 vehicles per day).
- Inclusion of sources within a 1km radius for cumulative odour assessment.
- Use of the 99.9th percentile of 1-hour modelling predictions to remove outliers / reduce uncertainty.

5.3 South Australia

The principal regulation for air pollution in South Australia is the Environment Protection (Air Quality) Policy 1994, which specifies the limits for stationary sources but does not distinguish between cumulative and other effects. Guidance for assessing new or existing emissions sources is outlined in the South Australian (SA) EPA guidelines for air quality impact assessment (SA EPA, 2006), which require dispersion model predictions to be assessed against design ground level concentrations (DGLC).

The maximum predicted modelling incremental is compared directly against the DGLC with no additional requirements for cumulative assessment.

There are no DGLC specified for PM and therefore air quality assessment needs to refer to the NEPM standards, which are adopted by SA EPA to address air quality concerns. In comparing to NEPM standards, cumulative assessment would therefore be required.

A separate DGLC is specified for NO_2 in the Adelaide metropolitan region, set at approximately 50% of the NEPM standard, to account for the fact that this is a constrained airshed.

The SA EPA guidelines also allow for a simplified screening approach for stacks with relatively small emission rates. If emissions from a stack, at the point of release, are less than 100 times the DGLC, no further assessment is required. This screening approach only applies for stacks that are 3 m higher than surrounding obstacles, with an exit velocity greater than 10 m/s, no impediment to vertical momentum (such as a rain cap) and that are situated in flat terrain.

SOUTH AUSTRALIA

Summary / key features for evaluation

- Use of design ground level concentrations for assessment of incremental project risk.
- 100th percentile used for all averaging periods.
- Lower design ground level concentrations specified for NO_2 in Adelaide (i.e. constrained airshed limit).
- Screening assessment approach for relatively small stack sources. No significant impact if concentration is less than 100 times the design ground level concentrations at the point of release.

5.4 Western Australia

Air quality assessment of existing or proposed emission sources is required under the Environment Protection Act (1986), as part of an environmental impact assessment or works approval application. The Department of Environment Regulation (DER) publish an Air Quality Modelling Guidance Notes (DoE, 2006), which outlines the expectations for air quality assessment.

Cumulative impacts must be considered and the assessment must include "*existing concentrations caused by other sources plus (if significant) the background concentration (whether man made or natural)*".

The qualification of "if significant" for background is not prescribed in the guidance. The guidance requires that modelling results are presented for existing sources plus background (pre-proposal), for the proposed development in isolation and the combined cumulative results of existing, proposed plus background. The guidance also requires that "existing sources" include committed future development that is approved.

Informally, the regulators in WA have provided project specific advice that if the predicted GLCs from a proposed source(s) in isolation exceeds 10% of the relevant ambient standards, then cumulative impact is warranted. Cumulative assessments are typically limited to specific receptor locations for which ambient monitoring data are available. The maximum recorded short-term ambient concentrations are typically adopted for conservative, screening level cumulative assessments at nominated receptors (using monitoring sites). If the cumulative value indicates unacceptable air quality impacts, the approach is refined and a percentile value of the monitored concentrations may be applied if appropriate.

Cumulative assessment in constrained airsheds is covered by specific requirements or advice from the DER (i.e. Port Hedland) or regulatory frameworks (i.e. Environmental Protection (Kwinana) (Atmospheric Wastes) Policy 1999 (Kwinana EPP) and Environmental Protection (Goldfields Residential Areas) (Sulfur Dioxide) Policy 2003 (Kalgoorlie EPP)).

In the case of Port Hedland, existing facilities are required to demonstrate that an expansion can be achieved without any increase above existing ambient air quality levels. Previously, new emissions sources were considered based on the percentage contribution to any predicted exceedences, with reference also to high contribution of background sources. More recently, DER have advised that air quality modelling is not appropriate to determine the acceptability of a proposal that will further increase PM emissions into the Port Hedland airshed. Emphasis is placed on best practice management and modelling is only considered beneficial where it is used to identify and compare proposals and options for emissions variations, such as an offset for an increase in emissions. This is similar to the approach used in the U.S. for nonattainment areas, where modelling is not required and new proposals need to demonstrate lowest achievable emission rates and emission offsets (see **Section 6.1**). An (interim) guideline of 70 μg/m^3 has been established for 24-hour PM_{10} in the Port Hedland town that is different to the NEPM and other monitoring locations around Port Hedland. The Port Hedland Industries Council is working on improving collaboration between industries in relation to cumulative assessment and management of dust impacts in Port Hedland.

Elsewhere, the Collie Basin Airshed Study is intended to provide a modelling tool for cumulative air quality assessment and provide a framework for sharing the cost of future emissions control among existing and future industry (Shire of Collie, 2009).

5.4.1 Kwinana EPP

The purpose of the Kwinana EPP is emissions management in a constrained airshed, with the primary focus on SO_2. Emissions management is achieved by assigning Maximum Permissible Quantities of SO_2 for all significant sources within the Kwinana Industrial Area. The Maximum Permissible Quantities are set, through modelling (see DEC, 2009), to ensure area specific

'Standards' and 'Limits'[9] can be met. The Kwinana EPP provides for the Maximum Permissible Quantities to be redetermined when required (e.g. to accommodate new significant industry). Significant industrial sources have been defined as those with a mass emission rate of greater than 2 g/s.

The Kwinana EPP Redetermination (DEC, 2009) provides the latest Maximum Permissible Quantities of SO_2 emissions (g/s) for all 'significant' industrial sources within the Kwinana Industrial Area. A statistical (probabilistic) basis was derived as a means to allow emissions reaching various levels including, for some industries, high emissions associated with plant upset conditions that occur for a small fraction of the year. The probabilistic approach uses all non-negligible combinations of probabilistic emissions, across a full year, and determines exceedance frequencies for that combination of emissions. These are multiplied by the probability of the emissions combination and summed to derive probability-weighted exceedance frequencies. The same outcome was found to occur using a Monte Carlo simulation.

A region-specific equation for NO_x conversion has been developed by Dames & Moore (1993) for the Kwinana Industrial Area, based on regional NO_x monitoring data.

CASE STUDY

Air quality assessment for Kwinana Waste to Energy Project (ENVIRON, 2014)
The approach for cumulative assessment for SO_2 was based on procedures used in the most recent redetermination of Maximum Permissible Quantities under the Kwinana EPP, whereby all significant sources were modelled cumulatively. Modelling results are presented for all existing industries without the proposal and for all existing industries with the proposal. The maximum predicted ground level concentrations were compared to the EPP *Limit* and the 99.9^{th} percentile was compared to the EPP *Standard*.

For other pollutants, the cumulative assessment approach was to model the proposed facility, add background and compare against NEPM standards or other relevant air quality goals. The maximum measured background concentrations were added to the modelling predictions for short-term averages. For 1-hour NO_2, both the maximum predicted and the 99.9^{th} percentile predicted concentrations were presented with the maximum measured background. For 24-hour average PM_{10} and $PM_{2.5}$, both the maximum predicted and the 99.5^{th} percentile predicted concentrations were presented with the maximum measured background. Where existing exceedances were present in the background data, these were retained and cumulative results were also presented as a % change or increase. Cumulative assessment was presented for the locations of the monitoring locations only.

[9] Limits are concentrations that are not to be exceeded. Standards are concentrations for which it is desirable not to exceed.

WESTERN AUSTRALIA

Summary / key features for evaluation

- Informal screening for significance based on predicted increment being greater than 10% of the ambient air quality goals. Triggers cumulative assessment.
- Regulatory framework for constrained airsheds (i.e. Kwinana EPP) aimed at emission management which sets Maximum Permissible Quantities of SO_2 for each industry. These are redetermined as required (i.e. for a significant new source) and the cumulative approach for the redetermination is prescribed.
- Significant new emissions sources are defined under the Kwinana EPP if emissions are greater than 2 g/s.
- The redetermination procedures includes a probabilistic approach to deal with varying emission levels (such as high emissions during start up), which could be applied for intermittent releases.
- Two tiered compliance standards prescribe under the Kwinana EPP - 'Standards' to be complied with most of the time (i.e. percentile based) and 'Limits' never to be exceeded (maximums).
- Regional airshed studies used as modelling tool for cumulative assessment.
- Region specific NOx/NO_2 relationship for ARM.

6. INTERNATIONAL JURISDICTIONAL REVIEW

6.1 United States

6.1.1 Attainment and Nonattainment Areas

The US EPA adopts National Ambient Air Quality Standards (NAAQS) for criteria pollutants including PM_{10}, $PM_{2.5}$, SO_2, NO_2, ozone, CO and lead. Areas are designed as either attainment, non-attainment based on whether the NAAQS are met or not. Areas are "unclassifiable" when there is insufficient information for classification, and for regulatory purposes are assumed to be in attainment.

Under 40 Code of Federal Regulations (CFR) Part 51, States are required to develop State Implementation Plans (SIPs) which outline how they will attain and/or maintain compliance with the NAAQS. SIPs typically include rules, emission inventories, ambient monitoring data, regional modelling and control strategies.

SIPs address cumulative air impacts from all sources at a regional level, but at a grid resolution that does not allow identification of local air quality impacts or hot spots. The local and regional air quality impacts from the construction or modification of a new facility is addressed under 40 CFR subpart I Review of New Sources and Modifications, including permitting requirements for new sources under 40 CFR §51.165 (Permit Requirements) which outlines for permitting requirements for new sources.

6.1.2 New Source Review (NSR) permitting

Established under the 1977 Clean Air Act Amendments, the New Source Review (NSR) requires stationary sources of air pollution to obtain a permit prior to construction or a new or modified source. There are different permit requirements for minor and major sources and those that are located in attainment and non-attainment areas, summarised as follows:

- Prevention of Significant Deterioration (PSD) permitting applies to major new or modified sources in attainment areas.
- Nonattainment NSR (NA NSR) permitting applies to major sources in nonattainment areas.
- Minor source permitting is used for other minor sources that do not require PSD or nonattainment NSR.

PSD permitting requires the installation of best available control technology (BACT) for the project, requires the proponent to complete an air quality analysis and an additional impact analysis and ensure public involvement in the process.

For nonattainment NSR, the requirements are customised for each nonattainment area, but as a minimum require that the project demonstrate the lowest achievable emission rate (LAER), emission offsets and ensure public involvement in the process. Emissions offsets allows a nonattainment area to move towards attainment while also allowing for some growth. To achieve a net emissions or air quality benefit the quantity of an offset is often greater than the new source of emissions. Modelling or cumulative assessment is not required for NA NSR as the emphasis is placed on LAER and offsets.

For minor source NSR, States are able to customise the permitting process, provided they meet the program's minimum requirements.

Emissions thresholds are used to identify whether a source is major or minor. For PSD, a major source is one with the potential to emit 250 tons[10] per year (of any pollutant), or 100 tons per year for certain industry (petroleum refineries, fossil fuel power stations, smelter, cement plants etc.). The maximum threshold for NA NSR is 100 tons per year.

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[10] The short tons (US) is equal to 2,000 pounds (equivalent to 907.18474 kg), as opposed to metric tons (tonnes) which are equal to 1,000 kg.

6.1.3 PSD permitting

An overview of the PSD permitting process is provided based on the procedures outlined by the Texas Commission on Environmental Quality (TCEQ), in their Air Quality Modelling Guidelines (TCEQ, 2015). Although Federal air permit modelling is approved by each State, who have their own prescriptive guidance on how to do modelling, the overall approach is typically consistent.

Under the Texas SIP, the TCEQ is the permitting authority for regulating air emissions in Texas, including the NSR permitting for major and minor sources. A number of key terms are defined in TCEQ, 2015 (see **Table 6-1**) to assist in the discussion on PSD permitting.

Table 6-1: Definitions relevant to NSR

Term	Explanation
Air Quality Related Value (AQRV)	A term used by federal land managers that include visibility, odour, flora, fauna; geological resources; archeological, historical, and other cultural resources; and soil and water resources
National Ambient Air Quality Standards (NAAQS)	Levels of air quality to protect the public health and welfare (40 CFR 50.2). Primary standards are set to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly from the effects of "criteria air pollutants" and certain non-criteria pollutants. Secondary standards are set to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.
PSD Increment	The maximum allowable increase of an air pollutant that is allowed to occur above the applicable baseline concentration for that pollutant.
De minimis impact	A change in ground level concentration of an air contaminant as a result of the operation of any new major stationary source or of the operation of any existing source that has undergone a major modification that does not exceed the significance levels as specified in 40 Code of Federal Regulations.
Significant Impact Level (SIL)	The SIL is a de minimis threshold applied to individual facilities that apply for a permit to emit a regulated pollutant in an area that meets the NAAQS. The SIL is a measure of whether a source may cause or contribute to a violation of PSD increment or the NAAQS, i.e. a significant deterioration of air quality. If an individual facility projects an increase in emissions that result in ambient impacts greater than the established SIL, the permit applicant would be required to perform additional analyses to determine if those impacts will be more than the amount of the PSD increment. This analysis would combine the impact of the proposed facility when added on to all other sources in the area.
Significant Monitoring Concentration (SMC)	A de minimis level of impact that the EPA has concluded does not justify collecting pre-construction monitoring data for purposes of an air quality analysis.
Effects Screening Levels (ESL) to evaluate ambient air at a screening level.	Guideline concentrations derived by the Texas Commission on Environmental Quality (TCEQ) and used to evaluate ambient air concentrations of constituents. Based on a constituent's potential to cause adverse health effects, odor nuisances, vegetation effects, or materials damage. Health-based screening levels are set at levels lower than those reported to produce adverse health effects, and are set to protect the general public, including sensitive subgroups such as children, the elderly, or people with existing respiratory conditions. If an air concentration of a constituent is below the screening level, adverse effects are not expected. If an air concentration of a constituent is above the screening level, it is not indicative that an adverse effect will occur, but rather that further evaluation is warranted.

Term	Explanation
Class I area	An area defined by Congress that is afforded the greatest degree of air quality protection. Class I areas are deemed to have special natural, scenic, or historic value. The Prevention of Significant Deterioration (PSD) regulations provide special protection for Class I areas. Little deterioration of air quality is allowed.
Class II area	An area defined by Congress where a moderate degree of emissions growth is allowed. This includes virtually all non-Class I areas.
Class III area	Currently, there are no Class III areas that allow a large amount of degradation to the air quality.

Modified after: TCEQ (2015).

6.1.3.1 Preliminary impact determination

The permitting process is underpinned by an air quality analysis (AQA), required to demonstrate compliance with both the NAAQS and PSD increments. The AQA begins with a preliminary impact determination for the project emissions alone. The preliminary impact determination can use a screening level or refined modelling approach, as applicable. A preliminary impact determination models the new/modified source for all criteria pollutants and compares the maximum predicted concentrations against the significant impact level (SIL).

If the SIL is not exceeded, no further assessment is required. If there is a significant impact an area of impact (AOI) if defined and a full NAAQS and PSD Increment analysis is required. **Table 6-2** lists the NAAQS, SILs and PSD Increments for key criteria pollutants.

Table 6-2: SILs, SMC, NAAQS and PSD Increments for selected criteria pollutants

Pollutant	Averaging Period	SIL ($\mu g/m^3$)	SMC ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)	Class I PSD Increment ($\mu g/m^3$)	Class II PSD Increment ($\mu g/m^3$)
PM_{10}	Annual	1	-	-	4	17
	24-hour	5	10	150	8	30
$PM_{2.5}$	Annual	0.3	-	12	1	4
	24-hour	1.2	-	35	2	9
SO_2	Annual	1	-	80 [a]	2	20
	24-hour	5	13	365 [a]	5	91
	3-hour	25	-	-	25	512
	1-hour	7.8 [b]	-	196	-	-
NO_2	Annual	1	14	100	2.5	25
	1-hour	7.5 [b]	-	-	-	-

Notes: [a] EPA revoked both the 24-hour and annual NAAQS for SO^2
[b] Interim SILs for 1-hour NO^2 and SO^2

For minor source modelling, one year of meteorological data are sufficient. For PSD permit modelling, five years of meteorological data are required, unless site specific data are available (which can be limited to one year).

For minor source modelling, the maximum predicted concentration is assessed at and beyond the property line while for PSD modelling, the maximum predicted concentration is assessed at and beyond the fence line. The predicted high concentration can be related to the form of the standard (i.e. the allowable exceedance or percentile level).

It is noted that additional analysis is required to justify the use of a SIL for $PM_{2.5}$, as a result of a U.S. Court of Appeals decision that the EPA were not authorised to exempt sources from the requirements of the Clean Air Act when it established the SIL for $PM_{2.5}$. **Section 6.1.3.5** outlines the TCEQ recommended approach.

6.1.3.2 NAAQS analysis

Fundamental to the PSD permitting process is the demonstration that a proposed operation would not cause or contribute to either an NAAQS or PSD Increment violation. Air quality cannot deteriorate beyond the NAAQS, even if not all the PSD increment is used, and in this sense both the incremental increase and total cumulative impact is considered.

Where the predicted impact is significant (above the SIL), a full NAAQS analysis, including cumulative effects analysis, is required for all receptors within the area of interest (AOI). The AOI is the defined by the area where the predicted concentrations (from the preliminary impact determination) is above the SIL.

The cumulative requirements for a full NAAQS analysis require all other sources of emissions to be modelled and added to a representative background concentration for comparison against the NAAQS. TCEQ provide guidance for choosing a representative background (**Section 6.1.3.6**) while other States have a specific background values that are required for use.

Information for other emissions sources to be included in the modelling are typically provided by the state. For example, the TCEQ provides a list of all other sources and parameters for modelling, in model ready emission file format. All sources within a 50 km radius will be retrieved from the TCEQ Air Permits Database. The 50 km radius is based on the transport distance over which steady state assumptions are appropriate (TCEQ, 2015). The 50 km radius is fairly typical but some States also allow a ratio of emissions to distance method (Q/D method) to rank the significant of sources based on emission rate (Q) and distance to receptor/monitor (D). For example, if the Q/D ratio is below a certain value, it may be excluded from the air quality assessment.

Modelling is typically performed at the maximum allowable limit and only those sources that are already permitted or have filed a permit application, are required to be modelled.

The predicted concentrations can be related to the form of the NAAQS and the number of years modelled. For example, if 5 years were modelled for 1-hour NO_2, take the maximum 5-year average of the 98^{th} percentile of the annual distribution of maximum daily 1-hour predicted concentration for each receptor. For PM_{10}, report the sixth highest concentration for the 5 year modelled period.

The predicted concentration from all sources plus representative background are compared to the NAAQS. If the maximum concentration is at or below the NAAQS, then the demonstration is complete.

6.1.3.3 PSD Increment analysis

The PSD increment is the maximum increase in concentration that is allowed to occur above a baseline concentration for a pollutant. The baseline concentration is defined for each pollutant and, in general, is the ambient concentration existing at the time that the first complete PSD permit application affecting the area is submitted.

Significant deterioration is said to occur when the amount of new pollution exceeds the applicable PSD increment. The baseline concentration is not required to determine the PSD increment, however the change in emissions (increase or decrease) from sources in operation since the baseline date is required. The change in emissions is then calculated as the difference between the emissions at the baseline date and the actual emissions for the period of modelling. The modelled increment is the change in predicted concentration attributable to this emission change.

The PSD increment analysis models emissions at the site that affect the increment, as well as all other nearby sources that affect the increment. Sources with a negative emissions rate can be removed from the inventory unless they were in operation at the applicable baseline date. Any source that was permitted after the applicable baseline date, but is now shut down, should not be modelled.

The TCEQ recommend a tiered approach to PSD increment analysis whereby the predicted modelled concentration from the NAAQS analysis (including other sources) is first compared with the PSD increment. If equal to or less than the allowable increment, no further analysis is required (i.e. incorporating the change in emissions since baseline), as the modelling is based on the maximum allowable emission rate. This approach is not to be applied for those criteria pollutants with NAAQS that are statistically based. For example, for NO_2, the maximum is reported for each year modelled and for PM_{10} the second highest is report reported for each year modelled.

Tier II increment modelling uses actual emission rates for the applicant sources and all other sources at allowable emission rates. The Tier III increment approach models sources that existed at the applicable baseline date using the difference between the most recent emissions and their baseline emissions.

6.1.3.4 PSD Pre-Application analysis

The purpose of the PSD pre-application analysis is to describe and characterise the existing ambient air quality for an area where the new source is proposed and to meet the pre-construction monitoring requirements of the Clean Air Act (TCEQ, 2015).

Significant Monitoring Concentrations (SMC) (refer **Table 6-2**) are used to determine if additional analysis of ambient monitoring data are required, or if a site specific monitoring network should be established. Where the predicted concentrations from the preliminary impact determination are less than the SMC, no additional analysis is required. If the maximum concentrations is at or exceeds the SMC, additional analysis is required, using site representative monitoring data to describe background concentrations. If no existing monitoring data are available (representative and conservative) then a site specific monitoring network should be established.

6.1.3.5 Additional assessment of SIL for $PM_{2.5}$

The TCEQ provide guidance for additional justification for using a SIL for $PM_{2.5}$, following the U.S. Court of Appeals ruling that the EPA were not authorised to exempt sources from the requirements of the Clean Air Act.

The TCEQ recommends using the analysis conducted for the pre-application to determine the difference between the NAAQS and the measured background (which could be considered as the capacity for the airshed). If this difference (the airshed capacity) is greater than or equal to the SIL and the new source has an impact less than the SIL, it can be concluded that the new source would not cause or contribute to a violation of the NAAQS (TCEQ, 2015). In this case, the proponent may forego a cumulative modelling analysis.

If the difference between the NAAQS and the measured background concentrations is less than the SIL (i.e. a constrained airshed) a full NAAQS analysis is required.

6.1.3.6 Site representative background

TCEQ provides guidance for determination of an appropriate background concentration for NAAQS analysis. Preference if given to monitoring networks “near the site” within 1 to 10 km of the area of maximum concentrations from existing and / or proposed sources. Where nearby data are not available, the representativeness of the data, to the area of interest, need to be demonstrated, for example by comparing the types of sources and magnitude of emissions between the two locations, out to a radius of 10 km. Site representativeness can also be demonstrated through analysis of aerial photography for the two locations (land use), comparison of population density and existing emissions sources. For short term averaging periods, the representative background is typically taken as the form of the standard.

Monitoring data can be refined to exclude sources that are included in the modelling to avoid double counting. Options for background refinement, provide by TCEQ are:

- Exclude background data values where a modelled source is determined to impact on that value based on an analysis of wind direction.
- For receptors with significant predicted concentrations, determine the meteorological conditions under which these highest concentrations occur. Identify monitoring data with the same meteorological conditions and use these data as background.
- Identify a monitoring location that is not impacted by existing sources through dispersion modelling of the source and analysis of dispersion patterns.
- For PM, determine if the high concentration was caused by a natural event such as a non-prescribe fire[11] or high wind speed and use the next highest concentration not influenced by these events.

6.1.3.7 NOx conversion

The regulatory approach for NO_x to NO_2 prescribes a three tier approach, all of which are considered screening methodologies. Tier 1 is used most often and conservatively assumes 100% conversion of NO_x to NO_2. Tier 2 refines the full conversion by using an (ARM) for NO_2/NO_x and national default values of 0.75 for annual average predictions and 0.8 for 1-hour averages are prescribed. Generally, Tier 2 can be used without justification but some local jurisdictions may provide different defaults based on local ambient ratio data. The default Tier 2 ratio is only applied to modelled concentrations and the background NO_2 is added for cumulative analysis.

Tier 3 is non-default and the use of either the ozone limiting method (OLM) or the plume volume molar ratio method (PVMRM) requires approval by the permitting authority. OLM is described in the Approved methods and is frequently used in NSW. The PVMRM determines the conversion of NO_x to NO_2 based on the NO_x moles emitted into the plume and the amount of ozone moles contained within the volume of the plume between the source and receptor.

Both OLM and PVMRM require and initial stack ratio (ISR) of NO_2/NO_x and a recommended default of 0.5 is provided. If this is too conservative the US EPA also provide a database of ISRs.

The alternative ARM2 has been introduced into AERMOD. ARM2 was developed based on 10 years of data from all national monitoring sites. Data are grouped into bins of 10 ppb increments for NO_x values less than 200 ppb and into bins of 20 ppb for NO_x in the range of 200-600 ppb. From each bin, the 98th percentile NO_2/NO_x ratio was determined and finally, a sixth-order polynomial regression was generated based on the 98th percentile ratios from each bin to obtain the ARM2 equation, which is used to compute a NO_2/NO_x ratio based on the total NO_x levels. An evaluation comparing modelled versus monitored NO_2 concentrations evaluations demonstrated that ARM2 is generally less conservative than full conversion and ARM and generally more conservative than PVMRM and OLM for peak highest concentrations (US EPA, 2014). The US EPA has indicated that ARM2 is not suitable when the NO_2/NO_x ISR of the source is relatively high or where there is high background ozone. If the total predicted NO_x (i.e. using full conversion) is between 150-200 ppb, then ARM2 should be appropriately conservative, regardless of the NO_2/NO_x ISR. If the total predicted NO_x (i.e. using full conversion) is greater than the 150-200 ppb threshold and the NO_2/NO_x ISR is below 0.2, then ARM2 should be appropriately conservative.

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[11] The EPA have a natural events policy for violations of PM_{10} concentrations

6.1.4 Guideline on Air Quality Models

The US EPA Guideline on Air Quality Models, made under 40 CFR Part 51, provides guidance on the models used for the PSD program. On 29 July 2015, a revision to the Guideline on Air Quality Models was proposed. Section 8 of the revised Guideline provides updated guidance on model inputs and background concentrations for cumulative impact analysis.

Of particular relevance to this review are:

- Revised requirements on how to characterise emissions from nearby sources to be explicitly modelled for purposes of a cumulative impact assessment.
- Revised recommendations on how to determine background concentrations as part of a cumulative impact analysis for NAAQS and PSD increments.

For isolated remote sources, cumulative contributions from other sources can be addressed through representative ambient monitoring data, using the most recent quality assured air quality monitoring data collected in the vicinity of the source. In most cases, data from the monitor closest to and upwind of the project area is recommended and where several monitors are available, preference should be given to the monitor with the most similar characteristics as the project area. If there are no monitors located in the vicinity of the source, a ''regional site'' may be used to determine background concentrations, provided it is impacted by similar or adequately representative sources. The metric to characterise background concentrations from ambient monitoring data is typically the same as the design value for the applicable NAAQS (i.e. percentiles) but some exceptions to this are given.

The US EPA specifically does not recommend pairing hourly or daily monitored background and modelled concentrations, except in rare cases of relatively isolated sources where the available monitor can be shown to be representative of the ambient concentration levels in the areas of maximum impact from the proposed new source. Seasonal (or quarterly) pairing of monitored and modelled concentrations is believed to sufficiently address situations to which the impacts from modelled emissions are not temporally correlated with background monitored levels.

For multi-source areas, cumulative impact analysis should involve the identification and characterisation of contributions from nearby sources through modelling plus characterisation of contributions from other sources through adequately representative ambient monitoring data. Guidance suggests that all sources in the vicinity of the source(s) under consideration that are not adequately represented by ambient monitoring data should be modelled. Sources that cause a significant concentration gradient in the vicinity of the source(s) under consideration are not likely to be adequately characterised by the monitored data. In most cases, nearby sources will be located within 10 to 20 km from the source(s) under consideration.

Background attributable to other sources (e.g., natural sources, minor and distance major sources) should be accounted for through use of ambient monitoring data ensuring that any source-oriented impacts from nearby sources are eliminated to avoid potential double counting of modelled and monitored contributions.

U.S. PERMITTING

Summary / key features for evaluation

- Airshed management for nonattainment of NAAQS.
- Definition of minor and major sources based on an emissions threshold of 250 tons per year (100 tons per year for certain industries).
- Preliminary impact determination using Significant Impact Level (SIL) criteria provides a screening level assessment prior to full cumulative analysis.
- Cumulative impact assessment is required to demonstrate compliance with PSD increments as well as NAAQS compliance.
- Area of Interest (AOI) for cumulative analysis based on the preliminary impact determination modelling results and the SIL.
- TCEQ allows for inclusion of "other" emissions sources within 50 km radius.
- Other states use a ratio or emissions to distance method.
- Additional use of the SIL (for $PM_{2.5}$) for comparison with the capacity of the airshed and the source increment.
- Procedures for adjustment of background to avoid double counting where required.
- Use of percentiles in the standard for both modelling predictions and background (i.e. 98th percentile for 1-hour NO_2.

6.2 U.S. NEPA

The National Environmental Policy Act (NEPA) requires federal agencies to consider the environmental impacts of their proposed actions. The NEPA environmental review process follows a tiered approach.

Firstly, categorical exclusion (CATEX) is used to screen out actions that do not individually or cumulatively have a significant effect, for example minor upgrades or modifications (US EPA 2008). Where CATEX does not apply, an Environmental Assessment is required to determine if the individual facility is below the single-source Threshold of Concern (TOC). If below, a Finding of No Significant Impact (FONSI) is reached and not further assessment is required. If above the TOC, a full Environmental Impact Statement (EIS) is required which includes cumulative assessment of all new sources in region. Large or significant projects tend to proceed directly to a full EIS.

Cumulative assessment in the near field typically involves modelling the Project (with AERMOD) and adding background (either a conservative maximum background added to maximum modelled or time matched background and modelled data). Other local sources may be included.

For cumulative assessment in the far-field, all other Reasonable Foreseeable Development (RFD) sources in the modelling domain need to be considered. The modelling domain needs to consider all Class I areas within 300 km of the project.

NEPA TOCs tend to follow national compliance reporting standards and cumulative assessments under NEPA are compared to the same Significant Impact Levels (SILs) and PSD increments used in PSD permitting. When cumulative AQ/AQRV impacts of a Project plus RFD exceed cumulative TOCs then Project needs to consider mitigation that is frequently adopted in the Record of Decision (ROD) for the Project.

U.S. FEDERAL APPROVAL UNDER NEPA

Summary / key features for evaluation

- Screening for significance using categorical exclusion for sources with no significant impact (no assessment) and Threshold of Concern for individual facilities (no cumulative assessment).
- All reasonably foreseeable development included in cumulative assessment.
- Use of percentiles in the standard for both modelling predictions and background (i.e. 98th percentile for 1-hour NO_2.
- Modelling completed for 3-5 years of data.
- New Tier 2 (ARM2) method for NO_x conversion.
- Inclusion of all sources within 50km for near field modelling.

6.3 Canada

6.3.1 Alberta

Guidelines for air quality assessment and recommendations for cumulative effects assessment are outlined in the Air Quality Model Guideline (AQMG), developed by the Air Policy section of the Alberta Environment and Sustainable Resources Development (AESRD, 2013).

The AQMG allow for a tiered approach for air quality assessment. The first tier allows for a screening level modelling assessment for initial indication of risk. If the predicted concentrations, plus background are below the ambient air quality objectives, no additional modelling is required.

The next tier (refined assessment) requires further consideration of cumulative effects, including the modelling of all existing sources within a radius of 5 km, plus representative baseline. A clarification note was subsequently released regarding the 5km radius for inclusion of other sources. The intent of 5km buffer was for sources that are remote or isolated. The clarification note redefines the "study area" as the area where all predicted ground level concentrations are at or above 10% of the ambient air quality guidelines or baseline (whichever is higher).

Percentiles are used in the AQMG to remove the highest short term modelling predictions. Values above the 99.9th percentile, for 1 hour averages, are considered outliers. Percentiles are also used in the treatment of background data, for consideration of short term impacts. For screening assessment, the maximum is taken as the 99.9th percentile while for refined assessment, the 90th percentile is used.

The AQMG provide a tiered assessment approach for NOx to NO_2. Firstly the total conversion approach is applied. If required, this is refined by either PMVRM, RIVAD/ARM3 method in Calpuff (rural only) or OLM. Only if there is still an exceedance is the ARM used. Guidance is provided for the use of ambient data for ARM. A default of 0.7 is provided if no suitable data are available (which generally should be downwind and distant from the source).

A time series of monthly and diurnally varying ozone concentration data supplied by AESRD for rural areas in the AQMG.

The AQMG also provides time series of monthly and diurnally varying ozone concentration data for both urban and rural areas, where no monitoring data are available. These data can be used in PMVRM, RIVAD or OLM. Both the default ARM and the timeseries data are based on an analysis of 10 years of monitoring data from urban and rural sites.

CASE STUDY

Air Quality Impact Assessment for Genesee Generating Station (Santec, 2013)
The report defines a study area of 22km x 22km based on the area where predicted concentrations from the facility are at or above 10% of the ambient air quality standards. Local emissions sources were modelled for cumulative assessment, incorporating neighbouring facilities within a radius of 11 km. Background was also derived for cumulative assessment, based on analysis from 4 regional monitoring stations. The 90th percentile was used to describe 1-hour background while maximums were selected for other averaging periods (but calculated from the reduced 90th percentile 1-hour dataset). OLM was used for NOx conversion and in the absence of ambient ozone data, the timeseries data provided in AESRD (2013) was used.

Alberta have also implemented a Cumulative Effects Management approach and have implemented a framework for the Capital Region and Industrial Heartland[12] which outlines the environmental outcomes for the region as a whole and provides strategies for managing growth.

The cumulative effects management framework aims to manage emissions for the entire Industrial Heartland airshed, rather than on a facility by facility, with emission targets set for all large industrial facilities combined – for example for NO_x (25,000) and SO_2 (28,000 tonnes) (ENVIRON, 2009a). For the Capital Region Air Quality Management Framework, trigger levels for air quality management actions are defined based on ambient concentrations of NO_x and SO_2.

ALBERTA, CANADA

Summary / key features for evaluation

- Tiered assessment including screening level modelling guidance.
- Use of percentiles to remove highest 1-hour model predictions and for describing baseline.
- Nearby sources for modelling defined as those within 5 km, or the study area (which is where the predicted ground level concentrations are at or above 10% of the ambient air quality guidelines or baseline (whichever is higher).
- Capital Region Cumulative Effects Management for regional airshed management

6.3.2 British Columbia

Guidelines for air quality assessment and recommendations for cumulative effects assessment are outlined in the *Guidelines For Air Quality Dispersion Modelling in British Columbia*, including 12 steps for good practice dispersion modelling (BC MoE, 2008).

Cumulative air quality, in the context of air quality assessment, is defined as:

$$Cumulative = Background + Predicted\ Increment\ (contribution\ from\ modelled\ emission)$$

Background is the contribution from all sources expect the source that is modelled.

The guidelines allow for three levels of assessment (Levels 1, 2 and 3) depending on complexity of assessment and the level of risk associated with the project emissions. Level 1 is a screening approach (using a screening model, however all levels of assessment are required to consider background.

[12] http://esrd.alberta.ca/focus/cumulative-effects/capital-region-industrial-heartland/capital-region-cumulative-effects-management.aspx

Background should be derived, in order of priority, as follows:

- a network of long-term ambient monitoring stations near the source under study.
- long-term ambient monitoring at a different location that is adequately representative.
- modelled background.

Where no suitable background data are available, an estimate can be made or a value from elsewhere use, if justifiable and subject to acceptance from the regulators.

Percentiles are used for short-term cumulative assessment (for refined Level 2 and 3 assessments). A background value not lower than the 98th percentile is recommended.

A tiered assessment approach for NOx to NO_2 is outlined. Firstly the total conversion approach is applied. If required, this is refined by either ARM (if one year of representative data are available), OLM (if adequate data are not available to establish NO/NO2 ratios, or PMVRM if AERMOD is used for modelling. Only if there is still an exceedance is ARM used.

For existing permits, it is possible to demonstrate that a modification will reduce emissions or increase emissions by less than 10% of the permitted values, a minor permit amendment can be submitted (ENVIRON, 2009a).

BRITISH COLUMBIA, CANADA

Summary / key features for evaluation

- Use of 98th percentile to describe short term background for cumulative assessment.
- Screening approach for existing permits based on < 10% increase in emissions.

6.3.3 Ontario

The province of Ontario regulates emissions to air through Ontario Regulation 419/05, made under the Environmental Protection Act (1990). While O.Reg. 419/05 includes very prescriptive mandatory requirements for air approvals (permits), these requirements address the impact of the facility only, and do not consider cumulative effects.

To obtain approval for a new facility, an Emission Summary and Dispersion Modelling (ESDM) report is prepared which presents the predicted maximum point of impingement (POI) concentration for that facility. The POI is compared with the applicable air standard and if the facility can demonstrate compliance, no additional assessment is required. Air standards or POI limits differ from Ambient Air Quality Standards, in a similar way that impact assessment criteria in NSW differ from NEPM compliance standards.

As a result of the Ontario Court of Appeal refusing leave to appeal a Divisional Court decision which upheld neighbours rights to challenge a cement company’s approval to burn municipal waste and tyres. As a result of the decision, many stakeholder have expressed concern regarding the consideration of cumulative effects into the permitting process (ENVIRON, 2009a). The Ontario Environmental Commissioner subsequently commissioned a jurisdictional review of methodologies for cumulative effects assessment (ENVIRON, 2009a, ENVIRON, 2009b). It is understood that the Ministry of the Environment and Climate Change (MOECC) are now in the process of developing a framework for assessing cumulative effects, however nothing has been released to date.

The current approach assumes that air standards (applicable to single facilities) are sufficiently conservative to be protective. However, in a few cases where public comment on applications have demanded it, the MOECC has required the proponent to submit a “cumulative effects assessment”. The few cumulative effects assessments that have been completed are not publically available. The approach to cumulative effects assessment is left entirely to the proponent, although the MOECC will comment on the acceptability of the approach.

An example of an approach deemed acceptable is the addition of monitored background concentrations to dispersion modelling prediction of the facility only, and comparison against the Ambient Air Quality Criteria (). Cumulative assessment using this approach in Ontario is complicated by the fact that in many cases (e.g. TSP, PM_{10}) monitored concentrations already exceed the AAQC routinely. There is no current guidance or process for dealing with existing high background, although it is understood that in cases where the cumulative impact of a contaminant exceeds the AAQC, AAQC this does not necessarily result in an objection to approval.

6.4 United Kingdom

In the United Kingdom (UK), The Department of Environment, Food and Rural Affairs (DEFRA) provides guidance to local authorities on air quality management, principally through their system of Local Air Quality Management (LAQM). The LAQM Technical Guidance (LAQM TG) (DEFRA, 2009) provides guidance for local authorities for air quality management and includes approaches for screening assessment, detailed assessment, emissions estimation, modelling, etc.

The UK Environment Agency (EA) also issues horizontal guidance documents for permitting, which include guidance for cumulative assessment (Environment Agency (2011). Cumulative assessment requires background concentrations to be considered in air quality impact assessment to estimate the Predicted Environmental Concentration (PEC), as follows:

$$PEC = Process\ Contribution + Background\ Concentration$$

(Environment Agency, 2011)

There is a provision in the EA guidance for screening out "insignificant" impacts. If the contribution from a source is less than 1% of the annual standard or less than 10% of the short-term standard, the contribution can be screened as insignificant.

The UK Institute of Air Quality Management have also released a position paper on "*significance*" in air quality assessment (IAQM, 2009) and developed a generic magnitude of change descriptor, as shown in **Table 6-3**. The percentage change is related to the objective or limit value, not in relation to the existing ambient concentration.

The use of 1% as the threshold for an imperceptible change provides consistency with existing screening methods for air quality assessment specified by the Environment Agency.

Table 6-3: IAQM generic basis impact significant based on changes to ambient pollutant concentrations as percentage of an air quality objective or limit value

Magnitude of Change	Annual Mean
Large	Increase/decrease >10%
Medium	Increase/decrease 5 - 10%
Small	Increase/decrease 1 - 5%
Imperceptible	Increase/decrease <1%

The LAQM TG provides guidance for a phased assessment approach, using Screening Assessment to identify if significant changes require further consideration. Screening approaches are prescribed for various sources to decide if there is sufficient risk of an exceedance which would then justify a Detailed Assessment. Detailed Assessment involves the use of quality assured monitoring and validated modelling to determine current and future concentrations (DEFRA, 2009). Detailed Assessments might be used for declaring or revoking Air Quality Management Areas (AQMA), however some aspects of the phased assessment approach are worth considering for air quality assessment in general.

For traffic assessments, a screening model[13] is used to predict potential exceedances of the air quality objectives. Where certain significance criteria are met (i.e. such as volume of daily traffic, significant proportion of heavy good vehicles, level of population exposure) and the screening model predicts potential exceedances, the requirement for detailed assessment may be invoked. The screening tool does not calculate 1-hour concentrations, however it is assumed, for screening purposes, that if the annual mean does not exceed 60 µg/m³ there would be fewer than 18 hours above 200 µg/m³ and the exceedances of the air quality objective would be unlikely (based on the percentile form of the standard).

For industrial sources, a series of nomograms are presented in DEFRA (2009) to screen impacts from stacks and low level fugitive sources. The nomograms can be used as screening tools to determine if detailed assessment is required. The calculations used for the nomograms are also available in a spreadsheet tool.

An example is provided in **Figure 6-1**, showing the nomogram for PM_{10} for a ground level fugitive source. The point on 0m height line that corresponds to the distance to the closest receptor (read form the x-axis) is found and the corresponding emission rate determined from the y axis and compared with the actual emissions rate for the new emission source. If the actual emissions rate is equal to or higher, then a detailed assessment is required. The nomogram estimates the emission rate (in tonnes per annum) that would produce a 1 µg/m³ contribution to the 90th percentile of the 24-hour mean concentration.

It is also acknowledged that the impact of PM_{10} is largely dependent on background and a simplified and precautionary approach is described to derive a "background-adjusted" permitted emission level.

The procedure for use of the NO_2 nomograms also takes into account background / available headroom. A target ambient concentration is derived and is used to scale the annual emissions from the new emissions source. In this way, when there less headroom available, the scaled emissions from the new source is higher and the trigger for detailed assessment is more likely. The nomograms for NO_2 estimate the emission rate (in tonnes per annum) that would produce a 99.8th percentile ground level NO_2 concentration of 40 µg/m³ or 20% of the air quality objective and an annual average ground level NO_2 concentration of 1 µg/m³ or 2.5% of the air quality objective.

Another example is shown in **Figure 6-2**, showing the emission threshold from a 500m x 500m area that might result in an exceedance of the air quality objective for PM_{10}, based on various background values. This nomogram might, for example, be used in the assessment of any combined sources, such as wood heater emissions in an urban area.

[13] The Design Manual for Roads and Bridges Screening Model

Figure 5.9: PM_{10} emissions (tonnes per annum) from that will give an annual mean ground-level concentration of 1 µg/m³ at receptor locations up to 2km from fugitive and low-level sources (stack <10m).

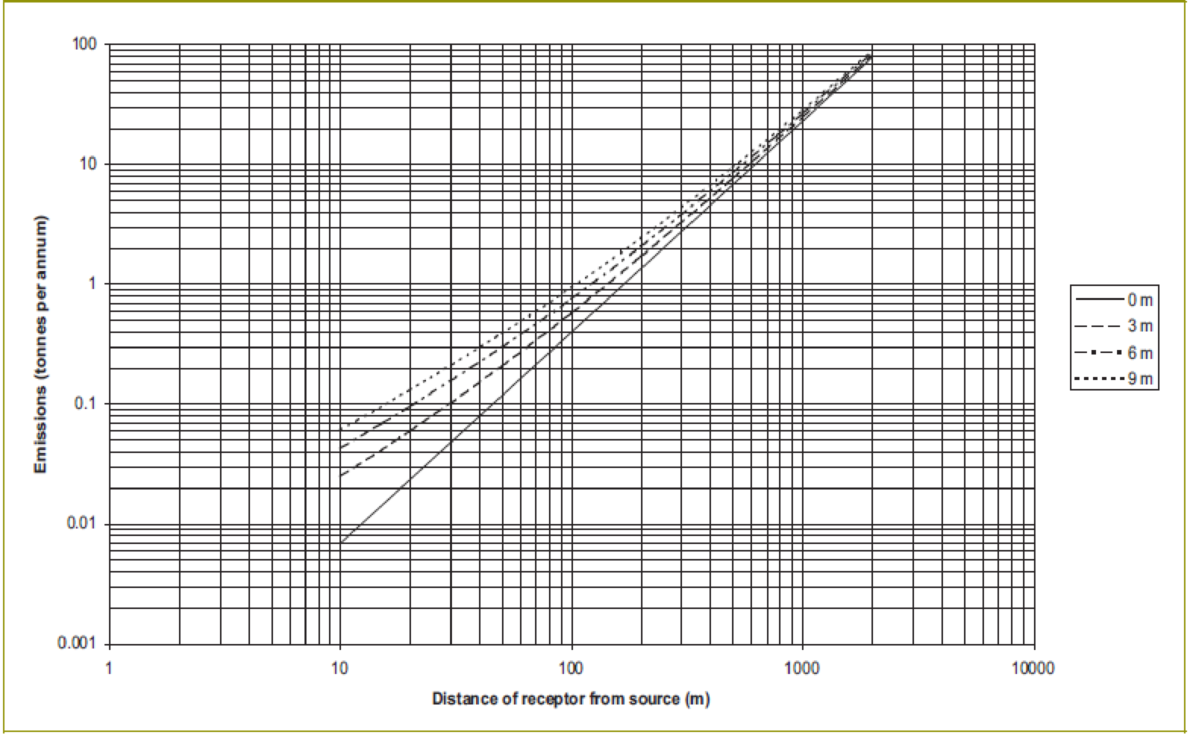

Figure 6-1: Nomogram for fugitive sources of PM_{10}

Figure 5.22: Threshold emissions density of emissions from a 500 m x 500 m area that may produce an exceedence of the daily mean objective for PM_{10}

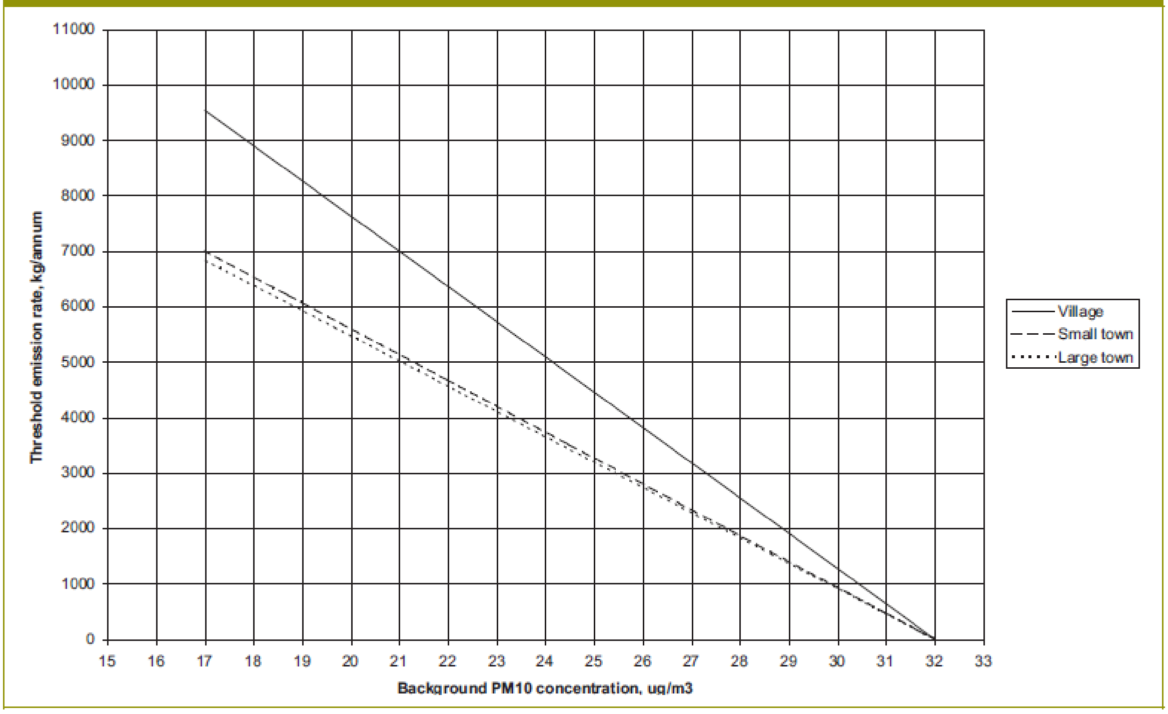

Figure 6-2: Nomogram for threshold emissions density that might produce an exceedance of PM_{10}

Source: (DEFRA, 2009)

6.4.1 Background data

Estimates of background concentrations for cumulative assessment can be made based on local monitoring data, background maps or by modelling background. Background maps for the UK are available at 1km x 1km resolution across England, Wales, Scotland and Northern Ireland. The maps are produced under the European Union directives on ambient air quality (Air Quality Directive (2008/50/EC); Air Quality Framework Directive (96/62/EC)) which require member states to undertake air quality assessments and to report the findings of these assessments to the European Commission on an annual basis.

The current version of the background maps (reference year 2011) contains estimates for NO_x, NO_2, PM_{10} and $PM_{2.5}$ for the period 2011 through to 2030 (DEFRA[14], 2014). Other pollutants are available for an earlier reference year and adjustment factors are provided to project the future background. For roadside measurements, a specific adjustment factor is provided for NO_2, to account for projected background NO_2 into the future, due to the changing proportions of primary NO_2 for different years.

DEFRA (2009) recommends that background maps are not used for short-term averages and for 24-hour PM_{10} recommends that the number of exceedances are determined based on the relationship to annual PM_{10} (see **Section 6.4.2**). Similarly for 1-hour concentrations, background maps cannot be used and an alternative approach is to use the hourly monitoring data from an appropriate background monitoring station.

Where monitoring data are used, if local background is being modelled in addition to the local source, a rural monitoring site should be used for background. Where only the local source is modelled, an urban background site should be used.

Background maps allow for spatial and temporal variation to be considered, although for some of the pollutants it is known that the projected decline in pollution is over optimistic. Sources can also be removed from the background maps, for example if that source is explicitly modelled in a local air quality assessment, to avoid double counting.

DEFRA (2009) also provides guidance on avoiding double counting when using monitoring data for background. For example, if a modelled source contribution is greater than 10% of the measured background, it is assumed that the background from this location would be unsuitable due to double counting. However this is more likely to be the case for certain pollutants (i.e. SO_2).

6.4.2 Short term averages

The Environment Agency H1 guidance (Environment Agency, 2011) provides guidance for short term effects and suggests a pragmatic approach in lieu of adding together two worst case concentrations. Short term background is taken as twice the long term background and therefore short terms impacts are expressed as:

$$PEC_{short\ term} = PC_{short\ term} + \left(2 \times Background_{long\ term}\right)$$

For 24-hour mean PM_{10} this often results in an exceedance and a different approach is prescribed in DEFRA (2009) for industrial sources. While adding hourly background to hourly model predictions is the preferred approach, the following methods can be used in the first instance.

The 90[th] percentile cumulative 24-hour mean PM_{10} is equal to the maximum of either:

$$90th\ \%ile\ 24hr\ mean\ background\ PM10 + annual\ mean\ process\ contribution\ PM10$$

$$90th\ \%ile\ 24hr\ mean\ process\ contribution + annual\ mean\ background$$

For Scotland's air quality objective, the 98[th] percentile cumulative 24-hour mean PM_{10} is equal to the maximum of either:

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[14] Department for the Environment Food and Rural Affairs

$$99th\ \%ile\ 24hr\ mean\ background\ PM10 + twice\ annual\ mean\ process\ contribution\ PM10$$

$$98th\ \%ile\ 24hr\ mean\ process\ contribution + twice\ annual\ mean\ background$$

The approach described above is likely to be conservative and can be used as a first pass. Where the predicted increase in 98th or 90th percentile (for PM_{10}) above background is greater than 50% of the available headroom, then a more detailed assessment is required.

A similar approach is described for considering background SO_2 and NO_2. The requirements for detailed assessment in this case, are when the concentration estimated are 75% of the air quality objective, detailed assessment is required.

Guidance is also provided on the relationship between percentiles and number of exceedances of short term air quality objectives. For monitoring and modelling data with data capture less than 90%, it is more preferable to express results as percentiles rather than number of exceedances. For example, the 35 permitted exceedances of the 24-hour PM_{10} air quality objective is considered equivalent to the 90th percentile.

DEFRA (2009) also presents a relationship between annual mean and the number of exceedances of the 50 µg/m³ standard which can be used to project future year exceedances in lieu of dispersion model predictions (which are considered less accurate for predicting the number of exceedances). The relationship is based on TEOM data (accounting for the default 1.3 adjustment factor) and takes the form:

$$Number\ of\ 24hr\ mean\ exceedances\ = -18.5 + 0.00145 \times annual\ mean^3 + \left(\frac{206}{annual\ mean}\right)$$

6.4.3 Elevated background

The 2011 reference year used in the background maps for the UK was an unusually high year for PM_{10} and $PM_{2.5}$ and scaling factors are provided to adjust these data. The scaling factors are based on measured data for the 5 years prior.

Where an EU Air Quality Limit is already exceeded, or may be exceeded by additional process contribution, there is a requirement to go beyond indicative BAT (which is a requirement for meeting national or non-statutory guidelines)

Where a new installation makes a minor contribution to a breach of the goal, it is normally more desirable for the Regulator to consider controls on more significant sources of air pollution, rather than refuse a permit. Where a new release constitutes a significant contribution to the breach, it is likely to be deemed unacceptable.

6.4.4 Air pollution hot spots

There is no specific approach prescribed for air pollution hot spots and standard guidance is followed for cumulative assessment. In situations where high level of risk are predicted a sensitivity analysis approach might be used and where ambient air quality guidelines are already exceeded, a risked based approach is typically applied.

The EU limit values and UK air quality objectives contain an allowable number of exceedances for all short term average standards. Where modelling and monitoring data are less than 90% complete, it is recommended that the data are presented in terms of percentiles equivalent to the relevant allowable exceedance.

Air Quality Management Areas (AQMA) are declared for areas where attainment of the air quality objectives are unlikely. In the UK, the AQMA are mostly related to road traffic emissions and the annual mean NO_2 objective is most at risk.

6.4.5 Assessment of total risk

Operators are required to summarise total risk by summing the Environment Quotient (EQ), which is expressed as a ratio of process contribution to the respective standard:

$$EQ_{substance} = \frac{Process\ contribution_{substance}}{Benchmark_{substance}}$$

and

$$EQ_{total} = EQ_1 + EQ_2 + EQ_3 \ldots.$$

The EQ approach allows for a comparison of options, for example where difference control options may be applied which might have differing controls for various emissions.

6.4.6 NOx conversion

A tiered approach is recommended by the UK Environmental Agency. At a screening level 50% conversion is assumed for short term and 100% for long term. If the PEC is above the relevant air quality objective then a worst case scenario of 35% and 70% conversion is assumed (for short and long term). If the PEC remains above relevant air quality objective then a more detailed assessment is required.

DEFRA (2009) describes an approach for roadway assessment based on taking into account fresh emissions of NO_x, background NO_x, available O_3 and the change in primary NO_2 for different assessment years. A tool is made available for this analysis.

Modelling approaches using chemical reaction sets can be used, however primary NO_2 needs to be justified. The approach outlined in DEFRA (2009) for industrial emissions is:

The 99.8th percentile NO_2 is equal to the minimum of:

$$99.8\text{th \%ile hourly background total oxidant} + 0.05 \text{ x } (99.8\text{th \%ile process contribution Nox}$$

Or the max of either:

$$99.8\text{th \%ile installation contribution of NOx} + 2 \text{ x annual mean background NO2}$$

$$99.8\text{th \%ile hourly background NO2} + 2 \text{ x annual mean installation contribution NOx}$$

Where predicted increment is >75% of available headroom, a more detailed approach required.

CASE STUDY

Air Quality Assessment for proposed heat and power biomass plant at the Tullis Russell Paper Factory (Taylor, 2011)

The approach to cumulative assessment used the Environment Agency approach of Process Contribution (PC) + Relevant Background Concentration (RBC) = Predicted Environment Concentration (PEC). Process Contributions were also compared to the significance screening criteria (long term PC < 1% of the standard and short term PC < 10% of the standard). Background was described from a combination of local monitoring data. In the absence of suitable national monitoring network sites, reference was also made to the "background maps" produced by Scottish Air Quality. Only annual average background values were reported and applied.

For cumulative NO_2 the screening methodology recommended by the Environment Agency was used, as was the NO_x chemistry module in ADMS. For the screening method, the long term average cumulative NO_2 is taken as 70% of the predicted long term NOx concentration plus the annual average background NO_2 concentration. The short-term cumulative NO_2 is taken as 35% of the predicted short term NO_x plus twice the annual average background NO_2 concentration. For cumulative PM_{10} the 98^{th} percentile 24-hour average is added to the annual background, despite the fact that the LAQM TG recommends twice the annual mean to be added for background.

UNITED KINGDOM

Summary / key features for evaluation

- EA screening for significance - if the contribution from a source is less than 1% of the annual standard or less than 10% of the short-term standard, the contribution can be screened as insignificant.
- DEFRA detailed screening assessment processes, including screening tools and nomograms.
- Background AQ maps available at 1km x 1km resolution.
- Short term background is taken as twice the long term background or short term cumulative impacts derived from percentiles and annual mean as a first pass.
- Relationship between annual mean and exceedances for 24-hour PM_{10}
- Use of percentiles in both modelling and background for cumulative assessment (90^{th} percentile for 24-hour PM_{10}, 99.8^{th} percentile for NO_2).
- For industrial sources either default ratios or a percentile based approach for cumulative NO_x. Specific approach and tools prescribed for roadway assessments.

6.5 France

In France, air quality is managed within a regulatory framework based on the requirements of EU Directives. For example, in environmental assessment of new permits, Code de l'environnement (the Environmental Code) is based on the requirements of the EU Directive (2011/92/EU) on the assessment of the effects of certain public and private projects in the environment.

Three levels of overlapping air quality standards are defined (European, national and local) and are used for the assessment of the population exposure, for the evaluation of the actions taken to limit pollution and to inform the public about ambient air quality.

Since 2013, Article R122-5 of the Environmental Code requires impact assessment to consider the cumulative impact of other known projects located in the surrounding area. There is no provision for incremental risk screening, however for small low risk projects with no major air quality issues, the level of detail can be minimal.

Guidance for cumulative assessment is generally limited to methodologies for characterisation of baseline air quality. For large industrial areas, specific guidelines (INERIS, 2011) are developed with requirements for baseline characterisation and consideration of other emission sources.

No specific perimeter is provided for the inclusion of other sources in cumulative assessment and this is typically based on expert judgement. Background concentrations are typically based on data from the national monitoring network, temporary campaign or the national modelling system Prev'Air. If no monitoring or modelling data are available, typical values are provided are provided for Urban, Industrial and rural areas in INERIS (2009).

For short term cumulative assessment, the preferred approach is the Level 2 assessment approach, however in the absence of suitable data, a constant background can be applied. The French standard for 24-hour PM_{10} is percentile based and therefore allows for elevated background (90.4^{th} or 35 exceedances a year).

NO_x conversion for cumulative NO_2 assessment is typically based on the methodologies embedded in AERMOD or ADMS, when full conversion is too conservative. The ADMS method uses background of NO_x ozone and basic photochemistry using a photolysis rate derived from date and cloud cover.

ADMS can also be used to calculate NO_2/NO_x ratio depending on the distance from the source, for different ambient conditions (for example for worst case high ozone concentrations, high solar radiation and low wind speed). A specific ratio is derived for each receptor based on the distance from the source.

Air Pollution Plans are the air quality management mechanisms for pollution "hot spots", typically large cities and/or large industrial areas. The Air Pollution Plan sets emission limit values (VLE) which can drive emission mitigation measures. Generally, the requirements for cumulative assessment in these areas are more onerous.

FRANCE

Summary / key features for evaluation

- National modelling system – Prev'Air – can be used for background in the absence of local monitoring data.
- If there are no monitoring or modelling data, 'typical' background values are provided for urban, industrial and rural areas.
- Air Pollution Plans are used in constrained airsheds to set Emissions Limits Values and drive emissions reductions. Specific limitations might be set for meteorological conditions and pollution events.
- Requirements for cumulative assessment in constrained airsheds are typically more onerous in terms of baseline characterisation and modelling other sources.
- Use of percentiles in standard (i.e. 90.4^{th} percentile for 24-hour $PM_{10)}$
- Contributions from existing sources in monitoring data are removed by analysing wind directions and determining when the monitoring data are impacted by the plume.

6.6 Italy

In Italy the central government has delegated air quality management to 20 Regional Governments which are responsible for reporting in air quality and development management and improvement plans. The Environment Act Decree 152/2006 outlines the limits for air emissions and provides guidelines for the preparation of Environmental impact assessment.

Environmental impact assessment is required for new sources of air emissions and although cumulative impacts need to be assessed, no specific guidance is provided. Cumulative assessment methodologies typically follow the Level 1 or Level 2 approach in the Approved Methods.

Some regional authorities ask for an interpolation of background data recorded at monitoring stations to account for spatial variation. Where no monitoring data are available, background is inferred based on representative data recorded elsewhere. Representative locations are selected on the basis of emissions sources and site characteristics. Where background is inferred, short term monitoring campaigns are used for validation purposes. The regulatory authorities require the assessment of future changes to background due to already approved projects not yet in operation, however no guidance is provided for what sources should be included.

For short term cumulative assessment, the Level 2 approach is commonly applied. Authorities do not accept probabilistic methodologies for permitting, however monte-carlo techniques have been used in legal cases.

NO_x conversion for cumulative NO_2 assessment is typically based on OLM, when full conversion is too conservative. Although commonly applied, OLM may not be sufficiently conservative for application in Italy.

In constrained airsheds when ambient air quality objectives are exceeded, emissions offsets or "compensation" may be required. For example, the owner of the new source may be asked to reduce the emissions from other sources in the same area or finance the reduction of emissions from the public sector.

ITALY

Summary / key features for evaluation

- System of emissions offsets or "compensation" for new sources of emissions in constrained airsheds.
- Spatial variation in background is sometimes dealt with by interpolation of existing monitoring data.
- Background can be estimated based on site characteristics and concentrations measured in similar environments. Usually validated with campaign monitoring.
- Future (approved) sources included in modelling.
- Use of percentiles in modelling predictions to match standard (i.e. 99.8th percentile for 1-hour NO_2)

6.7 Hong Kong

The Hong Kong Environmental Protection Department (EPD) approach to cumulative air assessment is outlined in their "*Guidelines on Assessing the Total Air Quality Impacts*[15]". The guidance is developed by the EPD Modelling Section of the Air Science Group, revised in March 2013.

In evaluating cumulative impacts, the guidelines require three tiers of emissions sources to be considered; primary, secondary and other contributors. Tier 1 or primary contributors are the project induced emissions sources and are often the major contributor to local air quality impacts. Tier 2 are the secondary contributors to local air quality impacts. A broad rule of thumb applied for local air quality impacts is that emissions sources within a 500m radius of the project are identified and included in an air quality assessment. If other significant sources exist that influence local air quality, this radius of influence may be extended.

Tier 3 refers to background or baseline air quality for the region which is not already accounted for in Tier 1 or 2 emissions sources. There are two approaches prescribed to represent Tier 3 contribution for analysis of 'total' impact, as follows:

- Chemical transport modelling based system, whereby gridded meteorological and air quality data are extracted from the regional scale model, on an hour by hour basis, and used to drive the Tier 1 and Tier 2 local scale models and determine the Tier 3 contribution.
- Observation based system whereby hourly meteorological data and air quality measurement from one or more monitoring stations are used (drive the Tier 1 and Tier 2 local scale models and determine the Tier 3 contribution).

The guidance notes that either system, if applied correctly, will produce "*statistically valid results to meet EPD's EIA requirements*".

In applying the observation based approach, a longer term average of the most recent 5 years of data should be used for present and future background. However, this was considered an interim approach, while the PATH[16] modelling system was developed, and from 2014 the use of the PATH

[15] http://www.epd.gov.hk/epd/english/environmentinhk/air/guide_ref/guide_aqa_model_g2.html
[16] *Pollutants in the Atmosphere and their Transport over Hong Kong* (ERM-HK, 2000).

system should be adopted. The use of short term monitoring data is specifically no longer accepted.

The PATH model is a regional photochemical modelling system which incorporates regional and Hong Kong emission inventories, meteorological data and chemical reaction features for predicting the ambient concentrations for Hong Kong. Predictions are available for multiple years (2015, 2020 and 2030) and for multiple pollutants (SO_2, NO_2, RSP (PM_{10}) and O_3. For FSP ($PM_{2.5}$), there is no model available at present and the concentration and the number of exceedences is estimated by assuming that the level of FSP is roughly equal to 70% of RSP (based on observations at existing air quality monitoring stations). (ARUP, 2009).

Guidance is also provided to avoid double counting in the tiered emissions approach. PATH accounts for Tier 2 emissions and would need to be removed from the emissions grid to avoid double counting. For the observation based approach, the guidance notes that the choice of monitoring station should discounted the contribution from Tier 2. This implies that monitoring stations that are not significantly influenced by Tier 2 emissions sources should be used.

Some of the key advantages of using this tiered emissions approach of combining regional scale modelling with local impact assessment are:

- Provides a repeatable, consistent and objective approach to characterising meteorology and baseline.
- Can account for 'future baseline' by allowing for growth, technology changes and government policy in future emissions.
- Can account for spatial and temporal variation in meteorology and pollution.
- Can be applied for air pollution hot spots, through the application of tier 1, 2 and 3 emission sources.

HONG KONG

Summary / key features for evaluation

- PATH - a comprehensive regional photochemical modelling system which incorporates regional and Hong Kong emission inventories, meteorological data and chemical reaction features for predicting meteorology and ambient concentrations for an area of Hong Kong.

6.8 Netherlands

Similar to the UK and other member states, the National Institute for Public Health and the Environment (RIVM[17]) have developed background maps of air concentrations for the Netherlands for reporting requirement of the EU Directives. The maps are used in national air quality collaboration programmes and are also used in the Netherland for new planning to provide a reliable and consistent background for an area of interest, which can be added to modelled source contributions for prediction of cumulative impact. The maps provide spatial distribution of key pollutants (NO_2, PM, SO_2, ozone) for a base year (2013) and projections for future years (2015 -2030) (RIVM, 2014), however the approach is suitable for longer term averages only as they do not cover short-term impacts.

The maps are developed using an Operational Priority Substances (OPS) dispersion model, which calculates annual average concentrations based on emissions, dispersion, chemical conversion and deposition, at a resolution scale of 1km x 1km (Velders and Diederen, 2009).

[17] Rijksinstituut voor Volksgezondheid en Milieu (RVIM)

Anthropogenic emissions used in the OPS calculation are the official national emissions collected by the Pollutant Release & Transfer Register, also used for reporting emissions to, for example, the EC under the Convention on Long-Range Transboundary Air Pollution.

Base year model concentrations are calibrated using observations collected by the National Air Quality Monitoring Network, while future years take into account national policy on air quality management.

For modelling of future sources in air quality assessment, the contribution from the new source can be added to the background obtained from these maps.

An example of online maps[18] is shown in **Figure 6-3** and can be zoomed to a specific area of interest.

NETHERLANDS

Summary / key features for evaluation

- Online background maps for key pollutants, used as the basis for cumulative air quality assessment.

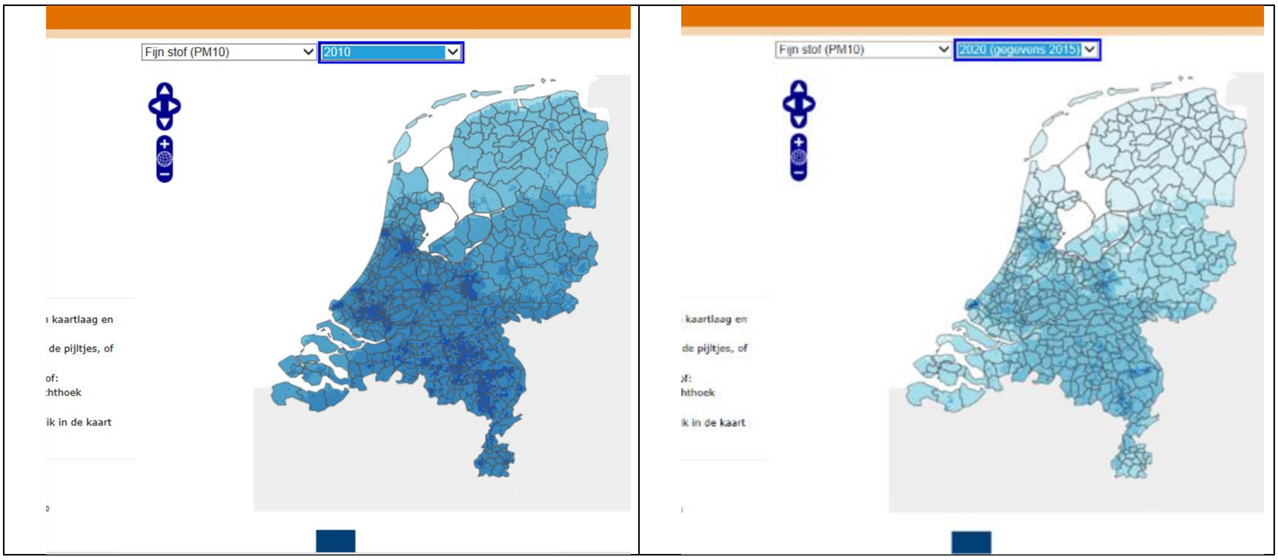


Figure 6-3: Background maps for Netherland for 2010 and 2020

6.9 New Zealand

The New Zealand Ministry for the Environment (NZ MfE) publish Good Practice Guides for air quality management, used by local councils for consenting and permitting. The good practice guides relevant to cumulative effects analysis are as follows:

- Good Practice Guide for Assessing Discharges to Air from Industry (NZ MfE, 2008[19]);
- Good Practice Guide for Atmospheric Dispersion Modelling (NZ MfE, 2004).

A tiered assessment approach is prescribed for new sources of emissions to air. Tier 1 is a preliminary assessment to determine if significant effects are likely. It typically allows for a qualitative approach and is suitable for controlled activity in a non-gazetted airshed, with minimal discharges to air, appropriately designed discharge points and no sensitive receptors located nearby.

[18] http://geodata.rivm.nl/gcn/

[19] The MfE is currently in the process of updating this guide.

Tier 2 is a screening level modelling assessment, using worst case inputs and assumptions. Tier 3 is a full assessment, required for example when a Tier 2 assessment predicts a significant impact or where the airshed is already constrained. Both Tier 2 and Tier 3 assessments are required to consider cumulative effects, however the level of detail is greater for Tier 3.

A constrained airshed where the PM_{10} standards are already breached have specific requirements for assessment of new emissions sources, depending on the significance of the additional source.

The Resource Management (National Environmental Standards for Air Quality) Regulations 2004[20] requires that an application for a resource consent must be refused if the proposal would increase 24-hour PM_{10} concentrations by 2.5 µg/m³ within a polluted airshed. A polluted airshed is defined by the number of exceedances of the goal, above the allowable exceedances, based on a 5 year monitoring period. There are exceptions to this rule, for example if the proposal does not increase emissions from the existing consent or if suitable emissions offsets can be provided.

For other pollutants (NOx, CO, VOC), the concept of a *principal source* is introduced. Where a discharge from a principal source is likely to breach the standards, consent cannot be given, however if a source can be demonstrated as minor or trivial, there may be flexibility on the required mitigation in certain circumstances.

For a Tier 2 assessment it is generally appropriate to make worst-case assumptions about background air quality by adopting the maximum value averaged over 5 years (if available) or by making a worst case assumption based on monitoring done elsewhere (such as an area of similar population density, sources and meteorology). Where no representative background data can be found, a best guess can be made and examples of this approach are provided.

For Tier 3 assessment, addition requirements for cumulative assessment are outlined. A suitable methodology for accounting for background needs to be carefully considered for Tier 3 assessment and may include the use of site specific or representative monitoring data or modelling of all local emissions sources. For short term impacts, it is recommended that hourly averaged background data are paired in time with modelling predictions for cumulative assessment, where the background data are available. The UK approach of using twice the annual background is also outlined as a potential approach. It is also recommended that 10 years of data are used to determine long terms trends.

Where exceedances of the air quality objectives are predicted, or where background already approaches or exceeds the guidelines, a health risk assessment is generally required.

The Good Practice Guide for Atmospheric Dispersion Modelling offers an alternative approach to OLM, for estimating cumulative NO_2.

The approach assumes that background ozone in New Zealand (in the range of 20 – 35 ppb) is available to produce a maximum NO_2 concentration of 72 µg/m³ and this is then combined with background and predicted NOx as follows:

$$NO2_{cum\,max} = 72 + NOx_{bkgrd\,tot} \times \%NO2_{bkgrd} + NOx_{emiss} \times \%NOx_{emiss}$$

where:

- $NO2_{cum\ max}$ is the maximum estimate of total cumulative NO_2 from both background NOx and the additional emission under consideration
- $NOx_{bkgrd\ tot}$ is the total background NOx Concentration in the receiving air
- $\%NO2_{bkgrd}$ is the percentage of nitrogen dioxide in the NOx emitted from the sources contributing to the background levels of NOx
- NOx_{emiss} is the concentration of NOx at the receptor originating from the emission

[20] The previous version of the Regulations defined a straight-line path (or curved line path) to meeting the standard which defined a path from an historical point of baseline PM_{10} concentration, at a certain date, to a point representing the standard, at a future date. Where a new emission source caused the airshed to go significantly above the straight-line path, consent could not be given unless the new emissions are offset.

- $\%NOx_{emiss}$ is the percentage of nitrogen dioxide in the NOx emitted from the source under consideration.

NEW ZEALAND

Summary / key features for evaluation

- Tiered approach allows for minor low risk projects to be considered qualitatively.
- Designation of polluted airsheds based on the number of measured exceedances, above what is allowable, over a 5 year period.
- Significant increment level of 2.5 µg/m^3 is defined for 24-hour average PM_{10} for polluted airsheds. For increments above this level, further levels of assessment may be required.
- Alternative approach for cumulative NO_2 based on the maximum available background ozone.
- Concept of a principal source introduced, to provide a pragmatic alternative to excessive mitigation that might not offer any air quality benefit.
- Health risk assessment required where exceedances are predicted or for constrained airshed.

6.10 Challenges faced in other jurisdiction

The questionnaire distributed during the literature review identified some of the cumulative assessment challenges faced in other jurisdictions. The challenges, summarised in **Table 6-4**, are similar to those faced in NSW.

Based on the outcomes of the literature review and the questionnaire response, many of the challenged faced in NSW also remain unresolved in other jurisdictions.

Table 6-4: Challenges in cumulative impact assessment faced in other jurisdictions

Jurisdiction	Challenge
UK	The main challenge identified was in obtaining suitable background monitoring data was identified as a challenge. This was surprising considering the AURN monitoring network and the availability of background maps for all of the UK
US permitting	The following challenges were identified for the US permitting process. • Obtaining suitable data for modelling other facilities. • Accounting for double counting when adding modelling predictions from neighbouring facilities on top of background that may already include some contribution from these local sources. • Lowering of the allowable air standards means the difference between background and the standard provides little room for additional impact.
US Federal approvals	The following challenges were identified for the US federal approval process under NEPA. • Development of a cumulative emissions inventory for reasonably foreseeable development. • The 1-hour NO2 standard is difficult to achieve when using conservative assumptions. • Lowering standards will bring certain areas above or close to the NAAQS.
France	The main challenge identified was lack of suitable representative monitoring data. Also, continuous monitoring data is limited to criteria pollutants and obtained background data for air toxics is difficult.
Western Australia	The following challenges were identified in Western Australia. • Obtaining suitable emissions data and release parameters for modelling other facilities. • Limited availability of background data. • Accounting for the PM contribution from dust storms and bushfires. • Lack of regional emissions inventories.
Victoria	The main challenge identified was lack of suitable representative monitoring data.

7. PRELIMINARY EVALUATION OF METHODOLOGIES

The ToR for the study require an evaluation of the relative conservatism and potential for broad application for each identified cumulative assessment methodology. The methodologies that are identified for evaluation are those that aim to address some of the common challenges in NSW (**Section 3.4**), as follows:

- Methodologies for short term cumulative assessment.
- Methodologies for selecting and incorporating background for cumulative assessment.
- Methodologies for selecting and incorporating other sources in cumulative assessment.
- Methodologies for significance screening prior to cumulative assessment.

To address the themes of conservatism and broad application, the preliminary evaluation is based on the following criteria:

- Does the methodology have broad application, in terms of suitability to:
  - Spatial and temporal variability.
  - Constrained airsheds and air pollution hot spots.
  - Rural and urban areas.
  - Different pollutants.
  - Various averaging periods.
- Is the methodology objective, in terms of selection of data inputs?
- Does the methodology ensure consistency in application of the approach?
- Is the methodology sufficiently conservative?
- What are the additional requirements (research / data) required for implementation in NSW?
- What is the level of difficulty for implementation in NSW?

For each identified methodology, an evaluation is presented in **Table 7-1** to **Table 7-8**.

The preliminary evaluation also recommends where additional, more detailed, evaluation may be required. The additional evaluation is either presented in **Section 9** or forms part of recommendations for future work, for example where the additional evaluation required would be beyond the scope for this study.

Table 7-1: Preliminary evaluation of methods for short term cumulative assessment

Challenge	Feature	Broad Application?						Objective?	Consistent?	Conservative?	Challenge
		Accounts for temporal variability	***Accounts for spatial variability***	***Suitable for air pollution hot spots***	***Suitable for different ave periods***	***Suitable for multiple pollutants***	***Suitable for rural and urban areas***				
Methodologies for short term cumulative impact assessment	Deriving a short term background based on twice the annual average	No	Perhaps, if spatial variation in short term averages is similar to annual averages.	Perhaps, if annual averages are also elevated	Used in the UK for 1-hour (Nox) and 24-hour (PM)	Yes	Yes	In most cases	Yes	Not in all circumstances	Methodologies for short term cumulative impact assessment
	Deriving a short term background based on percentiles	No	Perhaps, although spatial variation may be more likely for higher %iles	Higher %iles more likely to account for hot spots	Yes	Yes	Yes	In most cases	Yes	More likely for higher %iles	
	Deriving a relationship between annual mean and number of exceedances	No	Perhaps, if spatial variation in short term averages is similar to annual averages.	Perhaps, if annual averages are also elevated	Used in UK for 24-hour PM10 only	Used in UK for 24-hour PM10 only	Yes	Yes	Yes	Not in all circumstances	
	Combining percentiles values for background and modelling predictions	No	Perhaps, although spatial variation may be more likely for higher %iles	Higher %iles more likely to account for hot spots	Yes	Yes	Yes	In most cases	Yes	More likely for higher %iles	
	Probabilistic approach of adding background and showing risk of additional exceedances	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
	Level 1 assessment approach	No	Yes	Too conservative	Yes	Yes	Yes	In most cases	Yes	Yes	
	Level 2 assessment approach	Yes	Yes	Yes, but more challenging	Yes	Yes	Yes	Open to subjective data selection	Open to inconsistency in application	Yes	
	Two tiered limits - one set at a percentile and another set at a maximum never to be exceeded.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not in all circumstances	
	Significant increment level specified as % of goal or absolute value.	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Not in all circumstances	

Table 7-2: Requirements for implementation of methods for short term cumulative assessment

Feature	Implementation			
	Additional evaluation or research needed?	***Additional data needs?***	***Ease of implementation?***	***Feasible for implementation in NSW?***
Deriving a short term background based on twice the annual average	Evaluation for PM data presented in Section 9. Further evaluation would be required for other pollutants, however not recommended.	None	Low difficulty	Unlikely to be suitable for all circumstances.
Deriving a short term background based on percentiles	Evaluation for PM data presented in Section 9. Further evaluation would be required for other pollutants, however not recommended.	None	Low difficulty	Unlikely to be suitable for all circumstances.
Deriving a relationship between annual mean and number of exceedances	Preliminary evaluation presented in Section 9. Not considered for further evaluation.	None	Low difficulty	Unlikely to be suitable for all circumstances.
Combining percentiles values for background and modelling predictions	Not considered for further evaluation.	None	Low difficulty	Unlikely to be suitable for all circumstances.
Probabilistic approach of adding background and showing risk of additional exceedances	Evaluation presented in Section 9.	None	Low difficulty	Yes, assuming "no additional exceedance" test is critical factor.
Level 1 assessment approach	No	None	Already implemented	Already implemented
Level 2 assessment approach	No	None	Already implemented	Already implemented
Two tiered limits - one set at a percentile and another set at a maximum never to be exceeded.	Further research is recommended for the establishment of airshed management areas for NSW.	None	Medium difficulty	Yes
Significant increment level specified as % of goal or absolute value.	Further research is recommended if significance screening adopted for NSW.	None	Medium difficulty	Yes

Table 7-3: Preliminary evaluation of methods for incorporating background where no site specific data are available

Challenge	Feature	Broad Application?						Objective?	Consistent?	Conservative?
		Accounts for temporal variability	***Accounts for spatial variability***	***Suitable for air pollution hot spots***	***Suitable for different ave periods***	***Suitable for multiple pollutants***	***Suitable for rural and urban areas***			
Methodologies for selecting and incorporating background where no site specific data are available	Development of background maps for NSW based on monitoring data, regional emissions inventories and regional modelling	Yes	Yes	Yes	Most suited to annual averages. Could be used with percentile or probabilistic methodologies for short term impacts	Yes	Yes	Yes	Yes	Yes
	Developing prescribed background values for data sparse areas	No	No	No	Most suited to annual averages. Could be used with percentile methodologies for short term impacts	Yes	Yes	Yes	Yes	Not in all circumstances
	Modelling background	Yes	Yes	Yes	Yes	Yes	Yes	Open to subjective emission source selection	Open to inconsistency in application	Yes
	Using site representative data	Yes	No	No	Most suited to annual averages. Could be used with percentile methodologies for short term impacts	Yes	Yes	Open to subjective site selection	Open to inconsistency in application	Not in all circumstances
	Provide best guess based on site characteristics.	No	No	No	Most suited to annual averages. Could be used with percentile methodologies for short term impacts	Yes	Yes	No	No	Not in all circumstances

Table 7-4: Requirements for implementation of methods for incorporating background where no site specific data are available

Challenge	Feature	Implementation			
		Additional evaluation or research needed?	***Additional data needs?***	***Ease of implementation?***	***Feasible for implementation in NSW?***
Methodologies for selecting and incorporating background where no site specific data are available	Development of background maps for NSW based on monitoring data, regional emissions inventories and regional modelling	Significant effort needed to develop regional emissions inventories and modelling for entire state and/or additional monitoring for rural NSW.	Regional emissions inventories for non GMR areas of NSW. Additional monitoring data for rural NSW	High difficulty, significant time and cost investment	Not in the short-medium term but could be a longer term consideration.
	Developing prescribed background values for data sparse areas	Evaluation presented in Section 9, however analysis could be extended to include all available industry monitoring data and analysis of correlations to derive suitable values.	None	Medium difficulty	Yes but might not meet the EPA's 'future proof' criteria.
	Modelling background	Additional research may be needed on the suitability of NPI or EPL data.	Development of emission database.	Medium difficulty	Yes, depending on the quality and source of data.
	Using site representative data	Evaluation presented in Section 9, however analysis could be extended to include all available industry monitoring data and analysis of correlations to derive suitable values.	None	Low difficulty	Already implemented but approach can be supported by additional analysis.
	Provide best guess based on site characteristics.	Not recommended for further evaluation.	None	Low difficulty	Not recommended.

Table 7-5: Preliminary evaluation of methods for including other sources

Challenge	Feature	Broad Application?						Objective?	Consistent?	Conservative?
		Accounts for temporal variability	*Accounts for spatial variability*	*Suitable for air pollution hot spots*	*Suitable for different ave periods*	*Suitable for multiple pollutants*	*Suitable for rural and urban areas*			
Methodologies for selecting and incorporating other sources	All sources within fixed radius of influence - i.e. 50km	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	All sources within study area, defined as area where predicted concentrations are at or above 10% of air quality objective or the baseline	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Model source and determine area of impact based on SIL. Including all other sources in AOI.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Double AOI to incorporate other sources.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Ratio of emissions to distance method (Q/D)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 7-6: Requirements for implementation of methods for including other sources

Challenge	Feature	Implementation			
		Additional evaluation or research needed?	***Additional data needs?***	***Ease of implementation?***	***Feasible for implementation in NSW?***
Methodologies for selecting and incorporating other sources	All sources withing fixed radius of influence - i.e. 50km	Not considered for further evaluation.	Development of emission database.	Low difficulty	Not recommended.
	All sources within study area, defined as area where predicted concentrations are at or above 10% of air quality objective or the baseline	Preliminary evaluation presented in Section 9. Additional evaluation would be needed, but threshold appears too high.	Development of emission database.	Low difficulty	Threshold likely to be too high.
	Model source and determine area of impact based on SIL. Including all other sources in AOI.	Preliminary evaluation presented in Section 9. Additional evaluation would be needed, based on adopted SIL, should screening for significance adopted in NSW.	Development of emission database.	Low difficulty	Yes, subject to magnitude of SIL and how it is applied.
	Double AOI to incorporate other sources.	Preliminary evaluation presented in Section 9. Additional evaluation would be needed, based on adopted SIL, should screening for significance adopted in NSW.	Development of emission database.	Low difficulty	Yes, subject to magnitude of SIL and how it is applied.
	Ratio of emissions to distance method (Q/D)	Not considered for further evaluation, however could be considered to support or in lieu of AOI methodology.	Development of emission database.	Low difficulty	Yes

Table 7-7: Preliminary evaluation of methods for significance screening

Challenge	Feature	Broad Application?						Objective?	Consistent?	Conservative?
		Accounts for temporal variability	*Accounts for spatial variability*	*Suitable for air pollution hot spots*	*Suitable for different ave periods*	*Suitable for multiple pollutants*	*Suitable for rural and urban areas*			
Methodologies for screening for significance	Use of significant impact levels (SIL) / thresholds of concern (TOC).	No	No	No	Yes	Yes	Yes	Yes	Yes	Not in all cases
	Consider available "headroom" when screening against SIL	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Not in all cases
	Significance screening based on % of goal	No	No	No	Yes	Yes	Yes	Yes	Yes	Not in all cases
	Incremental criteria such as POI, DGLC	No	No	No	Yes	Yes	Yes	Yes	Yes	Not in all cases
	Screen for assessment based on an scale of development and distance to receptors	No	No	No	N/A	N/A	Rural only	Yes	Yes	Not in all cases
	Screen for assessment based on emissions threshold	No	No	No	No	Yes	Yes	Yes	Yes	Not in all cases
	Screen for assessment based on nomograms for various sources and pollutants	No	When headroom considered	No	Yes	Yes	Yes	Yes	Yes	Not in all cases
	Screening assessment checklists and screening models	No	When background considered	No	In some cases	Yes	Yes	Yes	Yes	Not in all cases

Table 7-8: Requirements for implementation of methods for significance screening

Challenge	Feature	Implementation			
		Additional evaluation or research needed?	***Additional data needs?***	***Ease of implementation?***	***Feasible for implementation in NSW?***
Methodologies for screening for significance	Use of significant impact levels (SIL) / thresholds of concern (TOC).	Preliminary evaluation presented in Section 9. Further research is recommened to derive SIL if significance screening adopted for NSW.	No	Medium difficulty	Yes, subject to further evaluation to derived a suitable SIL
	Consider available "headroom" when screening against SIL	Preliminary evaluation presented in Section 9. Further research is recommened to derive SIL if significance screening adopted for NSW.	No	Medium difficulty	Yes, subject to further evaluation to derived a suitable SIL
	Significance screening based on % of goal	Preliminary evaluation presented in Section 9. Further research is recommened to derive SIL if significance screening adopted for NSW.	No	Medium difficulty	Yes, subject to further evaluation to derived a suitable SIL
	Incremental criteria such as POI, DGLC	Not considered for further evaluation.	No	Medium difficulty	Not recommended
	Screen for assessment based on an scale of development and distance to receptors	Not considered for further evaluation.	No	Low difficulty	Not recommended
	Screen for assessment based on emissions threshold	Additional research would be needed to derive screening tool, however not considered for further evaluation.	No	Medium difficulty	Yes
	Screen for assessment based on nomograms for various sources and pollutants	Additional research would be needed to derive nomograms for various sources, however not considered for further evaluation.	No	Medium difficulty	Yes
	Screening assessment checklists and screening models	Not considered for further evaluation.	No	Low difficulty	Not recommended

8. SUGGESTED FRAMEWORK FOR CUMULATIVE IMPACT ASSESSMENT

There were a number of common themes for cumulative assessment identified in the jurisdictional review, for example both the UK and the US apply significance screening for project contribution alone, to determine the need or level of detailed required for cumulative assessment. Another common theme is the identification of airshed management areas where requirements for cumulative assessment differ from other cleaner airsheds. Based on these two common themes, an updated framework for cumulative air impact assessment in NSW is proposed and a pathway to cumulative impact assessment presented in **Figure 8-1**, designed to answer the following questions:

- Is the new emissions source proposed for an area in attainment or non-attainment with ambient air quality goals?
- Is the new emissions source predicted to have a significant impact?

Where a new emissions source is located in a non-attainment area, for the identified pollutant of potential concern (POPC), it is recommended that the proponent proceed directly to a detailed cumulative impact assessment.

For a new emissions source located in an attainment area, a provision to screen for significance is introduced into the cumulative impact assessment process. A preliminary impact determination is made, similar to the process prescribed for PSD permitting in the U.S, whereby the project contribution is modelled and compared against screening level criteria (i.e. a significant impact level (SIL)). Where the new emissions source increment is below the SIL, further cumulative assessment may not be required. Where the new emissions source increment is above the SIL, the requirement to proceed to cumulative impact assessment is triggered and an outline for the cumulative impact assessment process is shown in **Figure 8-2**.

An initial "*tier 1*" cumulative assessment is proposed, by adding project contribution to a suitable representative background, similar to the approach used in the UK to estimate the Predicted Environmental Concentration (PEC), as follows:

$$PEC = Process\ Contribution + Background\ Concentration$$

The requirement for more detailed cumulative assessment (i.e. "*tier 2*") may be triggered, for example, if the PEC is greater than 70% of the annual average goal.

Tier 2 or detailed cumulative assessment would include some or all components shown in the conceptual model presented in **Figure 1-1** (other local sources, reasonably foreseeable future development, regional background from non-modelled sources, indirect or induced effects). The proposed cumulative assessment framework is tested with a case study presented in **Section 9.6**, however, if a tiered cumulative assessment process is considered for NSW, the following questions would need to be answered:

- What are the most appropriate ways to define airshed management areas?
- What are the appropriate significant impact levels (SILs) for NSW?
- Is the preliminary modelling for significance screening presented with or without emission controls?
- What are suitable thresholds for progression to tier 2, for short-term and long-term averages?

Some initial discussion on these questions is presented **Section 9**. Specific recommendations for key components of cumulative assessment (incorporating background, short-term averaging periods, other local sources) is also provided in **Section 9**.

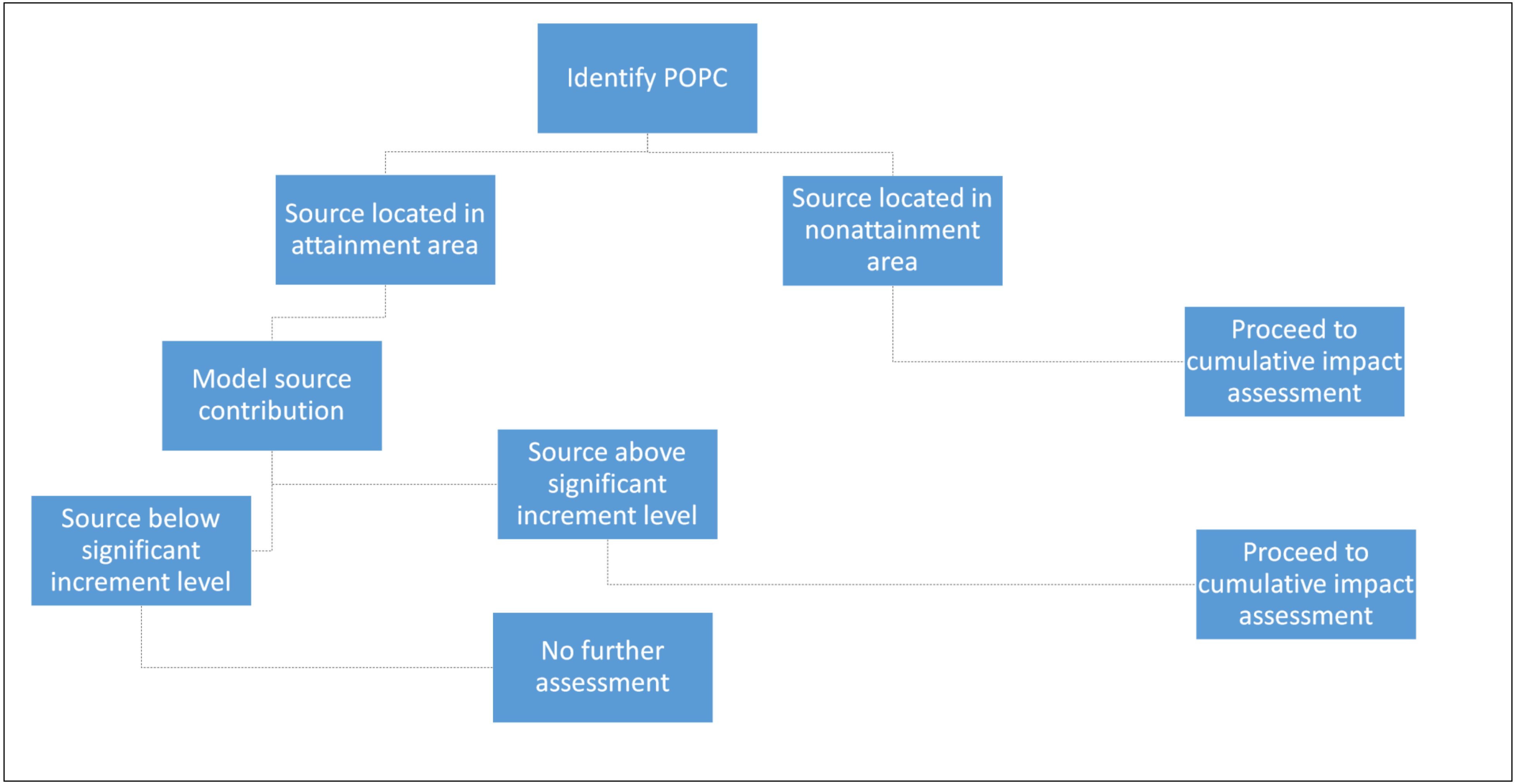


Figure 8-1: Pathway to cumulative impact assessment

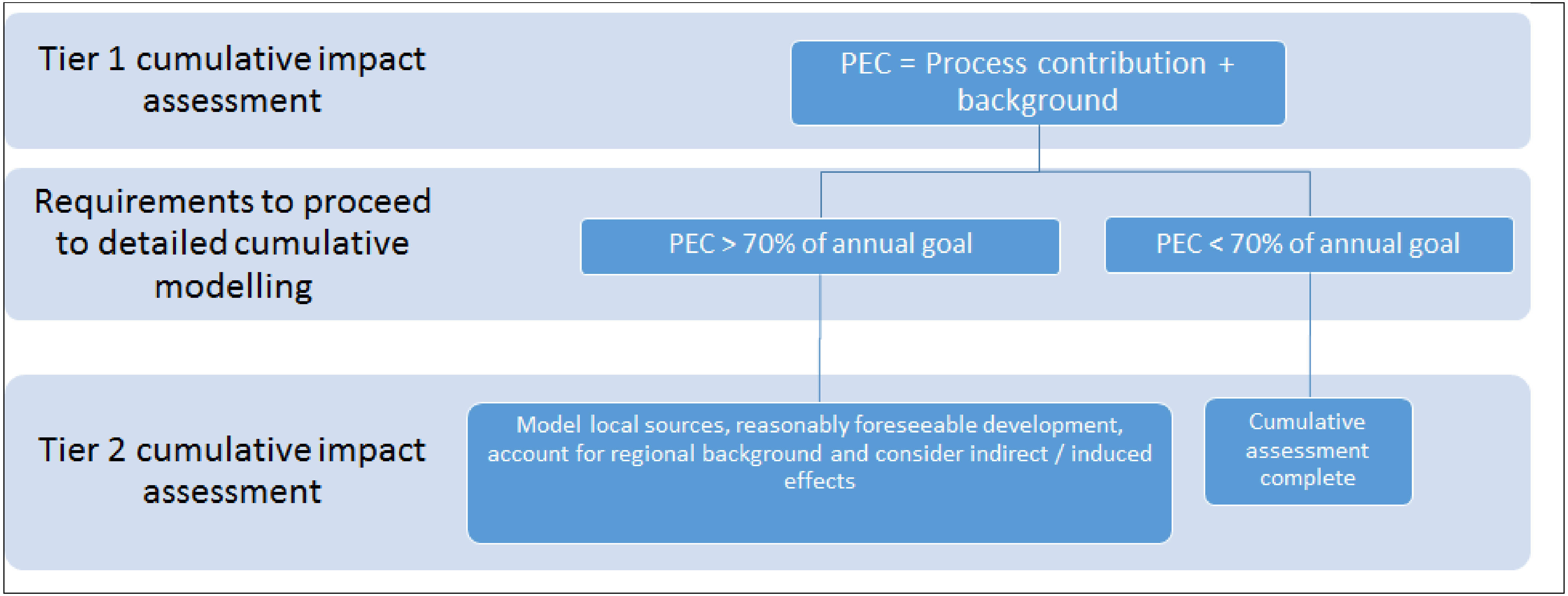


Figure 8-2: Cumulative impact assessment process for long term assessment

9. FURTHER EVALUATION OF METHODOLOGIES

9.1 Airshed management

The pathway to cumulative assessment presented in **Figure 8-1** introduces the concept of airshed management areas, where requirements for cumulative assessment are more detailed or prescriptive. Options for defining airshed management areas include:

- Predefined areas specified by the NSW EPA (i.e. GMR, Upper Hunter).
- Determined for each proposed project, on the basis of an analysis of background monitoring data.

Airshed management areas are predefined in some jurisdictions (Victoria, Western Australia) and the NSW EPA could, for example, designate certain areas of NSW where requirements for cumulative assessment would be more detailed. It is understood that EPA's preference is to "future proof" recommendations for air quality assessment in NSW, and therefore predefined airshed management areas may not necessarily meet this criterion. It is preferable, therefore, to determine if a project is within an airshed management area based on analysis of recent background monitoring data.

This approach is used for the tiered ozone assessment procedures for NSW (ENVIRON, 2011) which defines attainment and non-attainment for regions of NSW based on an analysis of the most recent 5 years of monitoring data. Areas where the 5-year average is greater than an acceptance limit, defined as 82% of the NEPM standard, are classified as non-attainment. The acceptance limit is taken from the NEPM screening procedures (NEPC, 2007), which uses acceptance limits to assess the monitoring needs of a region. For example, the acceptance limit for PM_{10} is 75% of the NEPM standard, when based on 5 years or more of historical monitoring data. By adopting these acceptance limits, attainment or non-attainment is not defined by compliance with the ambient air quality standard.

It is recommended that an analysis of the most recent 5 years of monitoring data is conducted for all OEH monitoring sites, and all pollutants, to evaluate the suitability of acceptance limits such as those outlined in the NEPC (2007). For example, based on the last 5 years of data and an acceptance limit for PM_{10} of 75% of the NEPM standard, do the areas of NSW that are currently a concern for the EPA fall within the definition of non-attainment. Other options for acceptance limits would be to use the number of exceedances of the standard, such as the approached used for PM_{10} in New Zealand.

9.2 Temporal and spatial variability in background

The ToR for the study requires a recommended approach to incorporate background concentrations in cumulative impact assessments within a tiered assessment framework. An evaluation of temporal and spatial variability in background is presented to answer the following questions:

1. How does background vary temporally and how suitable is existing (historical) OEH data in defining a future background for air quality assessment.
2. How many years of background data should be used to describe or characterise background?
3. How does background vary spatially and how suitable are the existing OEH sites in describing background for data sparse areas.

Long term trend analysis is used to investigate the suitability of historical data in describing future background and to inform the number of years of background data required to account for inter-annual variation. Time variation plot is also presented to compare a temporal variation between an urban and rural site. Correlation analysis is presented to inform spatial variability in background and analyse the confidence that existing sites can be used to describe background for other areas.

9.2.1 Analysis of temporal variation

Background data can exhibit inter-annual variation, for example related to climate variability effects related to ENSO. The monthly PM_{10} concentration at Beresfield is shown in **Figure 9-1** and a clear pattern is evident in the higher percentile data. The variation appears to follow an approximate four year cycle. Much less variation is evident in the lower percentile and median level.

The analysis presented in **Figure 9-1** does not describe if the trend is negative (PM_{10} concentrations decreasing) or positive (PM_{10} concentrations increasing). Additional trend analysis is presented in **Figure 9-2** for the same Beresfield dataset, plotted with the Theil-Sen function[21] in Openair.

An overall weak negative trend is observed in monthly mean PM_{10}, with a -0.56% change predicted per annum. At the 95% confidence interval, a weak negative to weak positive trend is estimated (-1.4% to 0.35% per year).

The general weak negative trend indicates that historical data would provide a conservative estimate for future background, assuming the trend continues. Where strong positive or negative trends are identified, the historical data could be scaled to account for future changes, for example by the estimated % change per year. The analysis is presented for other pollutants and OEH monitoring sites is in **Appendix 2**.

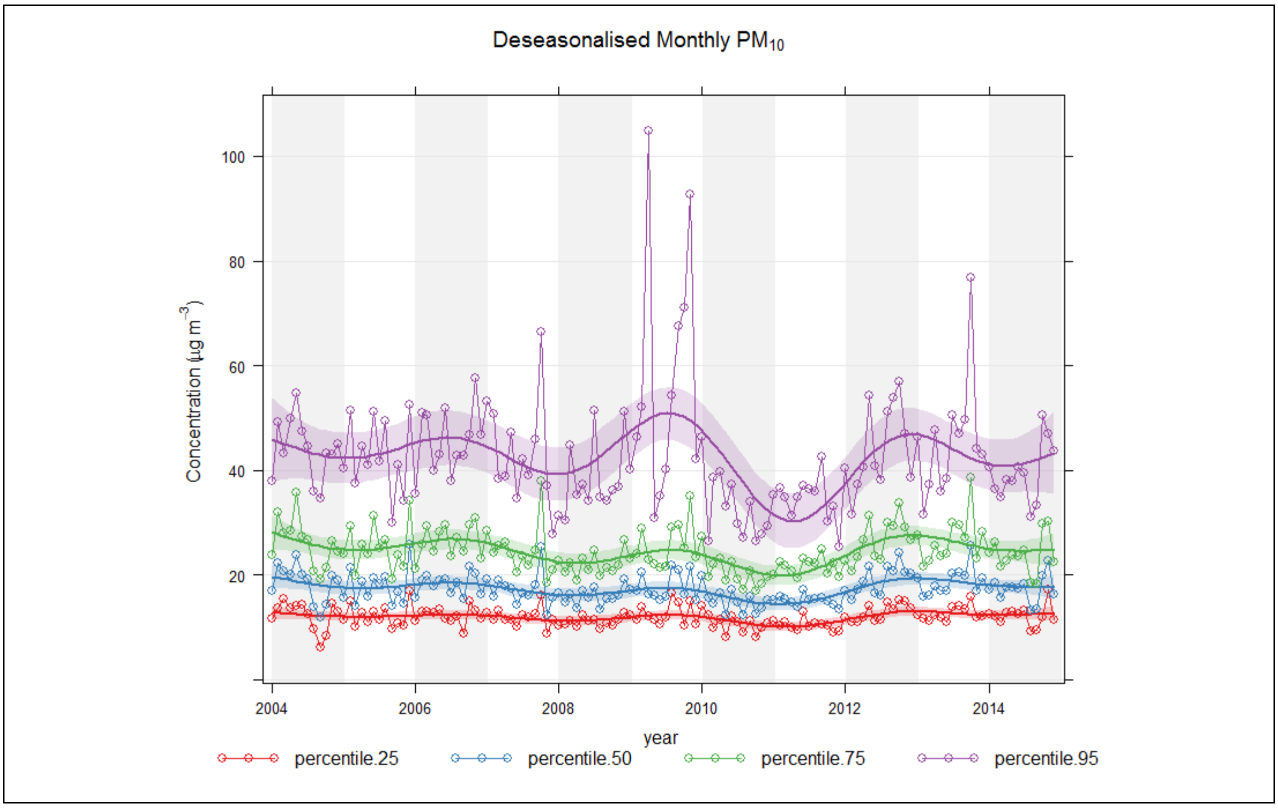


Figure 9-1: Monthly mean PM_{10} concentration at Beresfield with 95% confidence limits

Plotted using the openair smoothtrend function

[21] The Theil-Sen function calculates the slopes for all pairs of data points and estimates the slope based on the median of all slopes. It can provide accurate confidence intervals even with non-normal data and is resistant to outliers (Carslaw, 2015; Carslaw and Ropkins, 2012).

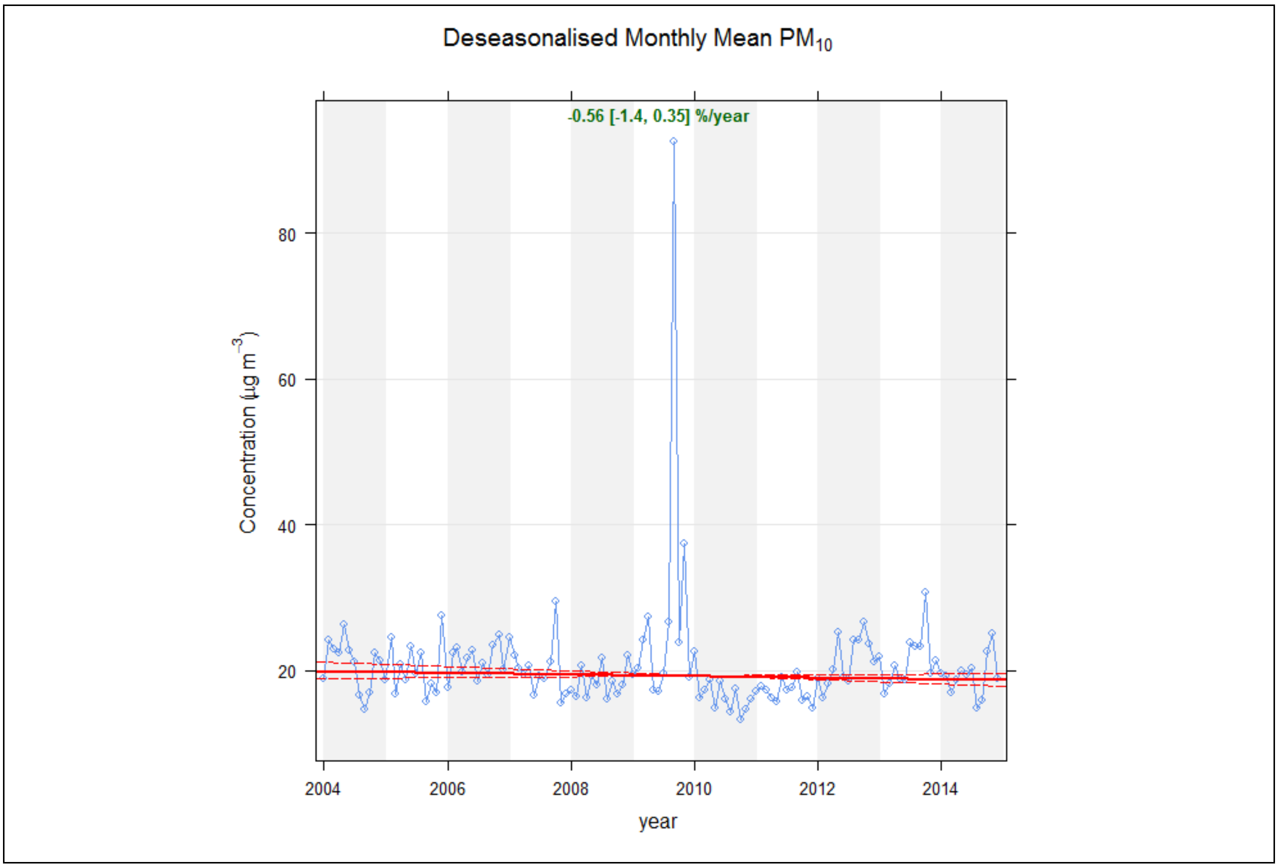


Figure 9-2: Trend in monthly mean concentration showing % change per year with 95% confidence limits

[1] Plotted using the openair TheilSen trend function

As discussed in **Section 6.1.4**, the US EPA Guidance on Air Quality Models suggests that seasonal (or quarterly) pairing of monitored and modelled concentrations is sufficient to address situations where impacts from modelled emissions are not temporally correlated with background levels.

An analysis of time varying PM concentrations for a rural and urban site is presented in **Figure 9-3**, showing hour of the day, month of the year and weekday variation. The analysis is useful to inform how temporal variation in background might relate to modelled source contribution.

It is clear from the hour of the day analysis that three separate peaks occur in PM_{10} concentrations at the urban site (Liverpool). These are probably caused by morning and afternoon peaks in traffic, with the evening peak most likely attributed to wood heaters. The morning and evening peak are also evident in the $PM_{2.5}$ concentrations, but not the afternoon peak. At the rural site (Tamworth) the morning and the evening peak occur in PM_{10} concentrations but the afternoon peak is not evident. The evening peak in PM_{10} concentration is higher than the urban site, which is the only time of the day that this occurs. For the rural site, both the morning and evening peak may be caused by wood heaters. There is also clear seasonal (or monthly variation) seen in the data. PM_{10} concentrations are generally higher in summer and lower in winter for both urban and rural sites, while the opposite occurs for urban $PM_{2.5}$ concentrations (which are higher in winter).

Therefore, as indicated by the US EPA, temporal variation should be considered depending on the source being modelled. In some cases, seasonal (or quarterly) pairing of monitored and modelled concentrations might be suitable, however if you are modelling a source that is correlated temporally with background (i.e. traffic sources in an urban area) it may be more appropriate to pair hourly monitored and modelled concentrations.

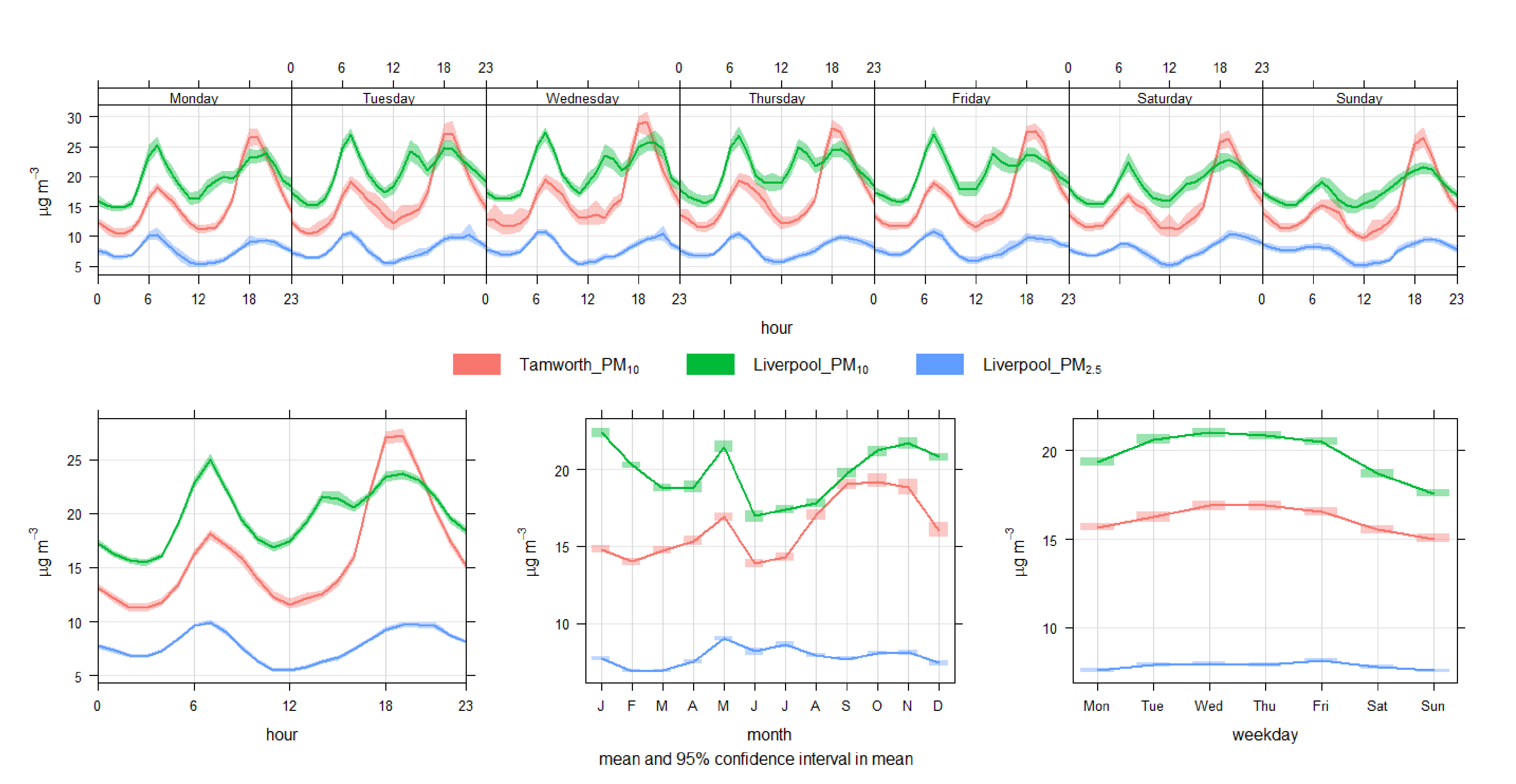


Figure 9-3: Time variation in ambient PM concentrations - rural and urban sites

9.2.2 Analysis of spatial variation

To understand the relationship between PM_{10} measured on a regional scale, a correlation matrix is established to compare PM_{10} concentrations across OEH sites for each region. The data are presented visually as an Openair "corPlot" fuction, showing the correlation coded by shape, colour and numeric value. The ellipses can be thought of as visual representations of scatter plot (the more elliptical, the better the correlation while a circle shows no correlation) and the number represents the correlation coefficient (Carslaw, 2015).

Figure 9-4 shows the correlation across sites in Sydney northwest. Two plots are shown, one with all available 24-hour PM_{10} concentrations and another with the highest values 24-hour PM_{10} concentrations removed. By removing the peak 24-hour PM_{10} concentrations, the correlation between sites drops but all sites remain strongly correlated, indicating spatial homogeneity in ambient PM_{10} concentrations for the region.

A different picture is seen for rural sites (**Figure 9-5**). On the left panel, the strong correlation between Tamworth and Bathurst is influenced by a single very high 24-hour PM_{10} concentration in September 2009. By passing a line of fit through this outlier, the correlation is magnified (r^2=94). The right panel shows the correlation drop significantly (r^2=54) by removing this (and other) a few other peak concentrations.

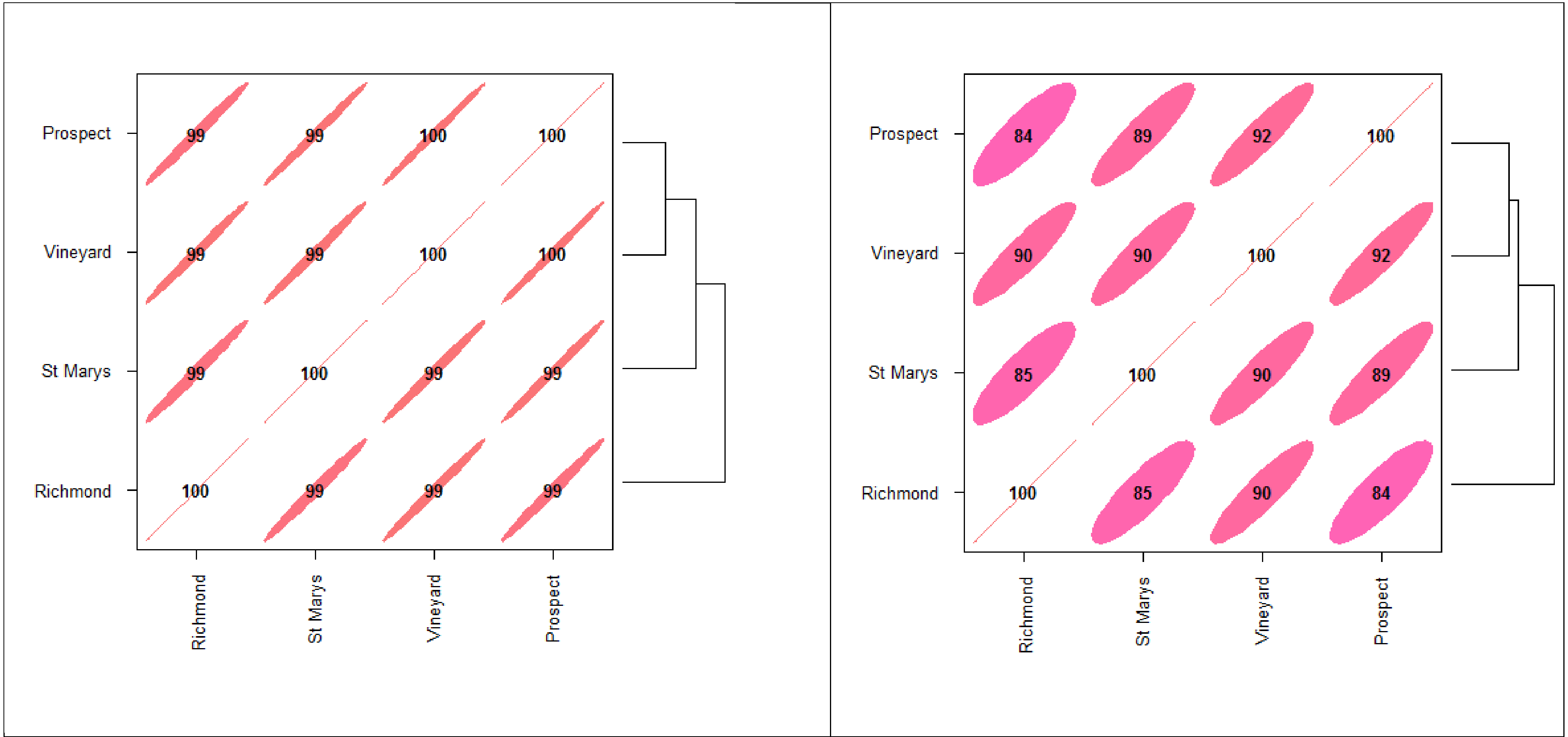
On the other hand, the correlation between Wagga Wagga and Albury is mostly unaffected by removing peak concentrations. This is mainly because the very high peak in September 2009 was not recorded at this sites. It is clear, nevertheless, that some degree of spatial homogeneity in ambient PM_{10} concentrations occurs for certain clusters of the rural monitoring sites.

Analysis is presented for other sites in **Appendix 4**. For each plot, the peak concentration occurring in September 2009 is removed. In Sydney central-east region, all sites are strongly correlated, while in Sydney southwest a number of sites are strongly correlated. It is noted that sites that are less correlated have a shorter record of data. For the Hunter, sites in the Lower Hunter are strongly correlated while sites in the Upper Hunter are less so. The correlation between Singleton and Camberwell is much stronger than with Muswellbrook and both sites are also more strongly correlated with Beresfield than with Muswellbrook.

The analysis demonstrates that strong patterns exist in PM_{10} concentrations across the different regions and derivation of a regional specific background, for data sparse area, may be possible.

In rural areas of NSW, with limited background, default values could be specified, similar to the approach for US EPA permitting, where appropriate background values are provided by the state regulators. This has the advantage of providing a consistent and objective background value for use in air quality assessment (for example where no local data are available).

Care should be taken to remove exceptional events, as extremely high peak concentrations can magnify the correlation between sites. Similar analysis can be presented for seasonal variation which may be useful to inform temporal variation in 24-hour PM_{10} concentrations. The analysis could also be improved with the inclusion of all available industry monitoring data.



All available 24-hour PM_{10} concentrations	Days with high 24-hour PM_{10} concentrations removed

Figure 9-4: Correlation matrix of 24-hour average PM10 concentration with hierarchical cluster analysis in Sydney northwest

Plotted using the openair corPlot function

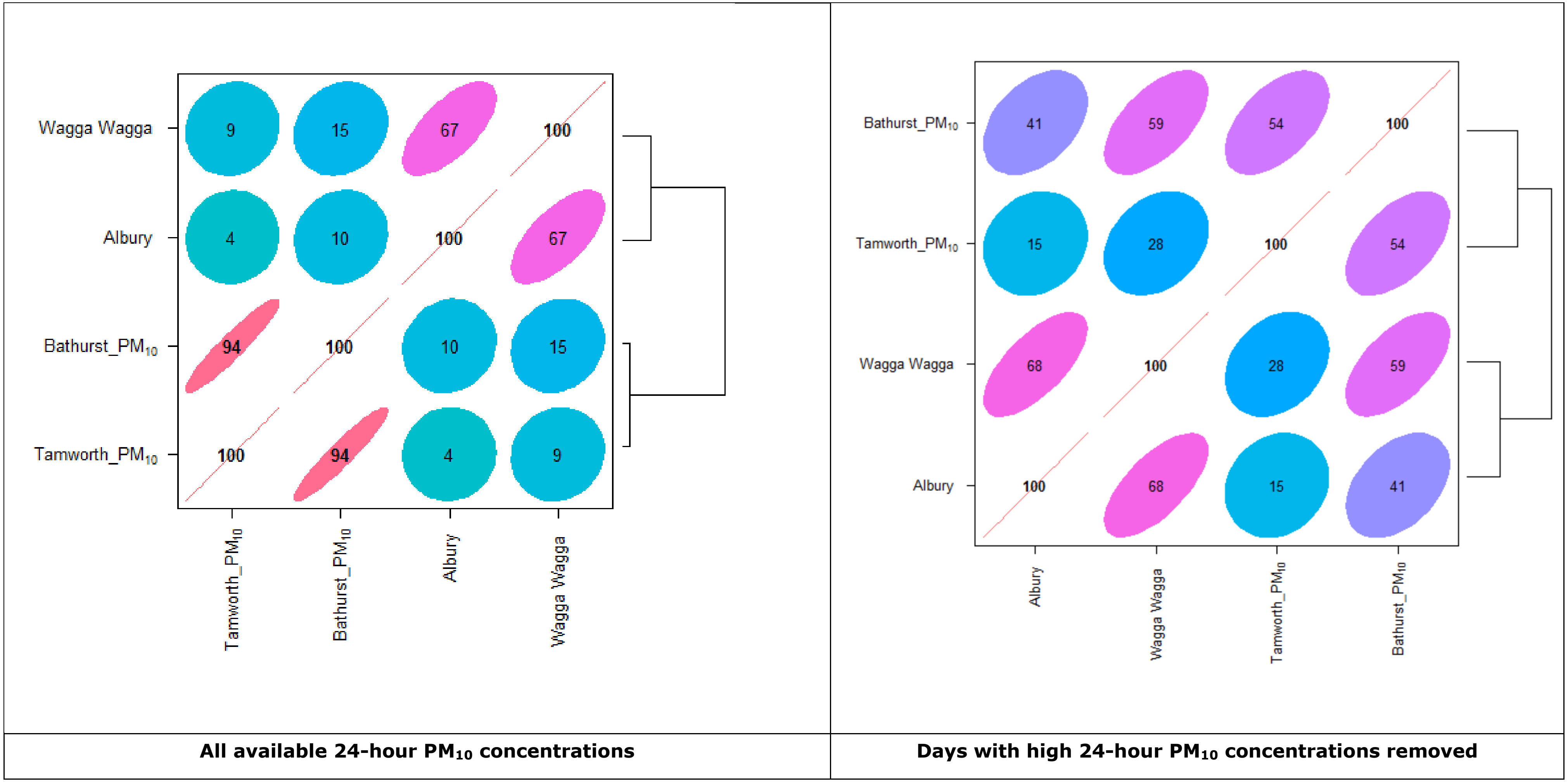


Figure 9-5: Correlation matrix of 24-hour average PM10 concentration with hierarchical cluster analysis in rural NSW

SUMMARY / RECOMMENDATIONS

Incorporating background

- Based on the trend analysis presented in **Appendix 2**, ambient concentrations of most pollutants in NSW[1] are declining and historical data are likely to be conservative for describing future background. Where analysis indicates that ambient concentrations may be increasing, this could be considered in detailed cumulative assessment if significant, for example with reference to a percentage change per year. Future changes to local air quality due to other future sources (direct or indirect) should be considered, if relevant, through the dispersion modelling for reasonably foreseeable or committed development.
- It is recommended that multiple years of data (3-5) are used to describe background in cumulative assessment, to account for inter-annual variation due to climate effects. This recommendation is mainly for PM and multiple years of data are not necessarily required for other pollutants.
- For tier 2 detailed cumulative assessment, involving modelling other significant local sources, it is recommended that a suitable 'distant' background site is selected to describe regional background for other non-modelled sources. For example, a rural monitoring site that is located at significant distance from local sources, such that the site is not significantly influenced. This is to avoid double counting of existing sources within local (i.e. industry operated) air quality monitoring data.
- For "tier 1" cumulative assessment, where other local sources are not explicitly modelled, the background sites should be the closest upwind and / or the most representative background site. The selection of background (local or distant sites) should attempt to eliminate or reduce the source-oriented impacts from nearby sources to avoid potential double counting.
- To demonstrate that a site is representative, analysis of spatial variation should be presented (such as described in **Section 9.1**), as well as discussion of influencing factors such as comparable land use, similar local emissions sources, similar population density etc.
- Where a background year is significantly influenced by bushfire events or dust storms, the median value may be a better statistical descriptor than the mean for describing background (refer to example in **Figure 3-2**). Alternatively a quantitative analysis of the background data should be used to justifiably remove these events from background data.

9.3 Short term averaging periods

As described in **Section 5** and **Section 6**, the most commonly applied approach to short term cumulative assessment in other jurisdictions is the application of percentiles or average values, applied to background data and modelling predictions, and combined to describe cumulative impact.

Probabilistic methodologies do not appear to be commonly applied in other jurisdictions (based on the questionnaire response provide in **Appendix 5**), however they have been recently used in NSW to estimate the risk of additional exceedances of the short term average impact assessment criteria (refer **Section 4.5**). A probabilistic approach, such as a Monte Carlo simulation, is useful in that it avoids using an average (or percentile) value in situations where there is a degree of uncertainty in an outcome.

Dispersion models are less accurate at predicting concentrations over short term averages than for longer time periods (e.g. annual averages). For short term averages, the magnitude of the highest concentration across time and space (i.e. the highest concentration occurring sometime and someplace within the modelling domain) might be reliable, however, more uncertainty arises in trying to predict a given concentration at a given point in time and space an (US EPA, 2005).

Therefore, combining a short term modelling prediction with time matched daily or hourly background incorporates a degree of inherent uncertainty that might be better described using s probabilistic approach.

DEFRA (2009)[22] also recognises this and in particular notes that dispersion models are inherently less accurate at predicting the number of exceedances of the 24-hour mean PM_{10} objective than for the annual mean objective. In response they developed a relationship between number of 24-hour PM_{10} exceedances and the annual mean, which they recommend for evaluating future impacts. Similarly, in the UK, short term impact assessment is typically described through the use of percentiles or relationships between short term averages and annual means. Analysis is presented in **Section 9.3.1** showing how these relationships might look for PM monitoring data in NSW.

A probabilistic risk based approach, as an alternative, is described and evaluated further in **Section 9.3.2**.

9.3.1 Percentiles and relationships between short term concentrations and annual means

The UK Environment Agency recommends that short-term concentrations are described on the basis of twice the annual mean and this approach is used for 1-hour NO_2 and 24-hour PM_{10} when assessing industrial emissions sources.

Figure 9-6 presents an analysis of the relationship (ratio) of various percentile values to annual mean concentrations. The mean and percentile calculations are based on the 10 years of daily PM_{10} concentrations (not annual periods) at all OEH monitoring sites and presents the minimum, average and maximum ratio across all sites. For example, the average ratio (across all sites) of the 50^{th} percentile (the median) to the annual mean approaches 1, as expected.

The data shows that twice the annual mean (ratio of 2) corresponds to somewhere between the 95^{th} and 98^{th} percentile for 24-hour PM_{10} and is therefore likely to provide a reasonable conservative estimate of short-term PM_{10} concentration.

Various jurisdictions use percentile values to describe short term background concentrations, usually at a value higher than 90^{th} percentile. The data presented in **Figure 9-6** suggests that the use of twice the annual mean for background PM_{10} in NSW would be, in most cases, be more conservative than the use of a percentiles value less than the 98^{th} percentile.

However, adopting either twice the annual mean or a high percentile for background is likely to result in exceedances of the short term criteria for PM in some areas of NSW and may provide too conservative an assessment of cumulative project risk.

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[22] Section 2.36 of DEFRA (2009)

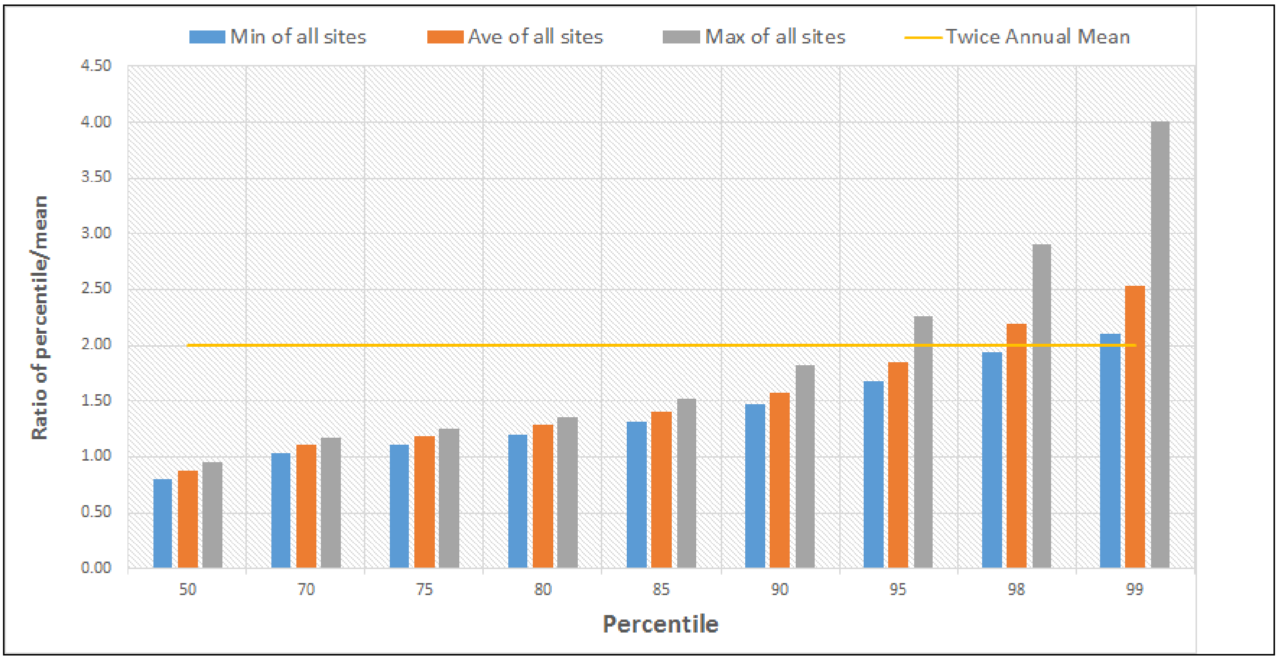

Figure 9-6: Ratio of percentile values to annual mean across all OEH monitoring sites

DEFRA in the UK also describe a relationship between annual mean and the number of exceedances of short term standards. For example, DEFRA (2009) suggests that exceedances of the 1-hour NO_2 goal are unlikely if the annual mean NO_2 concentration is less than 60 µg/m³.

This relationship is difficult to evaluate for NSW as there has been no exceedances of the 1-hour NO_2 criteria at OEH monitoring stations over the past 10 years and annual average NO_2 concentrations are typically less than 30 µg/m³. It is noted, however, that OEH do not operate roadside monitoring stations, where concentration of NO_2 are likely to be highest and where the biggest NO_2 issues occur in the UK. The absence of exceedances of the 1-hour goal (and corresponding low annual average concentrations) are indicative of areas of general population exposure, not hot spots such as near major roads.

For assessment of 24-hour PM_{10} exceedances DEFRA (2009) recommends that the modelled annual mean is used to estimate number of exceedances, based on their prescribed relationship. **Figure 9-7** and **Figure 9-8** present an analysis of the relationship between annual man PM_{10} concentrations and the number of recorded exceedances, based on 10 years of data recorded at OEH monitoring sites.

Figure 9-7 shows the relationship for combined data from all sites and **Figure 9-8** shows the relationship for data from rural sites. For the rural sites only, the relationship becomes more defined and annual mean concentrations below 20 µg/m³ generally correspond to less than 5 exceedances per annum.

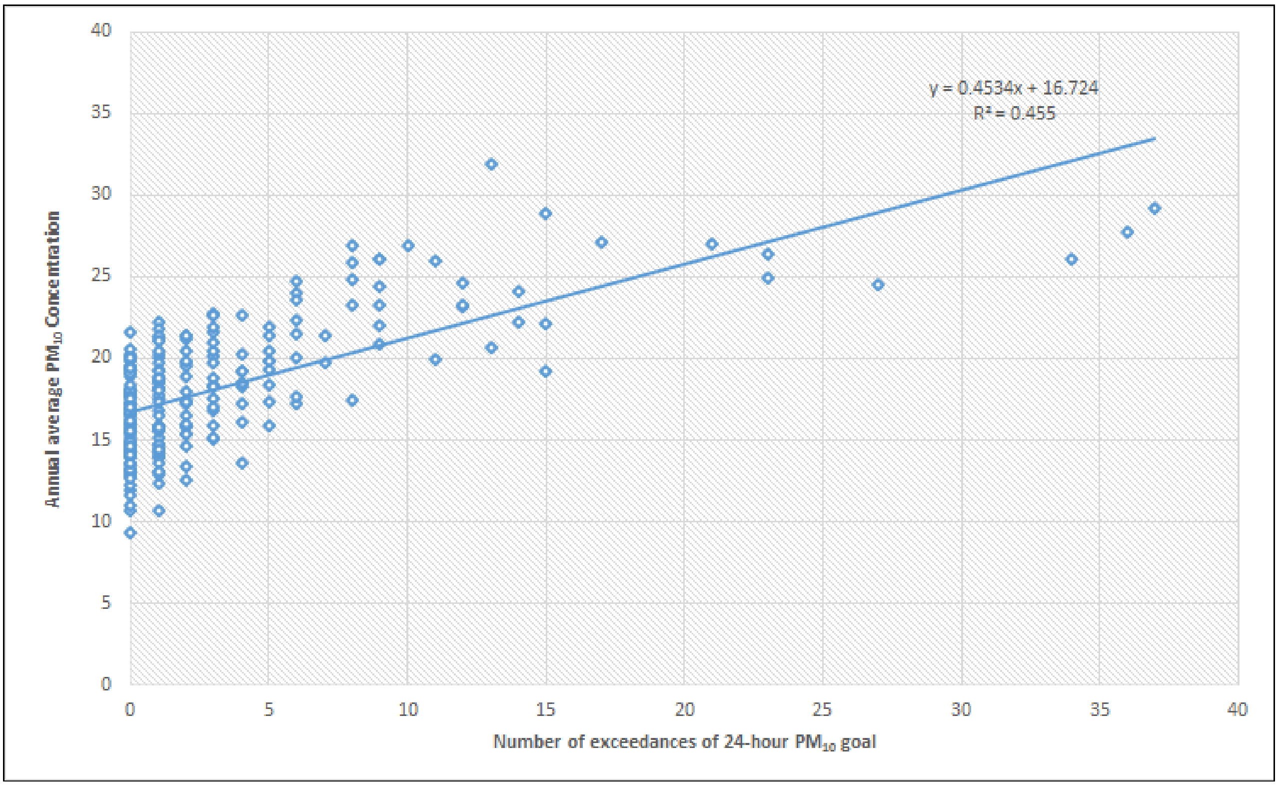

Figure 9-7: Relationship between annual mean and number of exceedances for all sites

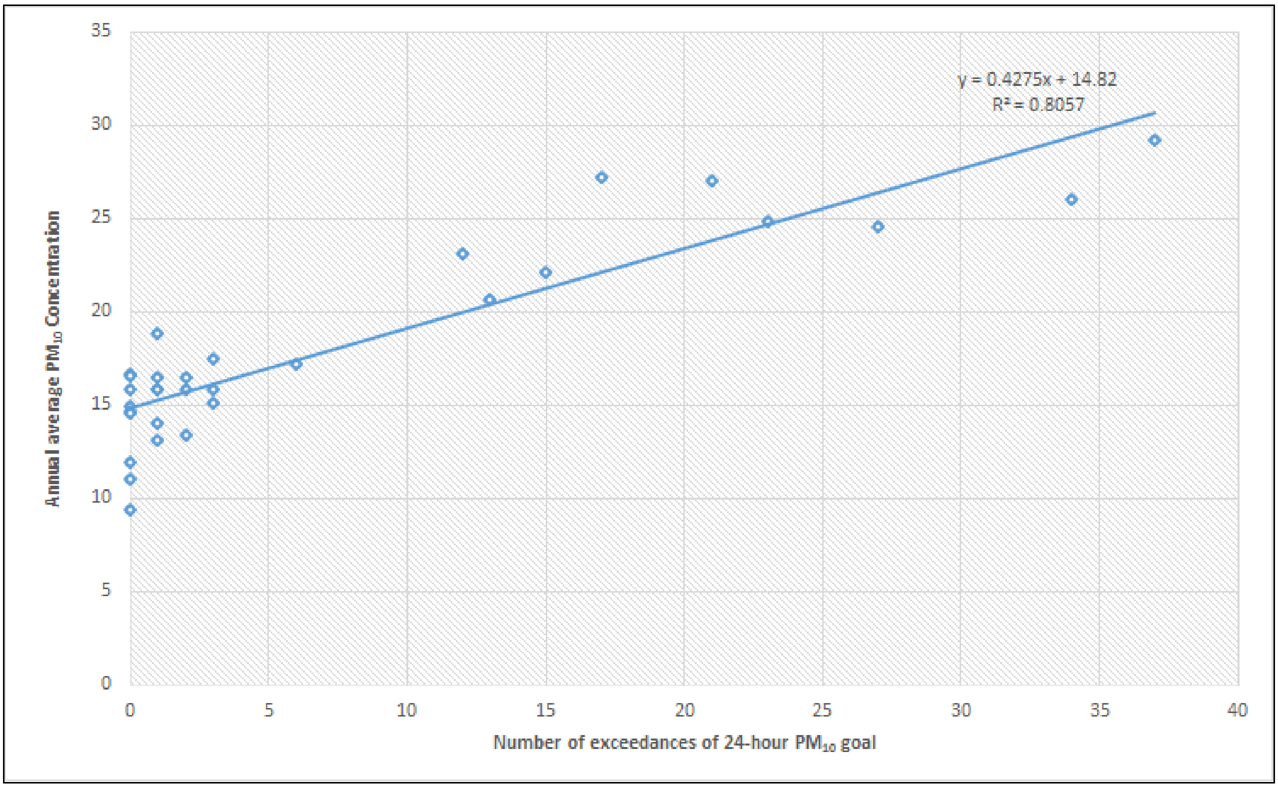

Figure 9-8: Relationship between annual mean and number of exceedances for rural sites

9.3.2 Probabilistic methodologies

The probabilistic approaches to cumulative PM_{10} concentration described in **Section 4.5** are compared and evaluated for two case studies, as follows:

- Case study 1: Project with a large predicted incremental PM_{10} in a remote area.
- Case study 2: Project with a small predicted incremental PM_{10} in the GMR.

Two approaches are evaluated, referred to as the "all combinations" and the "Monte Carlo simulation" approach. Multiple years of background data from multiple sites are used in the analysis, and for the "all combinations" approach each predicted (modelled) concentration is combined with every available background concentration. The "Monte Carlo simulation" approach combines a randomly selected percentile from the background dataset with a randomly selected percentile from the modelled dataset. Both approaches remove the time and space uncertainty in modelling predictions.

The "Monte Carlo simulation" creates a new distribution for the background dataset. **Figure 9-9** compares an actual PM_{10} dataset (top panel) with a simulated Monte Carlo dataset (bottom panel). The simulated Monte Carlo dataset is created using actual data, re-distributed uniformly based on the random function in excel.

The timeseries (on left) shows that for the Monte Carlo dataset gaps in the data are removed and that some of the variability, for example seasonal variation, is lost. However, the minimum, maximum, mean, median and percentile values are the same between the two datasets (note, there is no y axis scale so the absolute values cannot be compared). The histogram (on right) shows that the distribution of the two datasets is very similar and with enough repetitions (in this case over 40,000) a randomly generated background distribution mirrors the actual dataset.

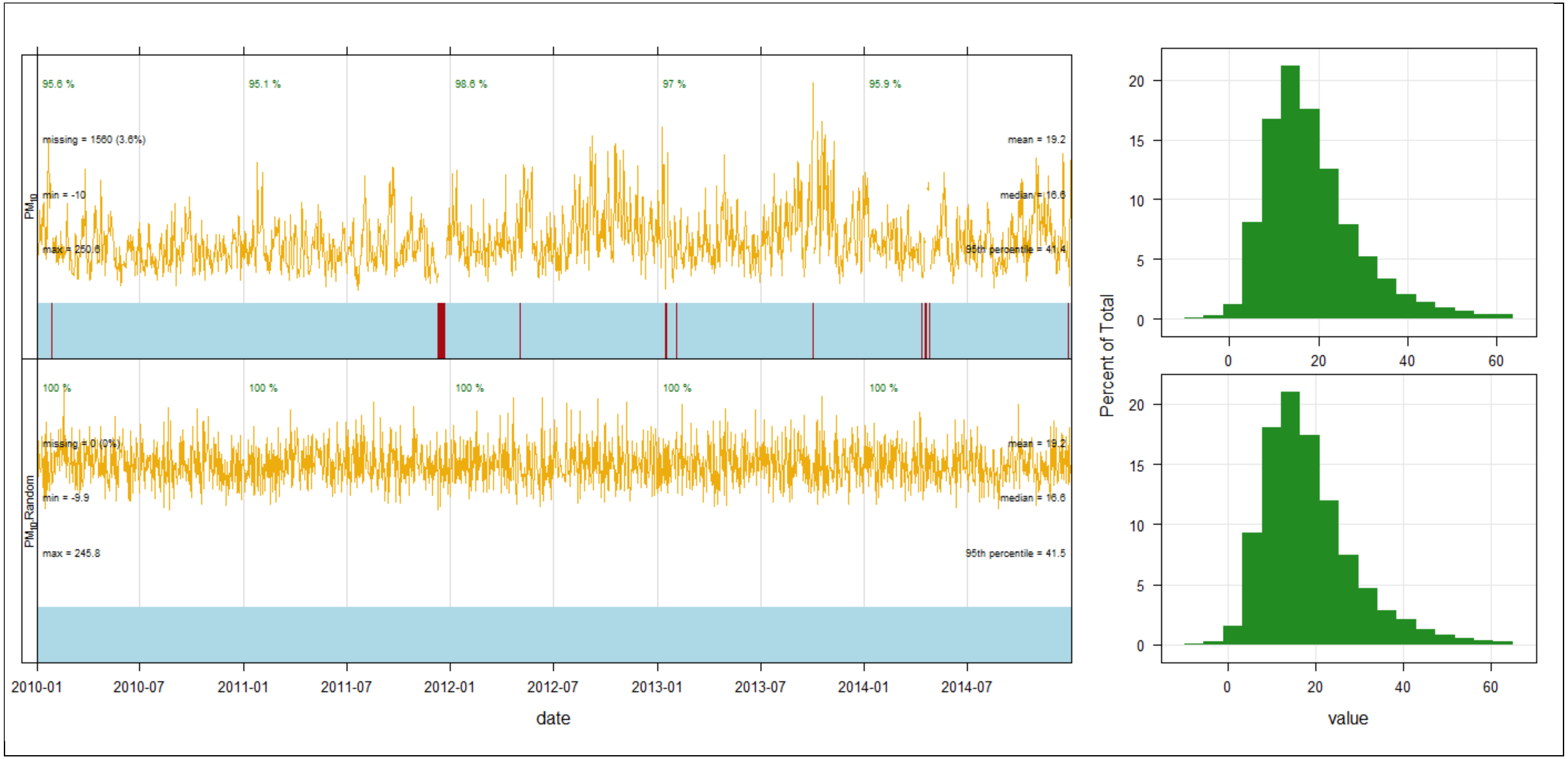

Figure 9-9: Comparison between actual PM_{10} data (top panel) and a Monte Carlo simulated dataset (bottom panel)

Case study 1

A frequency distribution of cumulative PM_{10} predictions for case study 1 is presented in **Figure 9-10**, comparing cumulative predictions using both the "all combinations" approach and the "Monte Carlo simulation". Both approaches use almost 7,000 days of background data (5 years of data from 3 different sites). These approaches are compared with the Level 2 assessment approach, which is applied using 1 year of data from the background dataset. 2009 is selected as the single year because it has a number of existing exceedances.

Figure 9-10 shows a frequency distribution for:

- Background – all available data.
- Background – 1 year for Level 2 assessment.
- Cumulative – using Level 2 approach.
- Cumulative – using all combinations approach.
- Cumulative – using Monte Carlo approach.

The frequency of concentrations above 50 µg/m³ for the single year of background is higher than the all available dataset, because the single year is 2009 with a significantly higher frequency of exceedances. The frequency of cumulative concentrations above 50 µg/m³ is therefore also higher for the single year of background. The analysis can be expressed as the frequency of time that additional concentrations above 50 µg/m³ are likely to occur, and in this way estimate the likelihood of additional days above 50 µg/m³.

It is noted that the all combinations and the Monte Carlo simulation approach produce over 2.5 million combinations of possible outcomes (of background plus increment), compared to 365 possible combinations for the Level 2 approach.

For this example, the frequency of time that additional concentrations above 50 µg/m³ are likely to occur is similar for the all combinations approach and the Level 2 approach and slightly less frequent for the Monte Carlo approach.

The number of days greater than 50 µg/m³ is 21 for the all combinations, compared to 12 for the "normalised" background (i.e. the 6992 background days divided by 237 exceedances times 365). The number of days greater than 50 µg/m³ is 18 for the Monte Carlo simulation.

The number of days greater than 50 µg/m³ is 34 for the Level 2 approach, compared to 21 for the background dataset (Wagga Wagga in 2009).

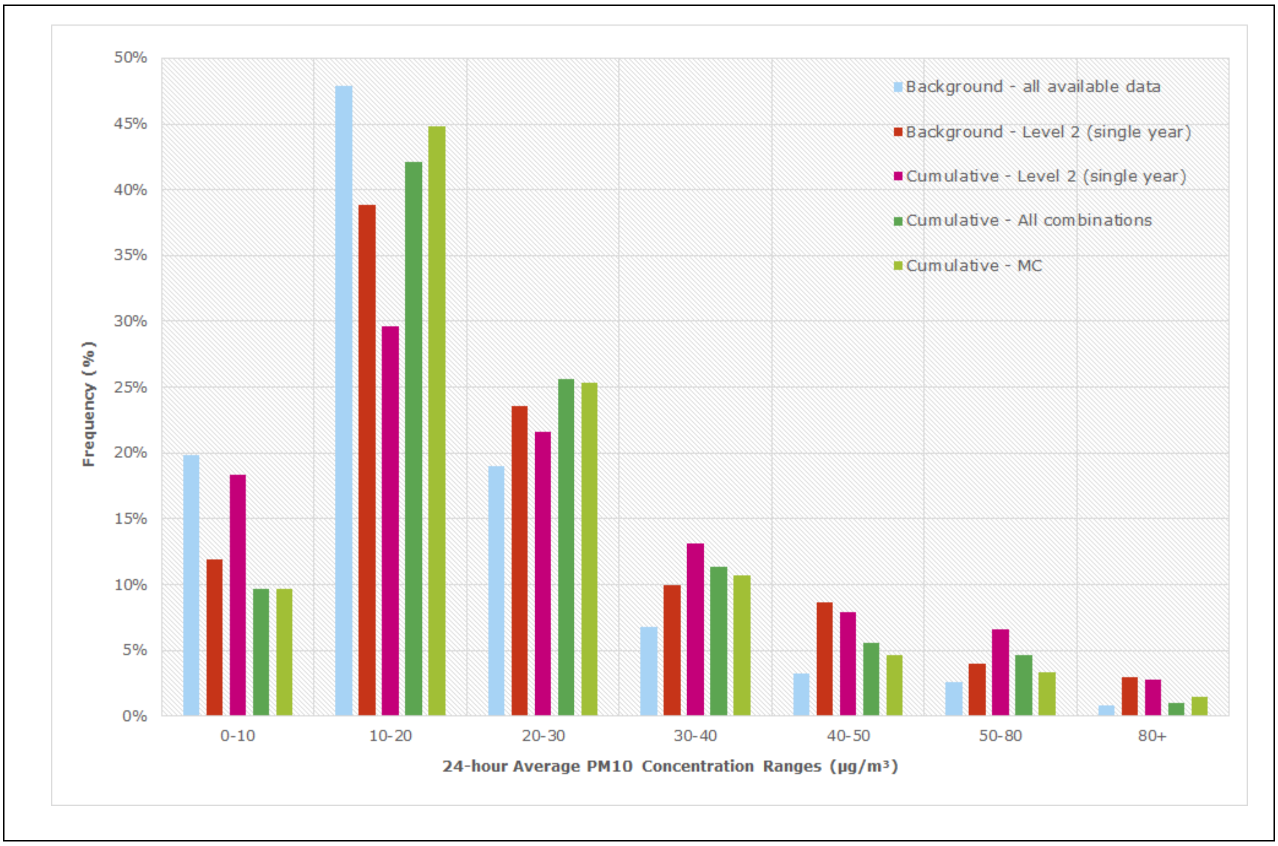

Figure 9-10: Case study 1 – frequency distribution of cumulative PM_{10} concentration using different approaches

For the second case study, relatively small incremental concentrations are combined a background dataset containing three years of daily values (2011 – 2013). The "all combinations" approach and the "Monte Carlo simulation" are compared with the Level 2 assessment approach, which is applied using 1 year of data from the background dataset (2013). Both the "all combinations" and the "Monte Carlo simulation" produce approximately 400,000 possible combinations, compared with 365 for the Level 2 approach.

Both background datasets (3 years and 1 year) contain three days where the 24-hour average PM_{10} concentration is greater than 50 µg/m³ (because all days are during 2013). The frequency distribution is presented in **Figure 9-11**, showing that when additional background years are included in the analysis the influence of a single higher background year (2013) is reduced.

For example, the number of days greater than 50 µg/m³ is 1.03 for the all combinations, reflecting the "normalised" background (i.e. the 1067 background days divided by 3 times 365). The number of days greater than 50 µg/m³ is 0.7 for the Monte Carlo simulation and for the Level 2 approach is 3 (as expected).

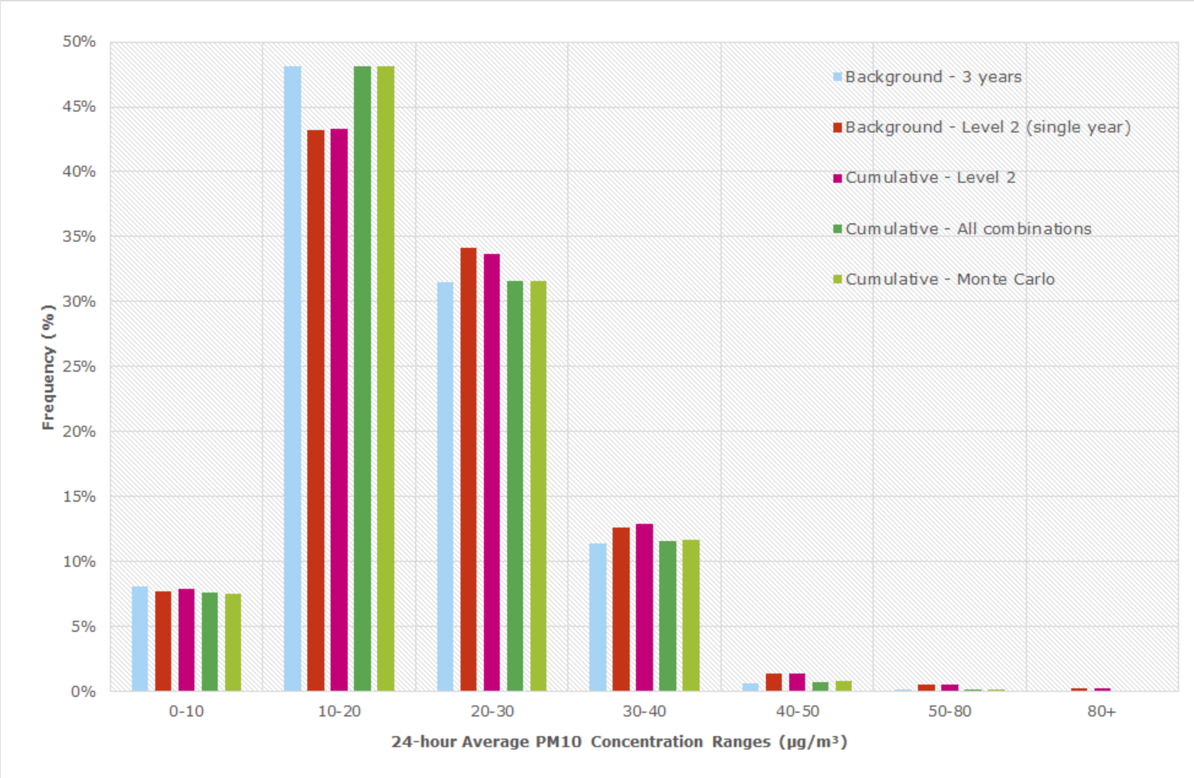

Figure 9-11: Case study 2 – frequency distribution of cumulative PM_{10} concentration using different approaches

In both case studies presented above, the analysis is done using relatively straightforward spreadsheets in excel. There are a number of proprietary software packages that can be purchased to perform Monte Carlo analysis, however for the purposes of a probabilistic determination of cumulative frequency distribution, excel can also be used. For example, the "all combinations" approach uses a matrix in excel, with modelled predictions presented in a row and background presented in a column, allowing all possible combinations to be quickly calculated. For the "Monte Carlo simulation" the same approach is used except instead of simply combining all values, a random percentile from each dataset is selected and combined.

The more years of the background data used, the greater the number of combinations available for the probabilistic analysis. For example, in case study 1, 5 years of data from three different sites produces 2.5 million combinations. For case study 2, three years of data from a single site produces 400,000 combinations. It is likely that computation limitations would limit the random percentile approach in excel to datasets similar in size to the case studies presented above. For example, case study 1 might only be possible on a relatively powerful desktop computer. This is because the percentile and random functions used will continuously re-calculate new values, and for large numbers of combinations, computational restrictions may occur.

SUMMARY / RECOMMENDATIONS

Short-term assessment

If the number of additional days above the criteria is the critical factor when assessing compliance with the 24-hour average impact assessment criteria, rather than the absolute cumulative short term concentration, then a probabilistic risk based approach is recommended as a suitable approach.

The advantages include:

- Removes some of the uncertainty involved in dispersion modelling predictions in time and space.
- Can remove the influence of a single year of high (or low) background.
- Allows for multiple years of background data from more than one site to be included in the analysis.
- Avoids the use of a single average or percentile value to describe a relatively uncertain outcome.

9.4 Significant impact levels

The pathway to cumulative assessment presented in **Figure 8-1** recommends a preliminary impact determination to screen for significance and determine the need for cumulative impact assessment. Appropriate significant increment levels (SILs) would need to be established for implementation in NSW.

For PSD permitting in the US, absolute concentrations are prescribed. For example, 1 µg/m³ is prescribed for annual mean PM_{10}, SO_2 and NO_2, while a SIL of 5 µg/m³ is prescribed for 24-hour PM_{10}. In the UK, screening increment levels are prescribed based on a % of the goal, 1% for annual and 10% for 24-hour. For PM_{10}, this equates to 5 µg/m³ for 24-hour averages and 0.3 µg/m³ for annual averages. DEFRA, in developing nomograms for screening assessment in local air quality management, use an increment of 1 µg/m³ for annual and 90^{th} percentile 24-hour average PM_{10}.

The Australian / New Zealand Standards for sampling of ambient air (the AS/NZ 3580 series), report various uncertainty and precision levels associated with PM_{10} monitoring techniques, which could also be used to inform a significant impact level. For example, if you cannot measure a value with certainty, how can you determine significance? The AS/NZ 3580.9.6:2003 (high volume air sampler) reports typical measurement precision of 5 µg/m³ for 24-hour average PM_{10}.

Similarly, AS/NZS 3580.9.9:2006 (low volume sampler) reports a measurement uncertainty of +/- 5 µg/m³. AS3580.9.8-2008 (TEOM) reports a precision of +/- 2%.

It is also important to consider where the SIL applies, for example at an existing sensitive receptor or at or beyond the fence line. Applying the criteria at or beyond the fence line would be more flexible, for example by allowing for future potential sensitive receptors and avoid the ambiguity sometimes encountered in defining what sensitive receptors, for example private but unoccupied land.

SUMMARY / RECOMMENDATIONS

Significant impact levels

If a procedure for significance screening is adopted for NSW, it is suggested that additional consideration is needed to derive suitable SILs, where they should be applied and the appropriate form (i.e. percentile based or maximums for short term averages).

9.5 Inclusion of other local sources in modelling

Modelling other local sources is recommended for detailed cumulative analysis. In situations where extensive local monitoring networks are available to describe background, there may be future changes to local emissions sources which require consideration in modelling.

A suitable approach to guide what sources are included in the modelling is to define an area of interest (AOI) based on modelling for the facility alone (as part of the preliminary impact determination). The AOI, for example, would be established for all locations where the facility alone results in ground level concentrations above a determined significant impact level.

Modelling of other local sources is common in AQIA for mines in the Upper Hunter Valley. For example, the AQIAs reviewed in **Section 4.1** modelled other mines within a radius of approximately 17 km (PEL, 2014; TAS, 2014a). It is not possible to determine from these AQIAs whether an AOI defined on the basis of a nominal SIL (such as 1 µg/m³ for annual average PM_{10}) would be suitable for cumulative assessment as contour plots at this level are not presented.

The AQIA for the Drayton South project (PEL, 2015), however does show incremental contour plots at the 1 µg/m³. Assuming a SIL at this level was used to define an AOI, only 1-2 other mines would be included in this modelling, compared to the 5 other mines that were actually included in the assessment. It is noted, however, that the modelling in PEL (2015) used a model calibration grid to scale the modelling results and this scaling may have reduced the 1 µg/m³ contour by up to 50%.

If a significance screening SIL is derived for application beyond the fence line (as opposed to at sensitive receptors) the use of the same SIL to define an AOI may not be appropriate. There are also likely to be situations where a major emissions source falls outside an AOI and a degree of common sense would need to apply in this instance.

It is recommended that further consideration is applied to defining an AOI, assuming that significance screening and SILs are adopted for NSW. Alternative methodologies for incorporating other sources, such as the ratio of emissions to distance method (Q/D method) could be used if an AOI approach is ruled out.

SUMMARY / RECOMMENDATIONS

Including other sources in modelling

- Further investigation of the AOI methodology if significance screening and SILs are adopted for NSW.
- Consideration of other methodologies, such as the ratio of emissions to distance method (Q/D method) could be used is an AOI approach is ruled out.

9.6 Case study to test cumulative assessment process

The following case studies are presented to evaluate the applicability of the proposed pathway and framework for cumulative assessment.

ENVIRON recently completed an air quality impact assessment for an intermodal facility in Moorebank, Western Sydney (ENVIRON, 2015). The AQIA included an assessment of emissions from diesel locomotives, container handling equipment and on-road trucks servicing the facility.

The closest air quality monitoring station to the facility is the Liverpool OEH site and based on review of baseline air quality presented in the AQIA, it is likely that the area would be defined / classified as an airshed management area. For example, exceedances of air quality standards were recorded in each of the prior 5 years (for ozone and PM) and annual average $PM_{2.5}$ is above the NEPM advisory reporting standards. In this instance, cumulative impact assessment would be automatically required and this is probably the desired outcome.

Notwithstanding an automatic trigger for cumulative assessment, modelling predictions (for PM) are reviewed to determine if the project increment would be considered significant. The following nominal SILs are selected:

- 5 µg/m³ for 24-hour average PM_{10} and 1 µg/m³ for annual average PM_{10}.
- 1.2 µg/m³ for 24-hour average $PM_{2.5}$ and 0.3 µg/m³ for annual average $PM_{2.5}$.

Based on a review of the modelling results for project increment, the SILs, if applied at the nearest existing sensitive receptor, would not be triggered and a cumulative impact assessment would not be required. However, if applied at and beyond the site fence line, a cumulative impact assessment would be triggered for each of the SIL. Again, this is probably the desired outcome in this case.

Cumulative results are also presented in the AQIA by combining modelling predictions with monitoring data from the Liverpool OEH station, equivalent to the tier 1 cumulative assessment process described in **Figure 8-2**. The highest cumulative annual average PM_{10} concentration (at a sensitive receptor) is approximately 69% of the impact assessment criteria. Under the framework proposed in **Figure 8-2**, no additional (detailed) cumulative assessment would be required for PM_{10}.

For $PM_{2.5}$, additional detailed cumulative assessment would be required, assuming the NEPM advisory reporting standard are used as impact assessment criteria. In this case, additional assessment would not add value as the background is already 95% of the standard. This is likely to be the case for the assessment of $PM_{2.5}$ in a number of areas of NSW and would require special consideration in a proposed cumulative assessment framework, assuming the proposed national standards are adopted for impact assessment in NSW.

10. CONCLUSION

Methodologies for cumulative air impact assessment in other jurisdictions have been reviewed and evaluated to determine feasibility for implementation in NSW. The review of methodologies was based on recent air quality impact assessment, guidance documentation and regulatory frameworks for air quality management in other jurisdictions. An evaluation of some of the key features is presented based on criteria including broad application, objectiveness, conservativeness, consistency and feasibility for implementation in NSW.

One of the outcomes of the review identified that some of the challenges faced in NSW are common to many other jurisdictions, and have not necessarily been resolved. For example, these include describing background for cumulative impact assessment and dealing with short term averaging periods. Nevertheless, common themes were identified in the jurisdictional review, some of which have been used to develop a proposed framework for cumulative air impact assessment in NSW. The proposed framework introduces the concept of airshed management, where requirements for cumulative assessment are more detailed. Also introduced is the concept of screening for significance, which can be used, outside of airshed management areas, to screen new emissions sources for risk. Screening for significance is particularly useful for situations where background monitoring data are unavailable for cumulative assessment and detailed cumulative modelling is not warranted due to low project risk.

RECOMMENDATION

Framework for cumulative impact assessment
A framework for cumulative impact assessment is recommended which incorporates:

- The concept of airshed management areas, identified based on attainment or nonattainment of air quality goals.
- A preliminary impact determination to screen for significance and determine the need for cumulative impact assessment.
- A tiered cumulative impact assessment process for sources identified as significant or located within an airshed management area.

For new emissions sources that are shown to be significant (or located in airshed management areas) cumulative impact assessment would be required. Depending on the level of complexity and/or risk, cumulative impact assessment should consider a combination of the following aspects:

- Direct change caused by a proposed action or emissions source.
- Other local sources of emissions.
- Existing background or baseline from other sources.
- Reasonably foreseeable future emission sources.
- Potential indirect or induced effects that might flow on from the proposed action.

A tiered approach is suggested for cumulative assessment, whereby an initial "*tier 1*" cumulative assessment could be performed by adding the project contribution to a suitable representative existing background. The requirement for more detailed cumulative assessment (i.e. "*tier 2*") might trigger, for example, when the *tier 1* cumulative assessment results are greater than 70% of the goal (for annual averages). *Tier 2* or detailed cumulative assessment would include modelling of other local sources, estimating emissions for reasonably foreseeable future development, estimating regional background from non-modelled sources and inclusion of indirect or induced effects, if relevant.

Additional evaluation is presented to inform specific recommendations for cumulative air impact assessment, summarised below. Recommendations for future work are also made, if the recommended methodologies are considered for implementation in NSW.

RECOMMENDATION

Incorporating background

- Historical data are, in most cases, likely to be conservative for describing a future background. It is recommended that multiple years of data (3-5) are used to describe background in cumulative assessment, to account for inter-annual variation due to climate effects (particularly for particulate matter (PM)).
- For detailed cumulative assessment (tier 2), where other significant local sources are modelled, it is recommended that a suitable 'distant' background site is selected to describe regional background for other non-modelled sources. This is to avoid double counting of existing sources within local (i.e. industry operated) air quality monitoring data.
- For tier 1 cumulative assessment, where other local sources are not explicitly modelled, the background site should be the closest upwind and / or the most representative background site. The selection of background (local or distant sites) should attempt to eliminate or reduce the source-oriented impacts from nearby sources to avoid potential double counting.
- For detailed cumulative assessment (tier 2), future air quality should be considered by including reasonably foreseeable or committed development in modelling or adjusting background based on a percentage change per year, derived from long term analysis of historical trends.
- To demonstrate that a site is representative, analysis of spatial variation should be presented as well as comparison of influencing factors such as land use, local emissions sources, population density etc.
- Where a background year is significantly influenced by bushfire events or dust storms, the median value may be a better statistical descriptor than the mean for describing background. Alternatively a quantitative analysis of the background data should be used to justifiably remove these events from background data.

Cumulative assessment for short term averaging periods

- Assuming that the "additional exceedance" test is the critical factor when assessing compliance with the short term impact assessment criteria, a probabilistic risk based approach is recommended.

Modelling other sources

- The Area of Impact (AOI) methodology may be appropriate if significance screening and Significant Impact Levels (SILs) are adopted for NSW. Consideration of other methodologies, such as the ratio of emissions to distance method (Q/D method) could be used if an AOI approach is ruled out. It is noted that the AOI approach is contingency on where the SIL is applied (receptor or beyond boundary), which has direct implications on the magnitude of the SIL value.

Cumulative assessment for short term averaging periods

- Assuming that the "additional exceedance" test is the critical factor when assessing compliance with the short term impact assessment criteria, a probabilistic risk based approach is recommended. This can be conducted using relatively straightforward spreadsheets or using more sophisticated proprietary software packages.

RECOMMENDATIONS FOR FUTURE WORK

Airshed management

- Detailed analysis of OEH monitoring data for the previous 5 years to evaluate the suitability of acceptance limit for defining attainment and non-attainment areas. For example, the analysis could be used by EPA to determine if the chosen acceptance limit does what it should, that is identifies/defines areas like Western Sydney or the Upper Hunter as potential airshed management areas.

SILs

- If a procedure for significance screening is adopted for NSW, it is suggested that additional consideration is needed to derive suitable SILs, where they should be applied and the appropriate form (i.e. percentile based or maximums for short term averages). Adopting a SIL from other jurisdictions may be appropriate where it is expressed as a percentage of the goal, as this could be directly applied to impact assessment criteria for NSW. However, adopting an absolute SIL value from elsewhere may not appropriate, for example due to difference in particle composition for difference areas. Furthermore, adopting a SIL that is prescribed for a discrete receptor location and applying it at the site boundary would not be appropriate without further investigation.

AOI

- Further investigation of the AOI methodology if significance screening and SILs are adopted for NSW.

Additional analysis of ambient air quality in NSW

- The trend and correlation analysis presented in this report would be extended for industry monitoring data, which would be particularly useful for rural NSW. Additional correlation analysis would also be useful comparing monitoring data with and without exceptional events removed.

Development of background maps for NSW

- A longer term recommendation is to develop regional emissions inventories and regional dispersion modelling to generate background maps for NSW. This could be commenced for the GMR, where detailed emissions inventories are already available. Regional dispersion modelling for the GMR could provide background maps similar to the PATH system developed for Hong Kong. The background maps would provide a consistent and reliable baseline for cumulative impact assessment. Ambient concentrations would be disaggregated to allow certain sources to be removed from background, to avoid double counting if included in the project modelling. The advantage of modelled background maps above monitoring data is that it provides better continuous cover, eliminates subjective data selection and can provide consistent background and meteorological inputs for AQIA done by difference consultants.

11. GLOSSARY OF TERMS AND ACONYMNS

µg/m³	micrograms per cubic metre
µm	micron
AAQC	Ambient Air Quality Criteria
ADMS	Atmospheric Dispersion Modelling System
AESRD	Alberta Environment and Sustainable Resources Development
AOI	Area of impact
Approved Methods	Approved Methods for the Modelling and Assessment of Air Pollutants in NSW
AQA	Air Quality Assessment
AQIA	Air quality impact assessment
AQMA	Air Quality Management Areas
AQMG	Air Quality Model Guideline
AQRV	Air Quality Related Value
ARM	Ambient ratio method
BACT	Best available control technology
BAT	Best Available Technology
BC MoE	British Columbia Ministry of Environment
BoM	Bureau of Meteorology
CATEX	Categorical exclusion
CEAA	Canadian Environmental Assessment Agency
CFR	Unnited States Code of Federal Regulations
CO	Carbon Monoxide
DEFRA	Department of Environment, Food and Rural Affairs
DER	Department of Environment Regulation
DGLC	Design ground level concentrations
DoE	Department of Environment
DPE	Department of Planning and Environment
DSEWPC	Department of Sustainability, Environment, Water, Population and Communities
DUAP	Department of Urban Affairs and Planning
EA	UK Environment Agency
EIS	Environmental Impact Statement
ENSO	El Niño Southern Oscillation
EPD	Hong Kong Environmental Protection Department
EPL	Environment Protection Licence
EPP	Environmental Protection Policy
EPP (Air)	Environmental Protection (Air) Policy 2008
EQ	Environment Quotient
ESDM	Emission Summary and Dispersion Modelling
ESL	Effects Screening Levels
EU	European Union
FONSI	Finding of No Significant Impact
FSP	Fine Suspended Particles (PM2.5)

GMR	Greater Metropolitan Region in New South Wales
HCl	Hydrogen Chloride
HF	Hydrogen Flouride
IAQM	UK Institute of Air Quality Management
ISR	Initial stack ratio
km	kilometre
LAER	Lowest achievable emission rate
LAQM	Local Air Quality Management
LAQM TG	Local Air Quality Management Technical Guidance
m	metre
MOECC	Ministry of the Environment and Climate Change
NA NSR	Nonattainment New Source Review
NAAQS	National Ambient Air Quality Standards
NEPA	US National Environmental Protection Act
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides
NPI	National Pollution Inventory
NSR	New Source Review
NSW EPA	New South Wales Environment Protection Authority
O.Reg	Ontario Regulation
O_3	ozone
OEH	NSW Office of Environment and Heritage
OLM	Ozone Limiting Method
OPS	Operational Priority Substances
PATH	Pollutants in the Atmosphere and their Transport over Hong Kong
PCO	Parliamentary Counsel's Office
PEC	Predicted Environmental Concentration
PEL	Pacific Environment Limited
PEM	Protocol for Environmental Management
PGMs	photochemical grid models
PM	particulate matter
PM_{10}	Particulate matter with an aerodynamic diameter of less than 10 µm
$PM_{2.5}$	Particulate matter with an aerodynamic diameter of less than 2.5 µm
POEO	Protection of the Environment Operations Act
POI	Point of impingement
POPC	Pollutant of potential concern
ppb	parts per billion
PSD	Prevention of significant deterioration
PVMRM	Plume volume molar ratio method
PWCS	Port Warratah Coal Services
Q/D	Ratio of emissions to distance

QLD	Queensland
QLD EPA	Queensland Environment Protection Agency
RFD	Reasonable Foreseeable Development
ROD	Record of Decision
RSP	Respirable Suspended Particles (PM10)
SEARs	Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SEPP AAQ	SEPP Ambient Air Quality
SEPP AQM	SEPP Air Quality Management
SEPPs	State Environment Protection Policies
SIL	Significant impact level
SMC	Significant Monitoring Concentration
SO_2	Sulphur Dioxide
SSD	State Significant Development
TAPM	The Air Pollution Model
TAS	Todoroski Air Sciences
TCEQ	Texas Commission on Environmental Quality
TOC	Threshold of Concern
ToR	Terms of Reference
UHAQMN	Upper Hunter Air Quality Monitoring Network
UK	United Kingdom
US EPA	United States Environment Protection Agency
VLE	Emission limit values
VOCs	volatile organic compounds

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APPENDIX 1
ANNUAL NUMBER OF EXCEEDANCES OF 24-HOUR PM_{10} STANDARD

Number of exceedances of 24-hour PM_{10} standards at OEH monitoring sites

OEH monitoring site	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
RANDWICK	0	1	1	0	9	0	0	0	3	0
ROZELLE	0	1	1	0	8	0	0	0	3	0
EARLWOOD	3	8	3	1	9	0	2	0	5	0
LINDFIELD	-	-	-	0	5	0	0	0	1	0
CHULLORA	1	3	2	0	9	0	7	1	4	0
LIVERPOOL	2	3	1	1	8	0	-	0	3	0
BRINGELLY	2	3	1	1	6	0	2	0	3	0
OAKDALE	0	1	0	1	6	0	1	0	4	1
BARGO	-	-	-	-	-	0	1	0	2	1
RICHMOND	0	2	0	0	6	0	0	3	5	0
ST MARYS	2	5	0	0	9	1	1	0	2	0
PROSPECT	-	-	0	0	11	0	0	0	4	0
VINEYARD	0	3	0	0	6	0	0	0	4	0
WOLLONGONG	1	4	3	1	6	0	0	0	7	0
KEMBLA GRANGE	4	9	5	4	14	0	1	3	4	1
ALBION PARK STH		2	1	1	9	0	1	0	2	0
WALLSEND	1	1	2	1	10	0	0	0		0
NEWCASTLE	0	1		2	13	1	0	0	4	2
BERESFIELD	1	2	5	5	15	1	0	1	5	0
MUSWELLBROOK	-	-	-	-	-	-	0	1	3	1
SINGLETON	-	-	-	-	-	-	2	7	12	1
TAMWORTH	-	0	-	3	17	0	1	1	0	1
BATHURST	0	3	2	1	12	0	0	2	3	0
ALBURY	3	14	11	8	15	2	0	1	2	5
WAGGA WAGGA	27	37	34	23	21	6	-	-	-	-
WAGGA WAGGA NTH	-	-	-	-	-	-	-	1	15	14

APPENDIX 2
TREND ANALYSIS FOR OEH MONTIORING DATA

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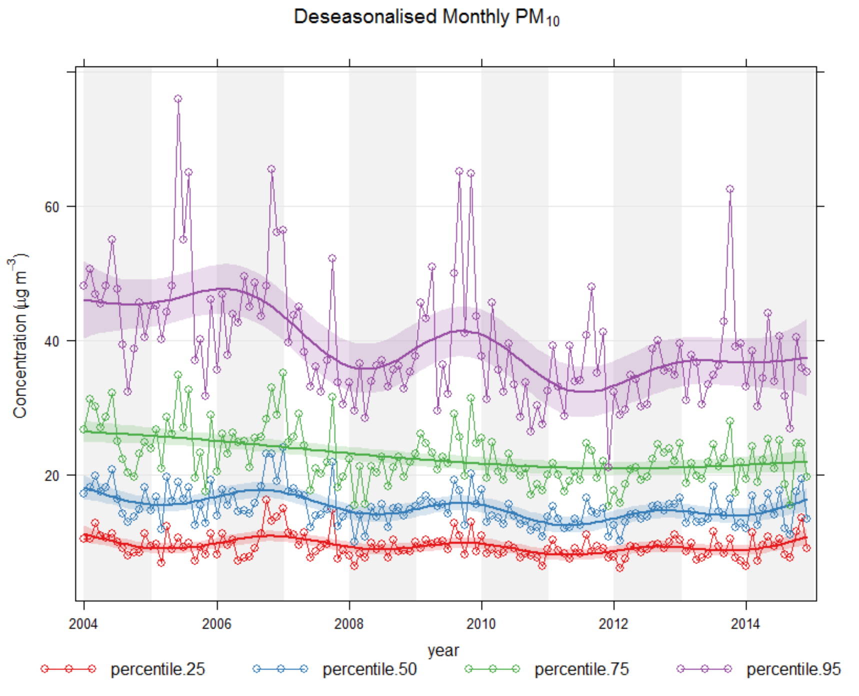	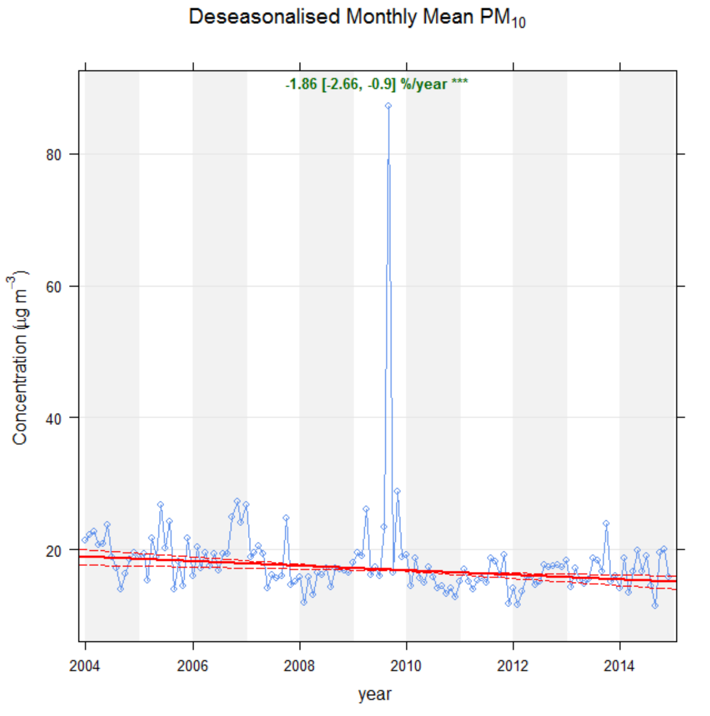
Monthly mean concentration with 95% confidence limits[1]	Trend in monthly mean concentration showing % change per year with 95% confidence limits[2]

[1] Plotted using the openair smoothtrend function
[2] Plotted using the openair TheilSen trend function

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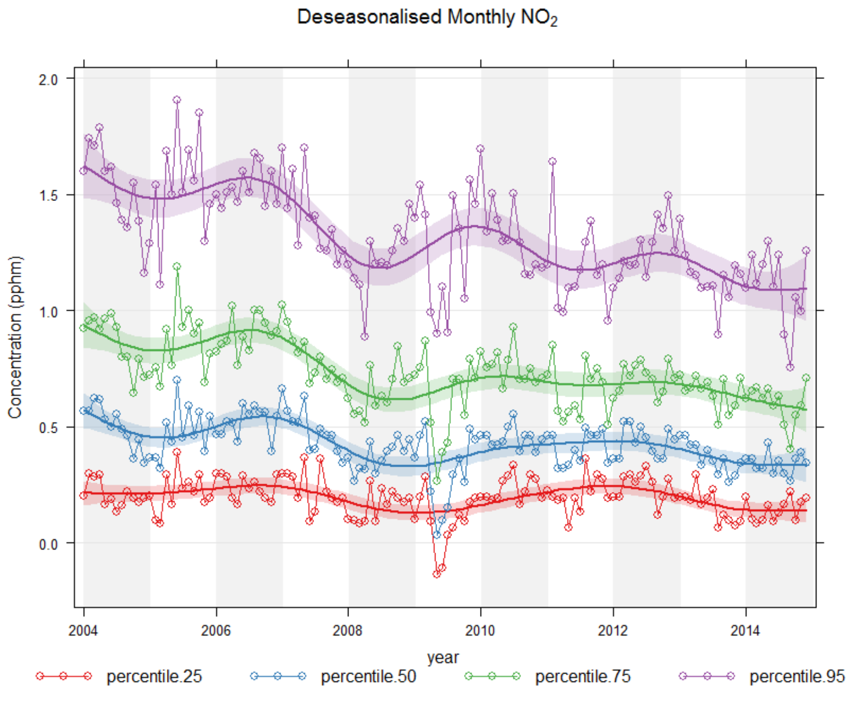
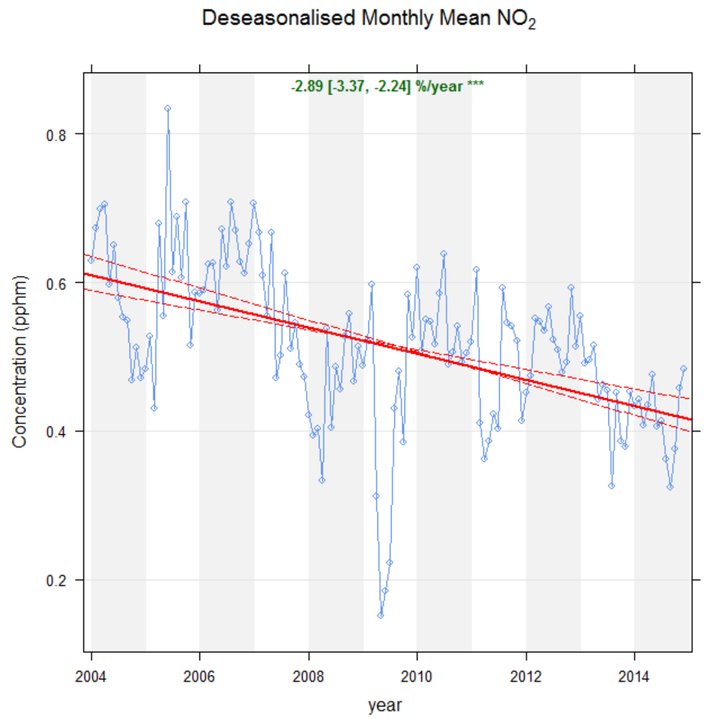
<tr><td>
</td><td>
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<tr><td>Monthly mean concentration with 95% confidence limits</td><td>Trend in monthly mean concentration showing % change per year with 95% confidence limits</td></tr>
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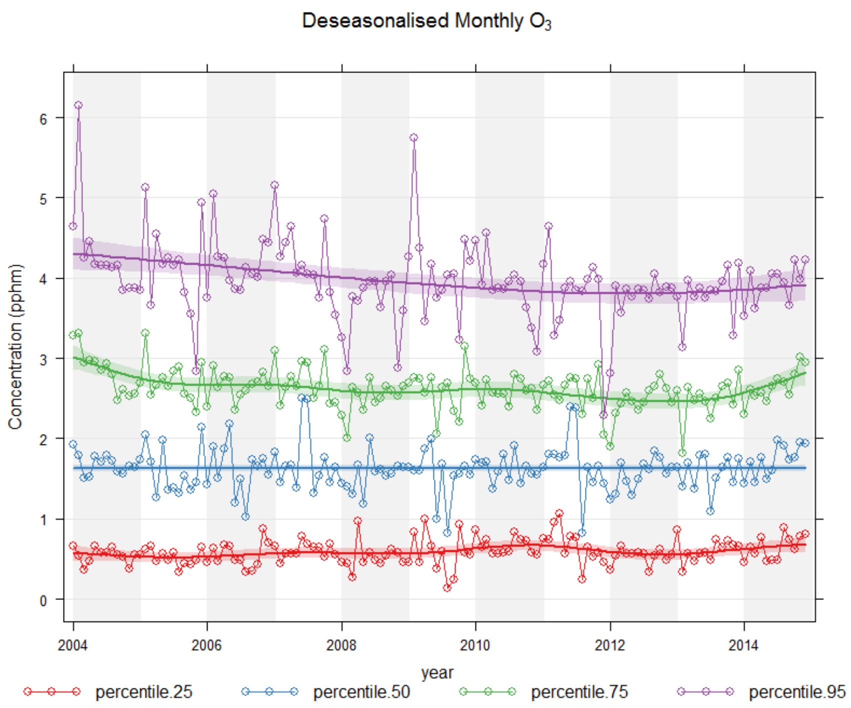	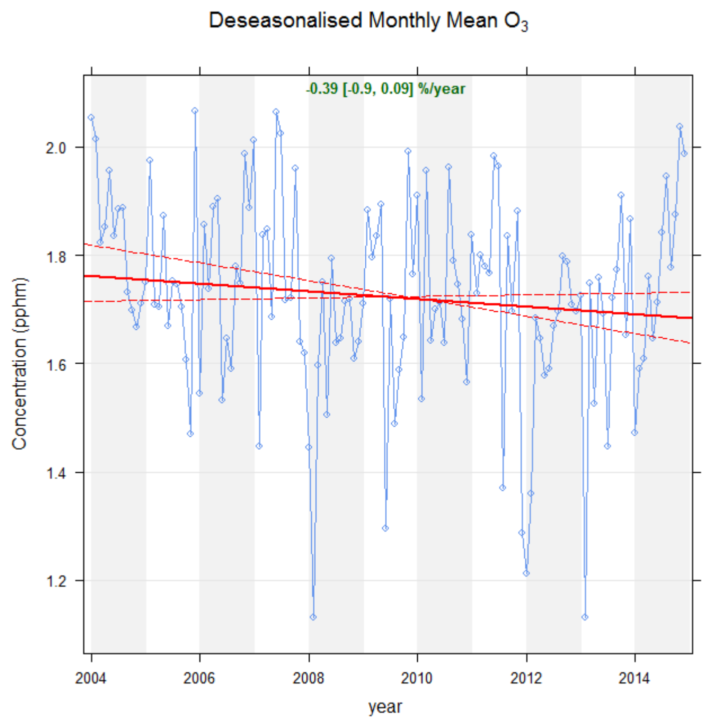
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

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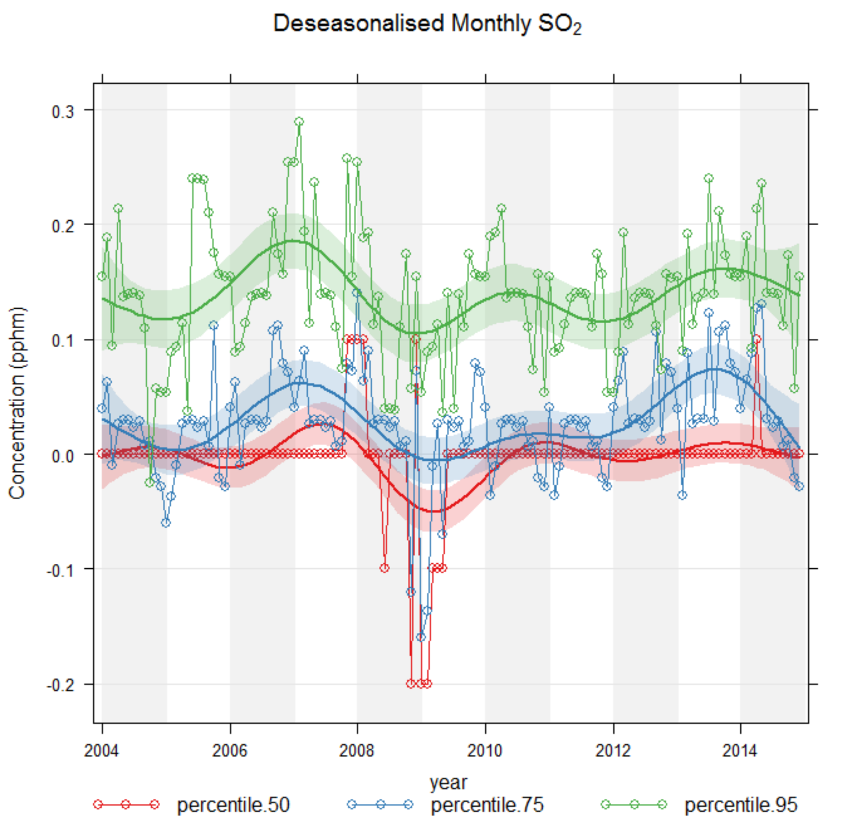
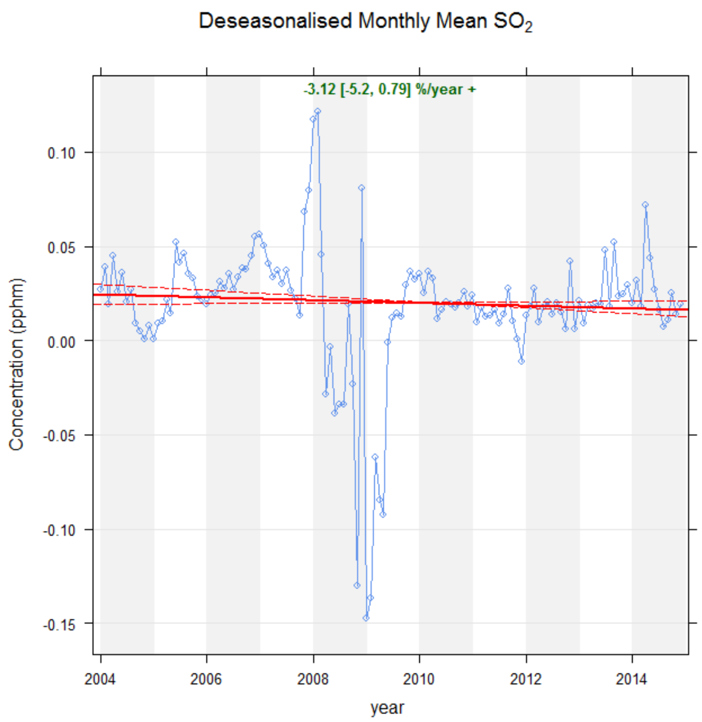
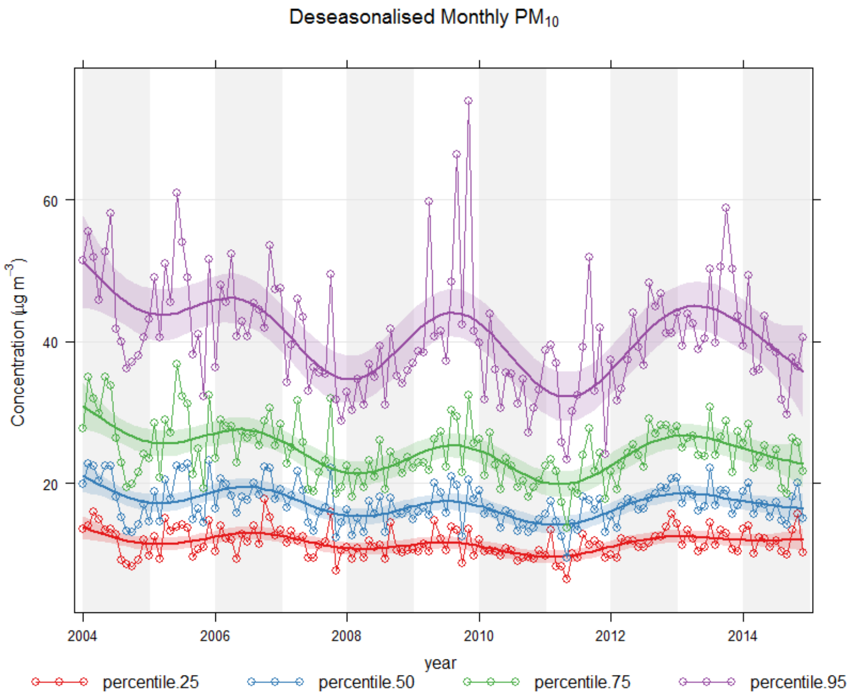
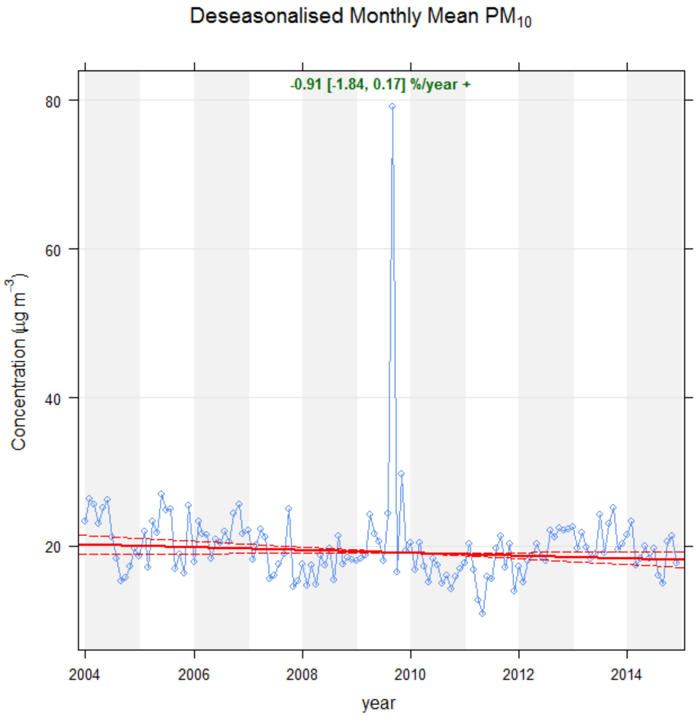
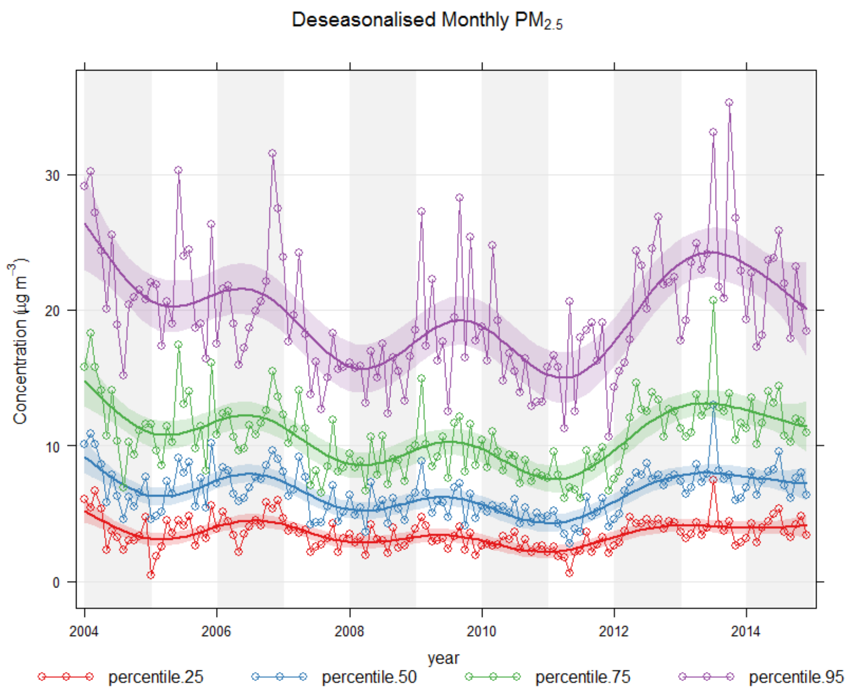
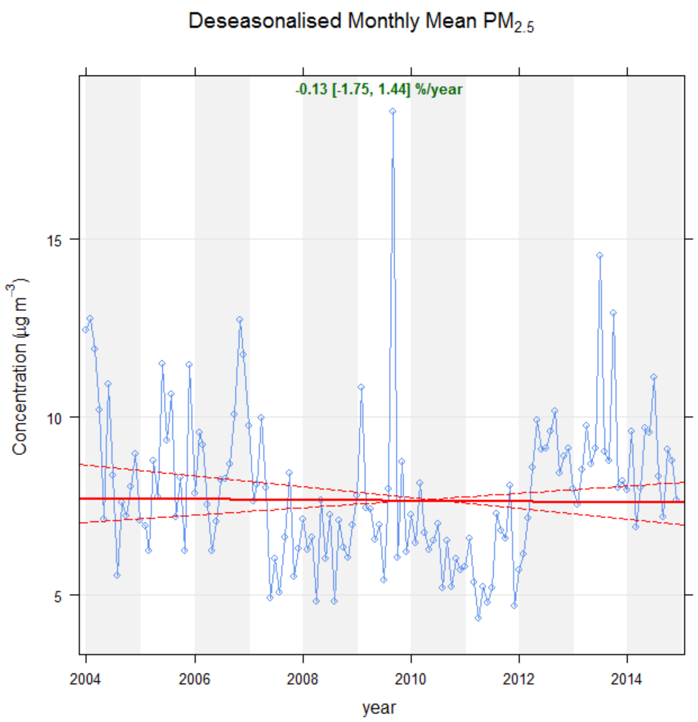
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

Liverpool	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

Liverpool	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

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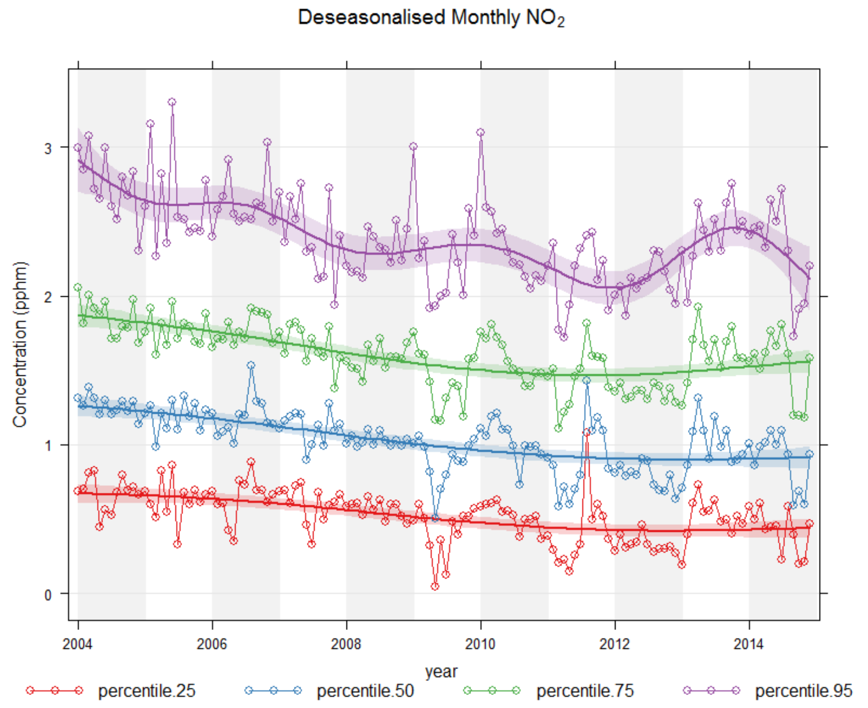
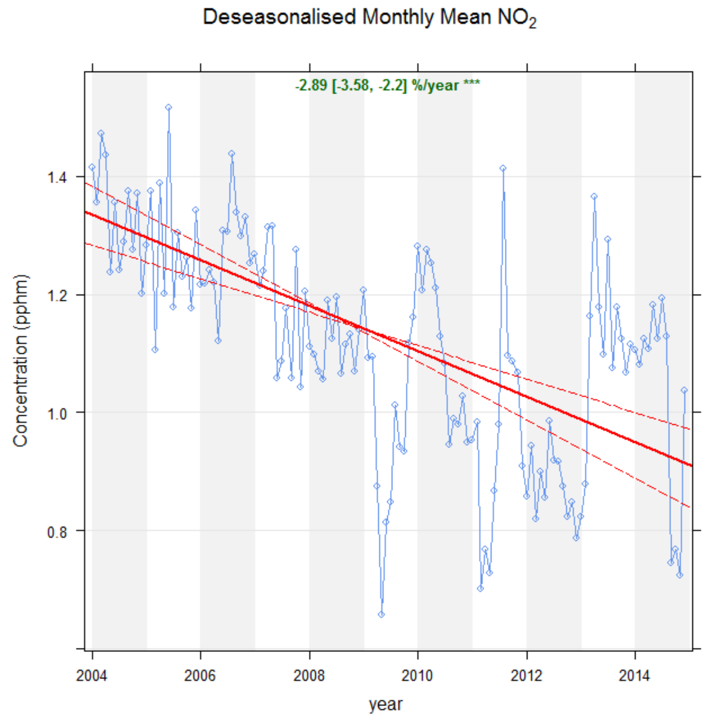
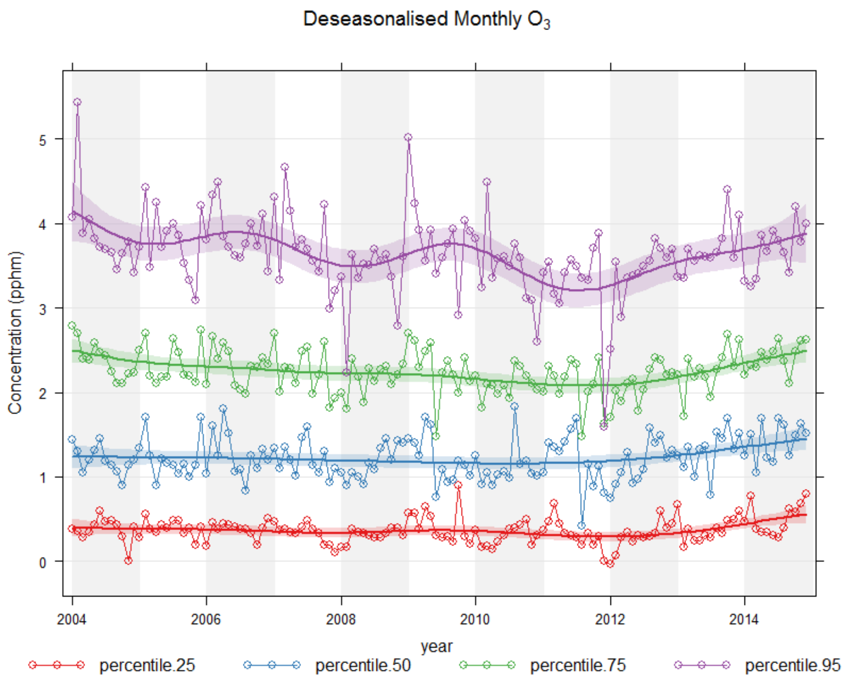
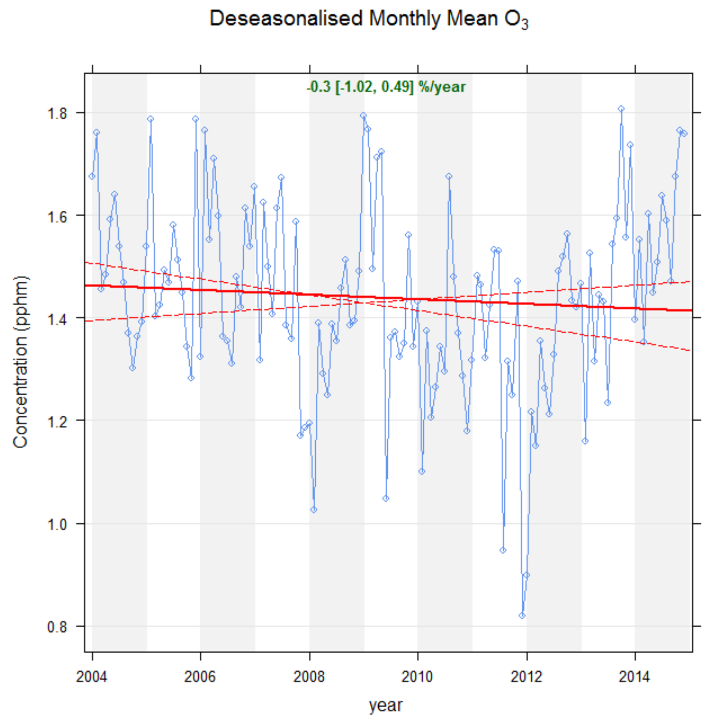
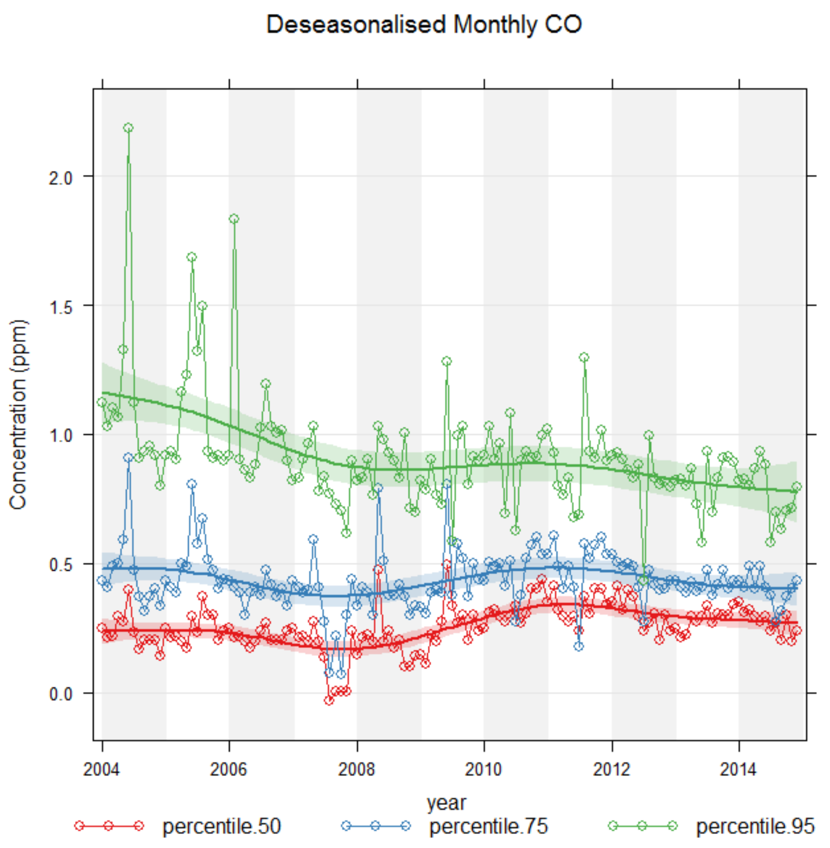
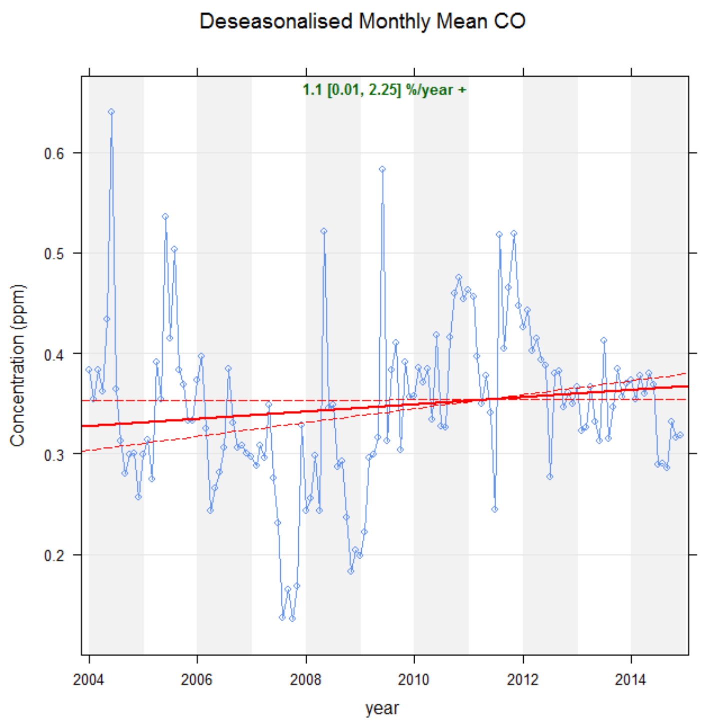
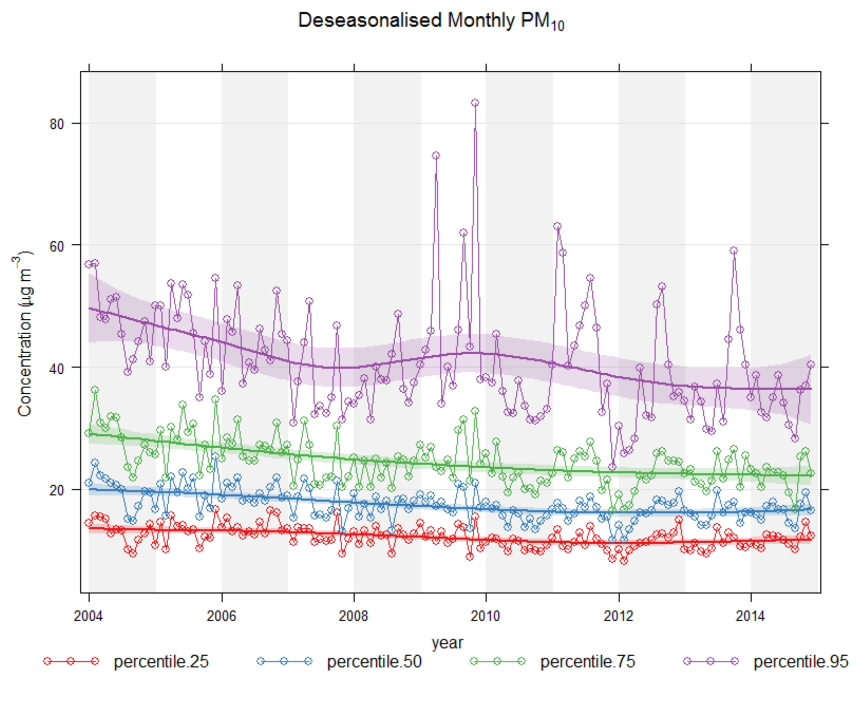
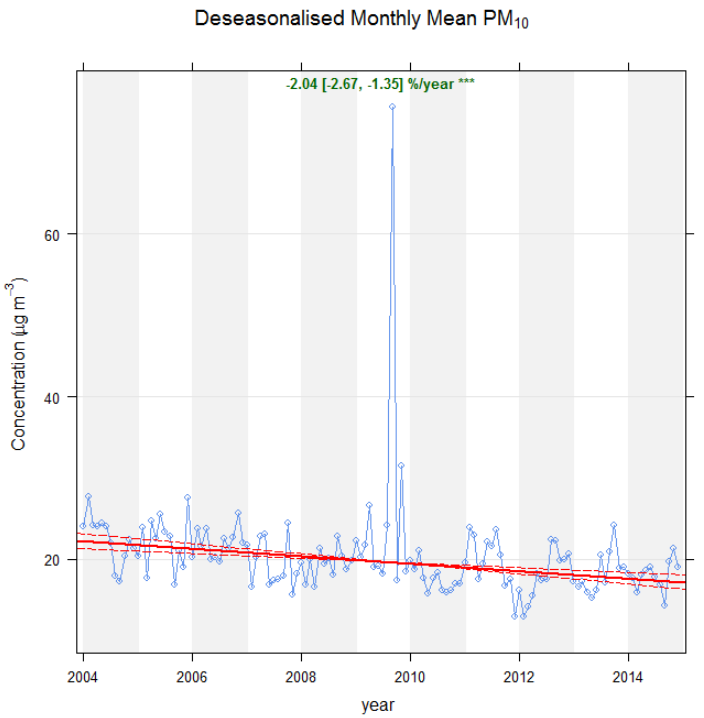
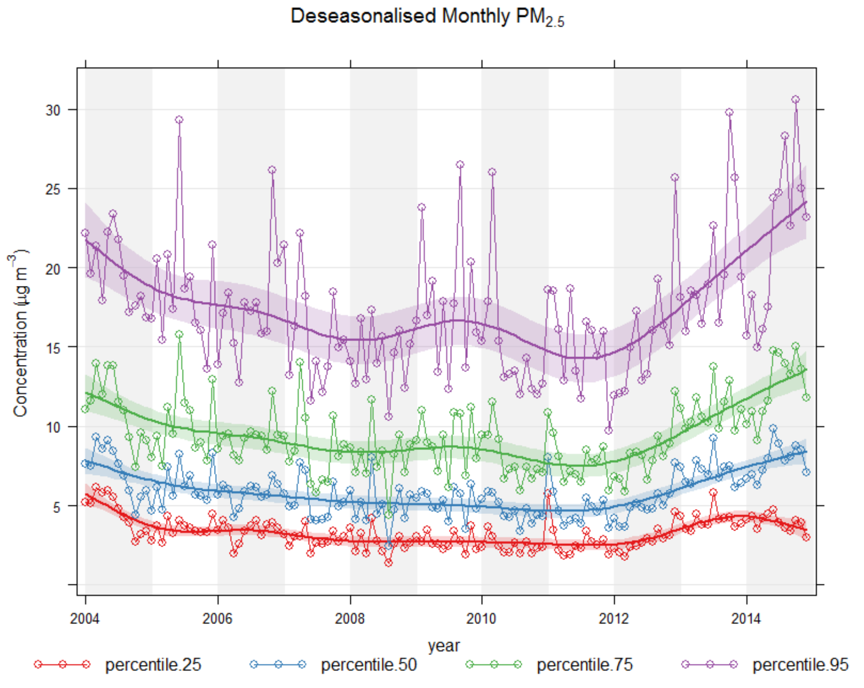
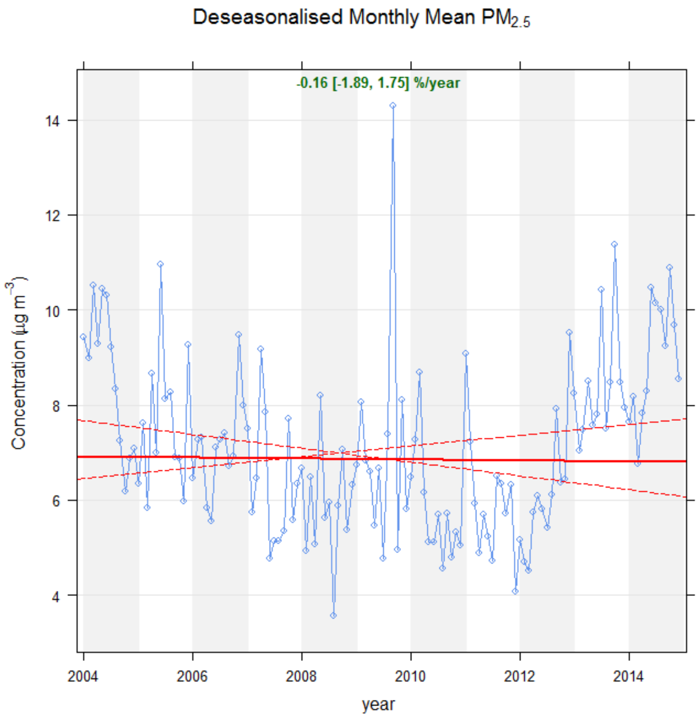
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

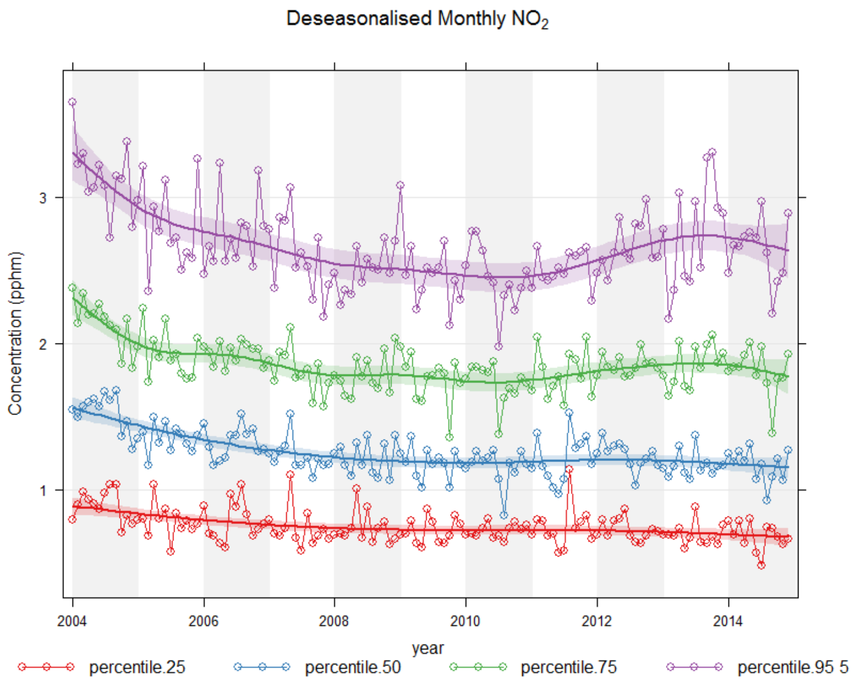
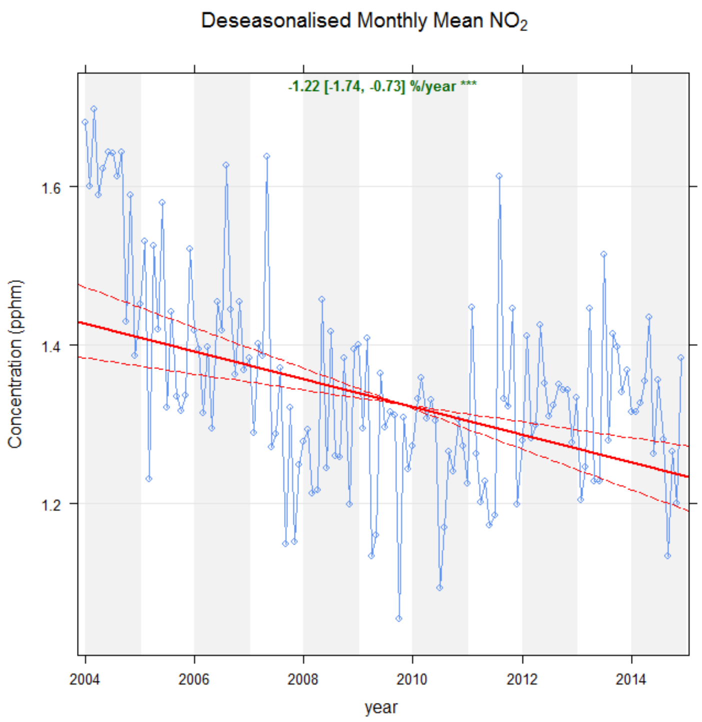
Liverpool	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

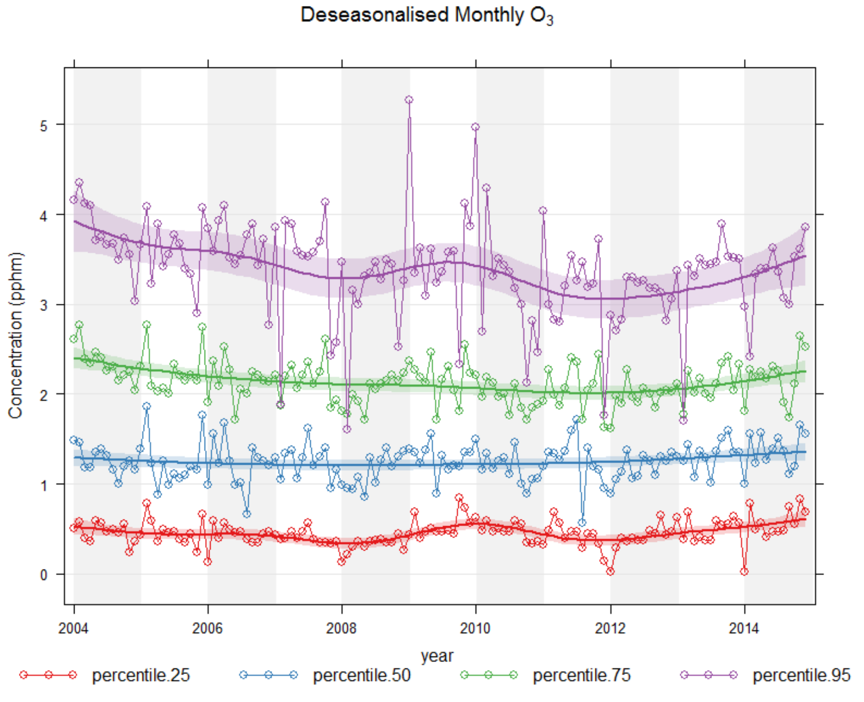
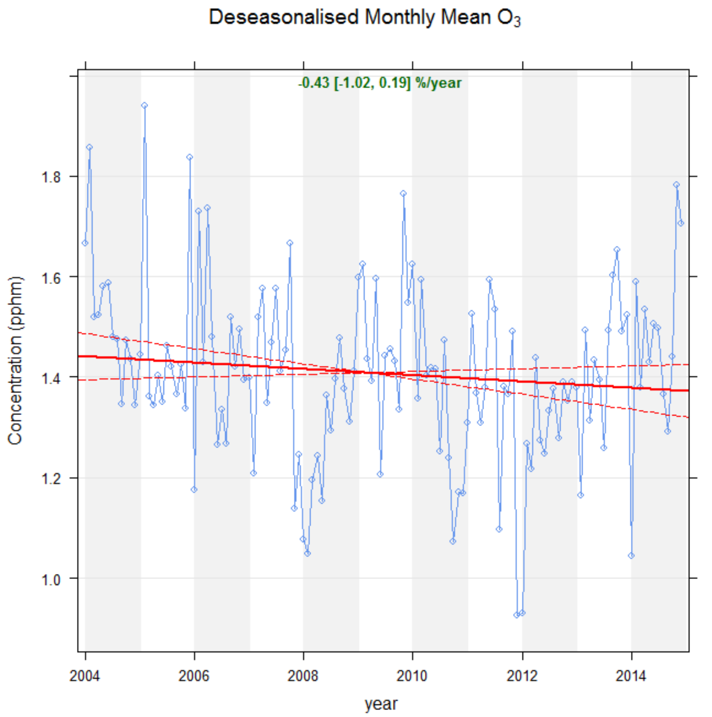
Liverpool	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

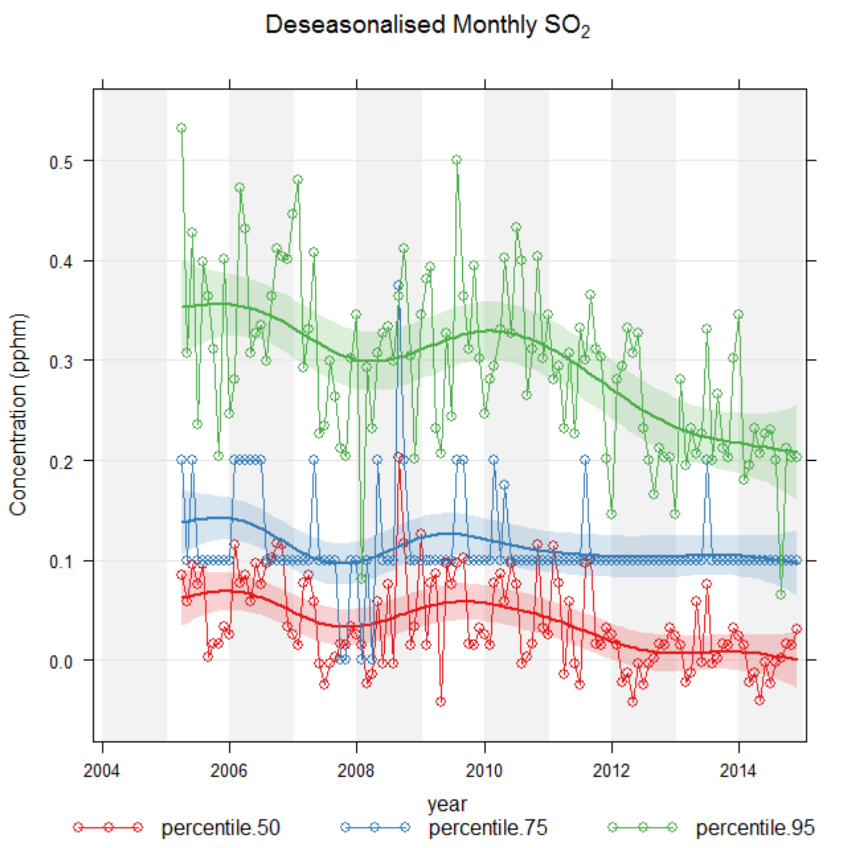
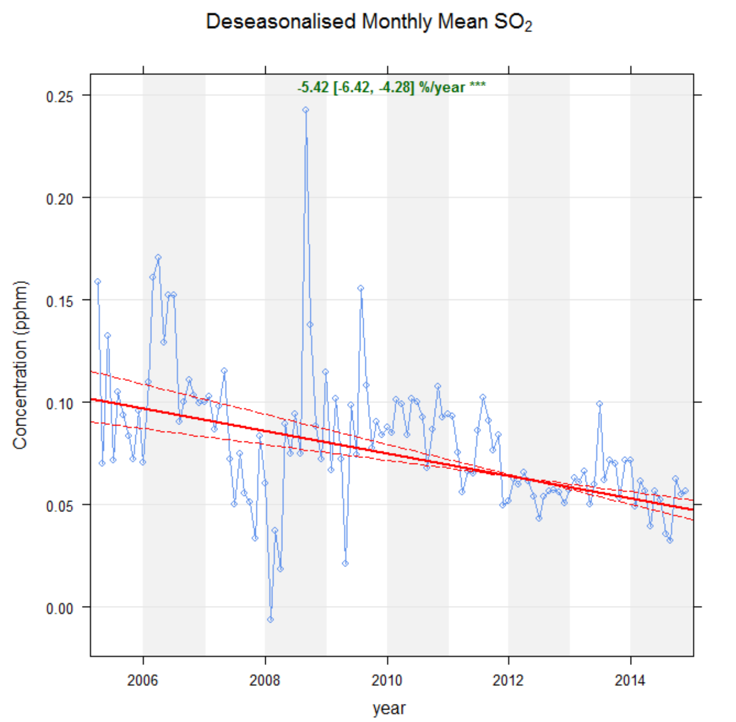
Chullora	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

Chullora	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

RAMBOLL ENVIRON

Chullora	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

Chullora	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

Chullora	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

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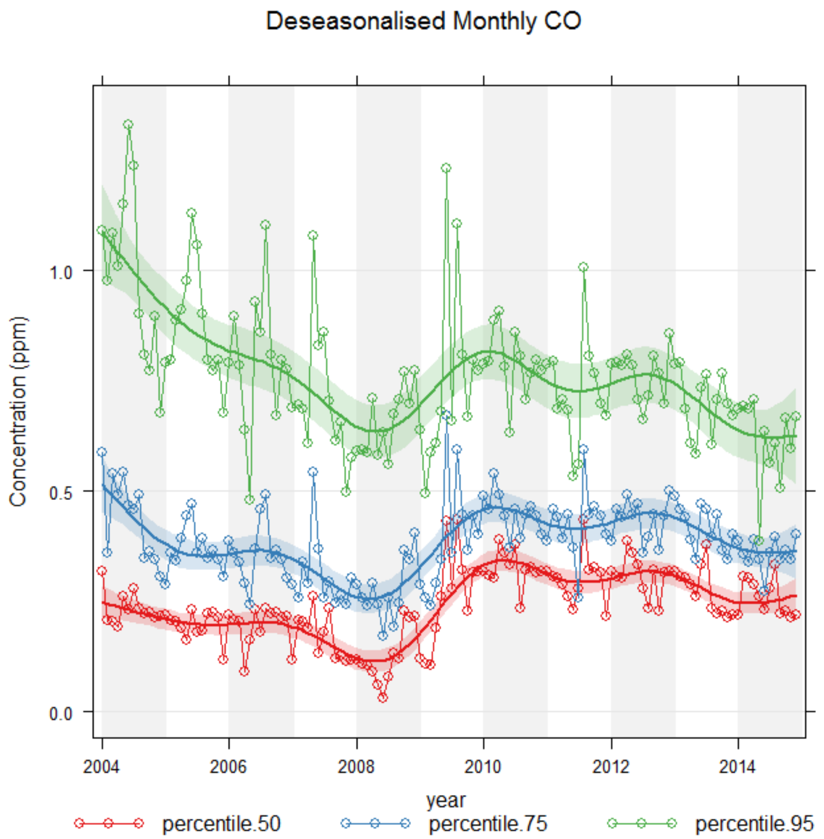
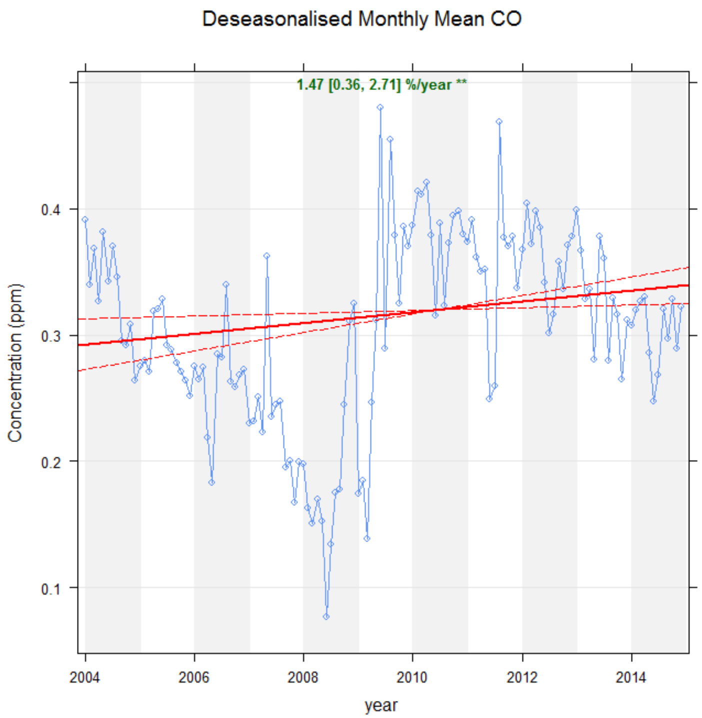
<tr><td>
</td><td>
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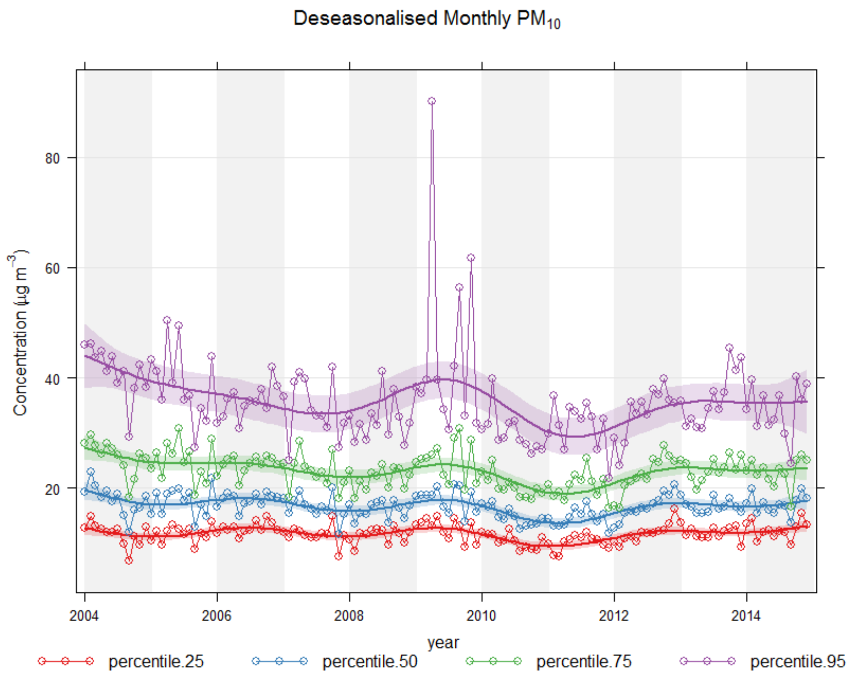
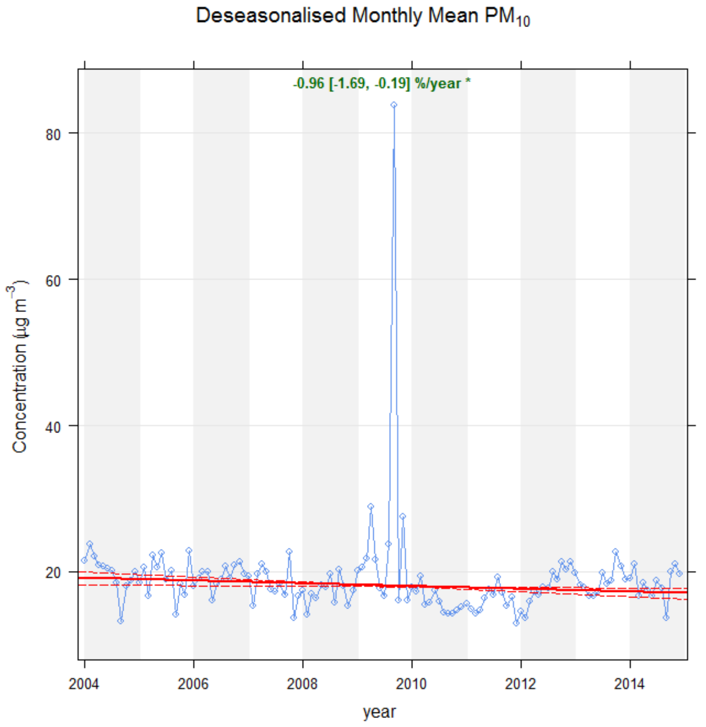
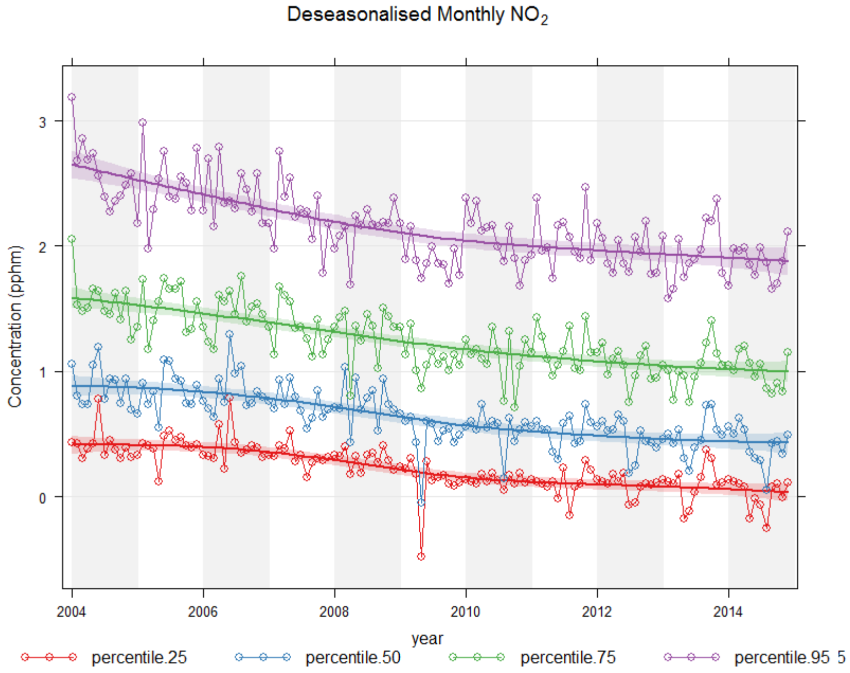
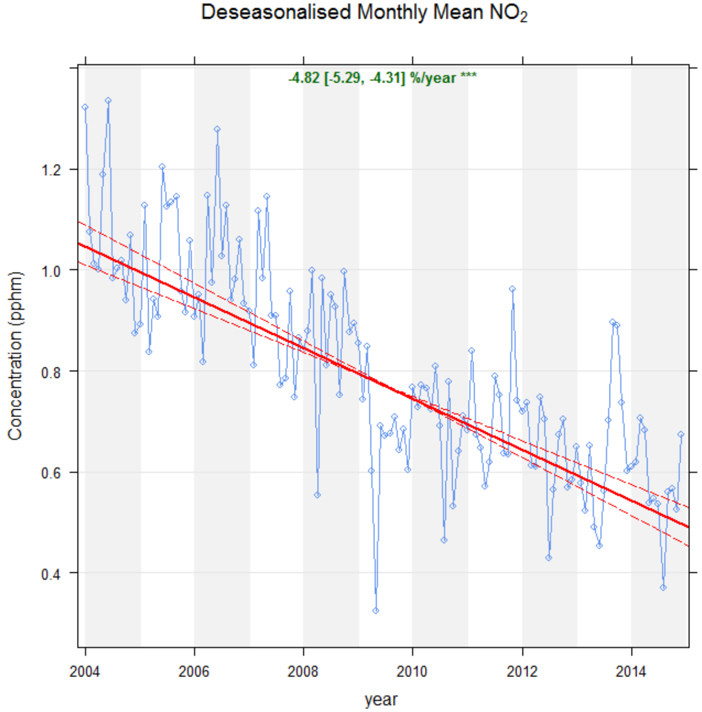
Randwick	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

RAMBOLL ENVIRON

Randwick



Monthly mean concentration with 95% confidence limits



Trend in monthly mean concentration showing % change per year with 95% confidence limits

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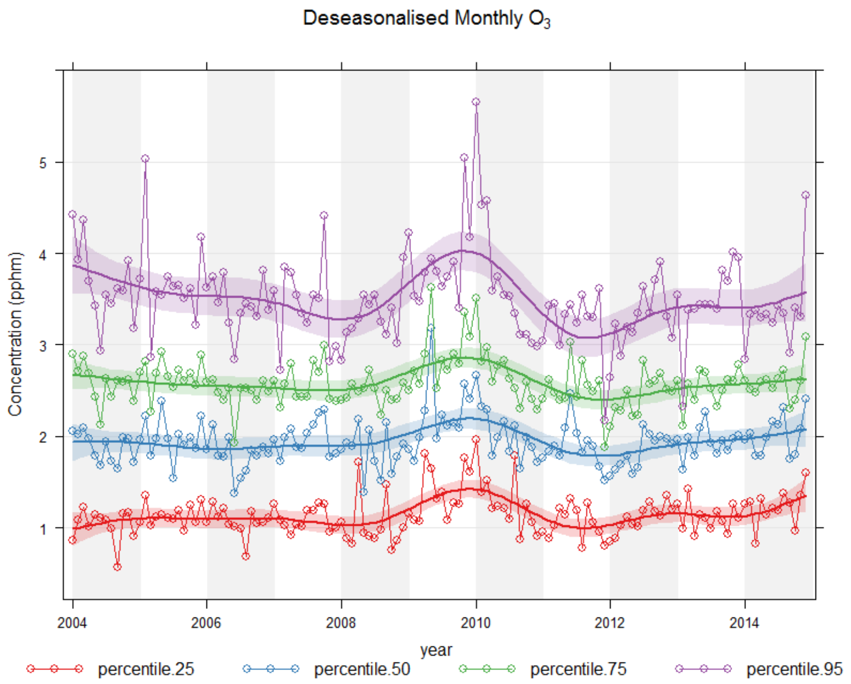
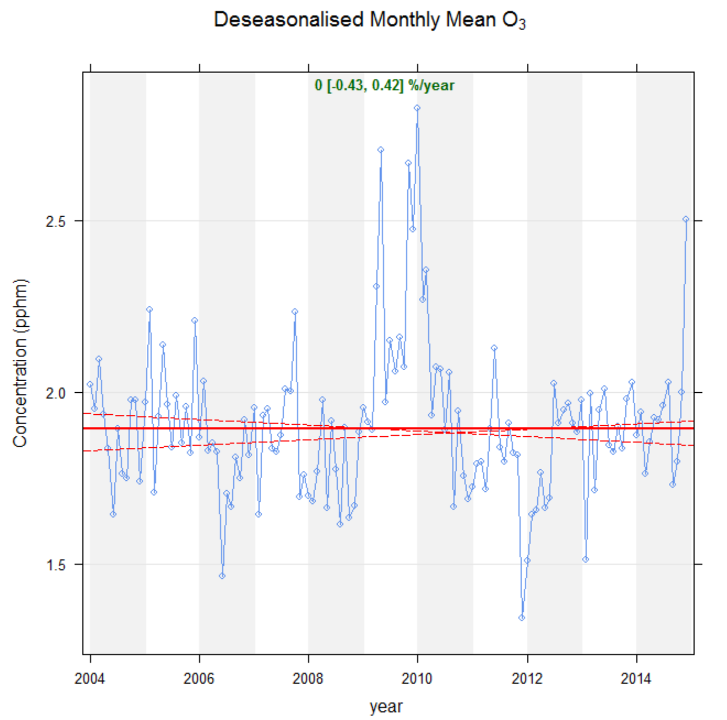
<tr><td>
</td><td>
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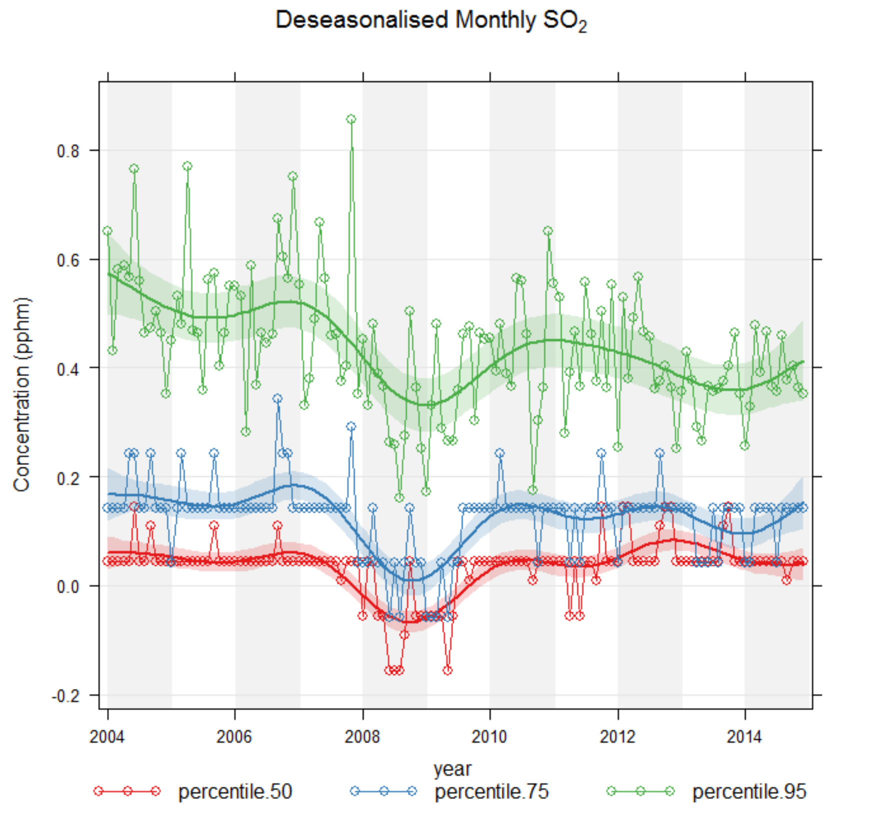
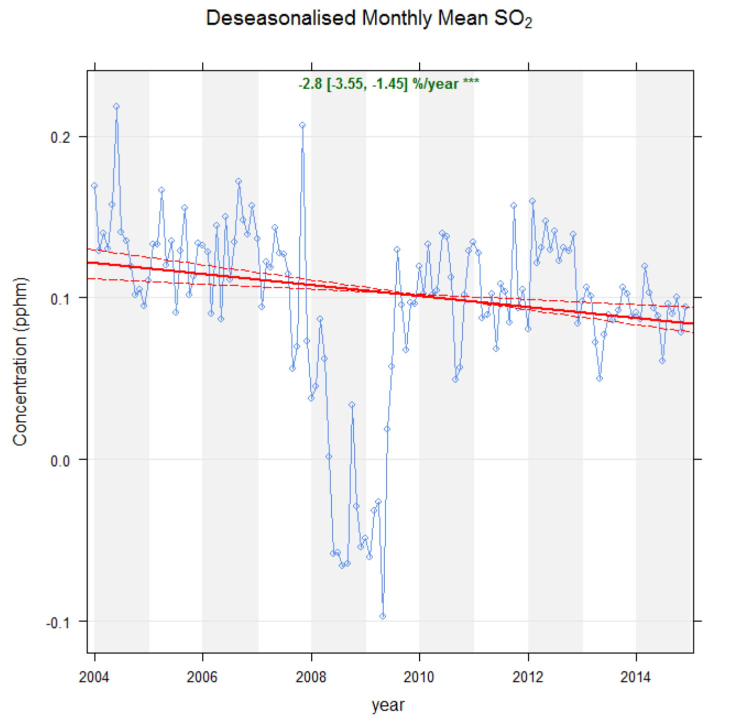
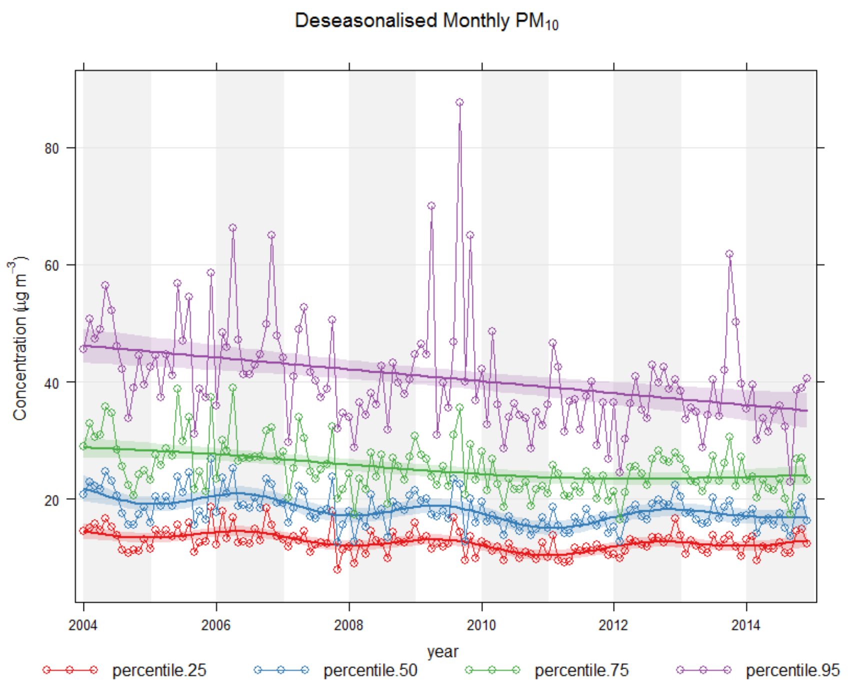
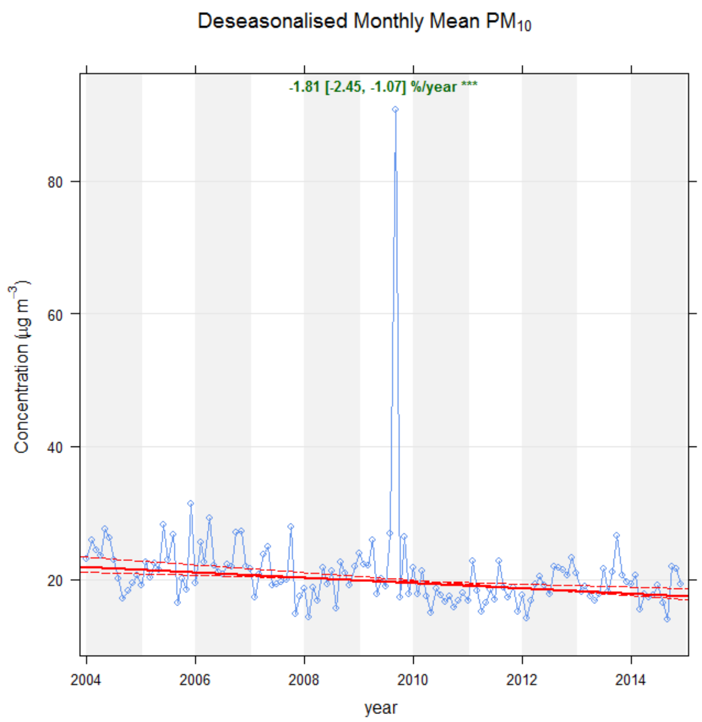
Randwick



Monthly mean concentration with 95% confidence limits



Trend in monthly mean concentration showing % change per year with 95% confidence limits

Earlwood	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

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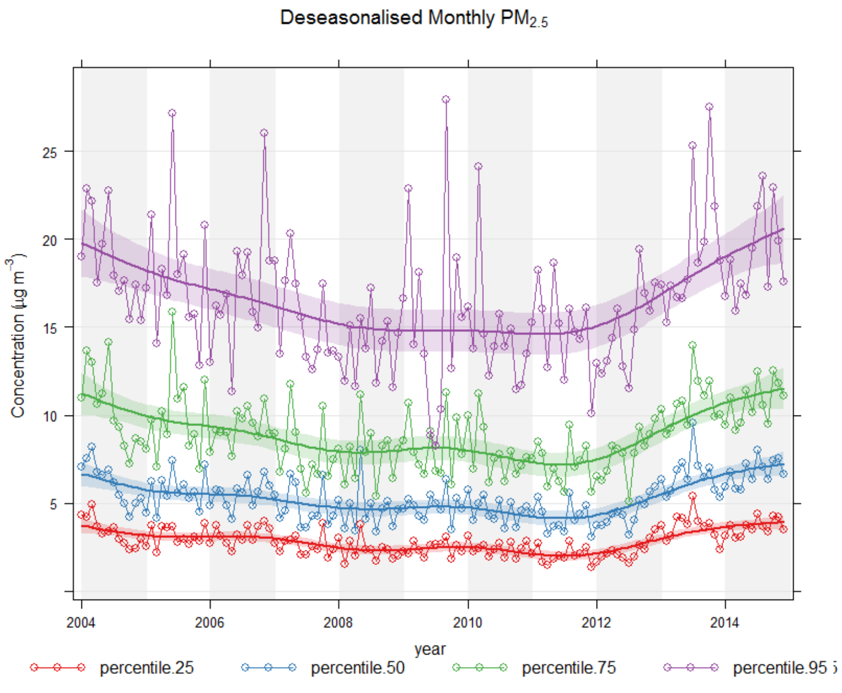
<tr><td>
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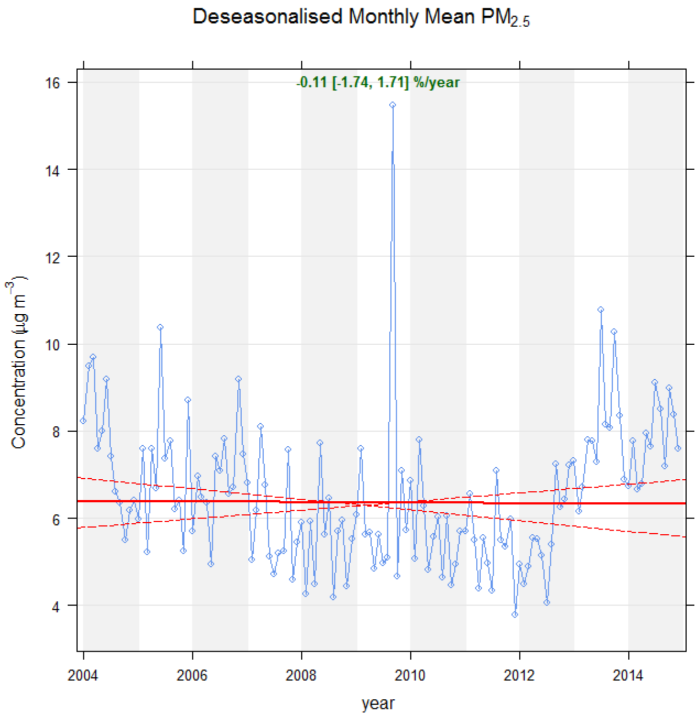
<td>
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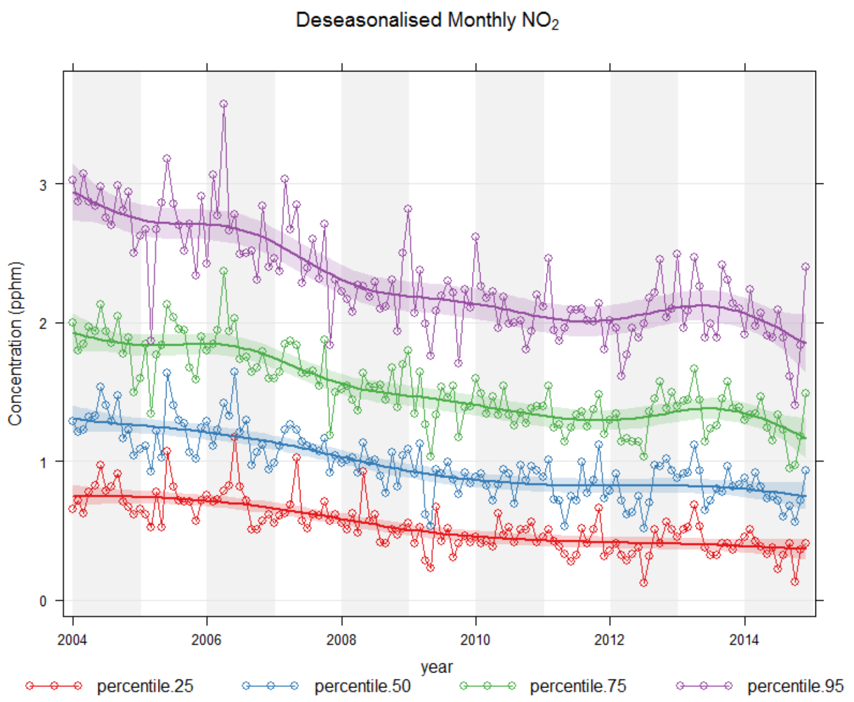
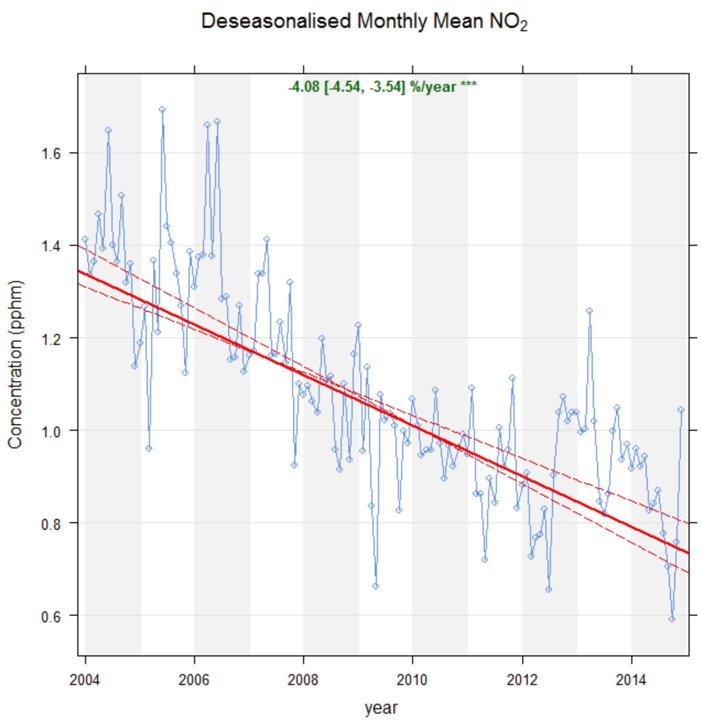
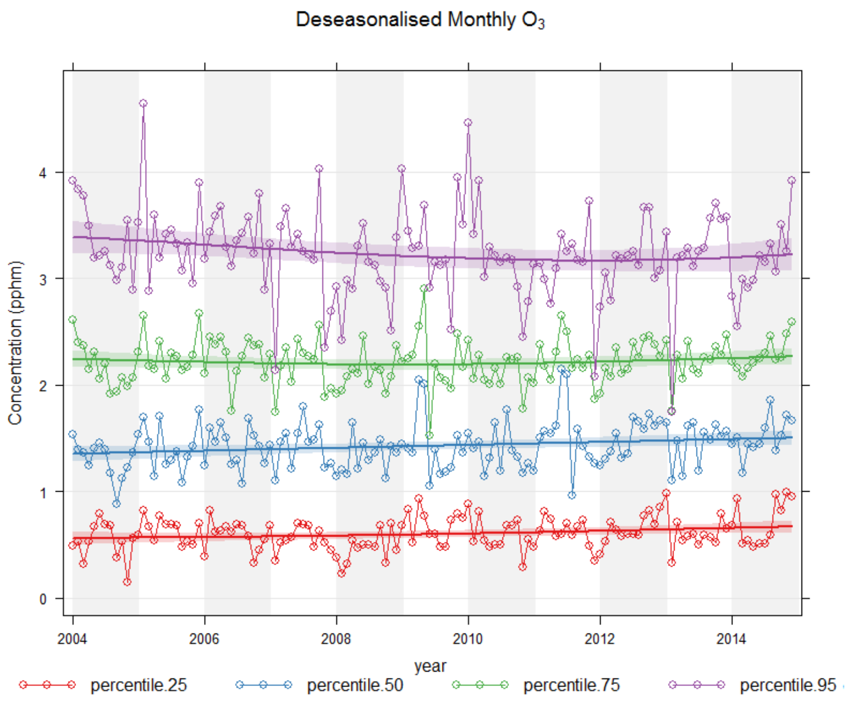
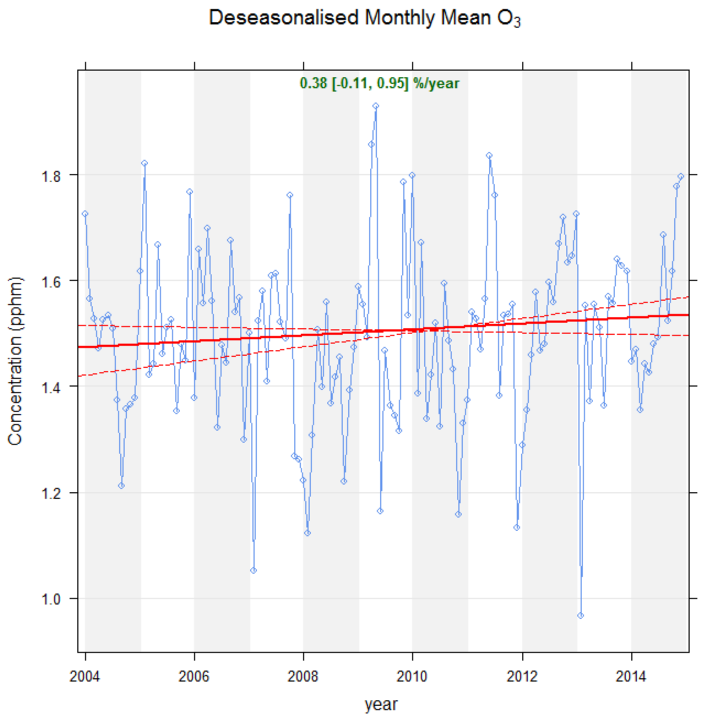
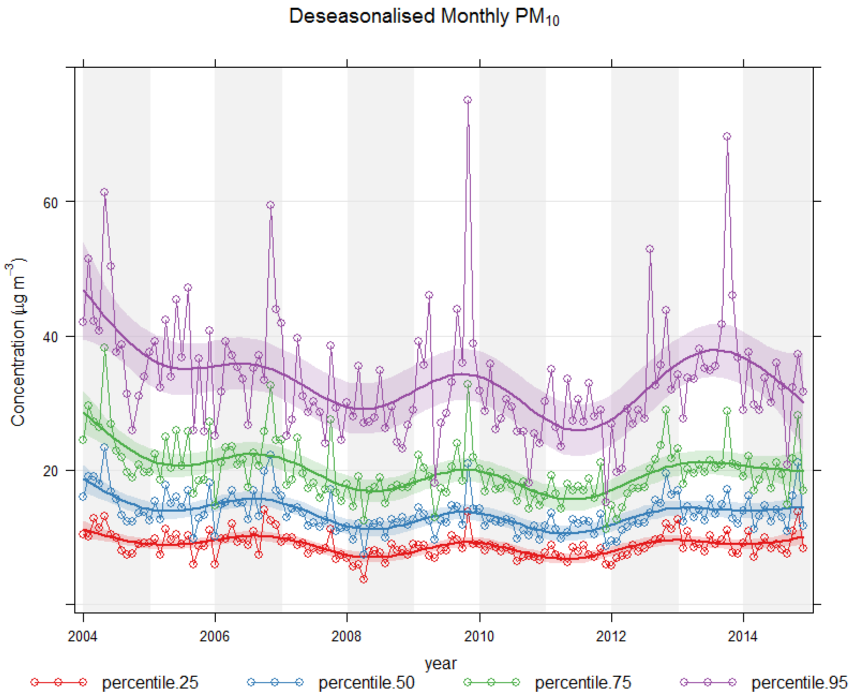
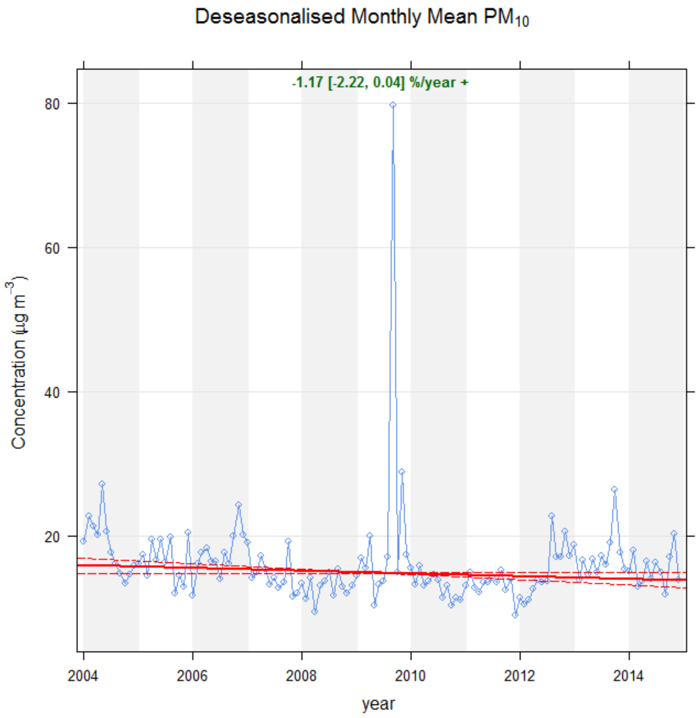
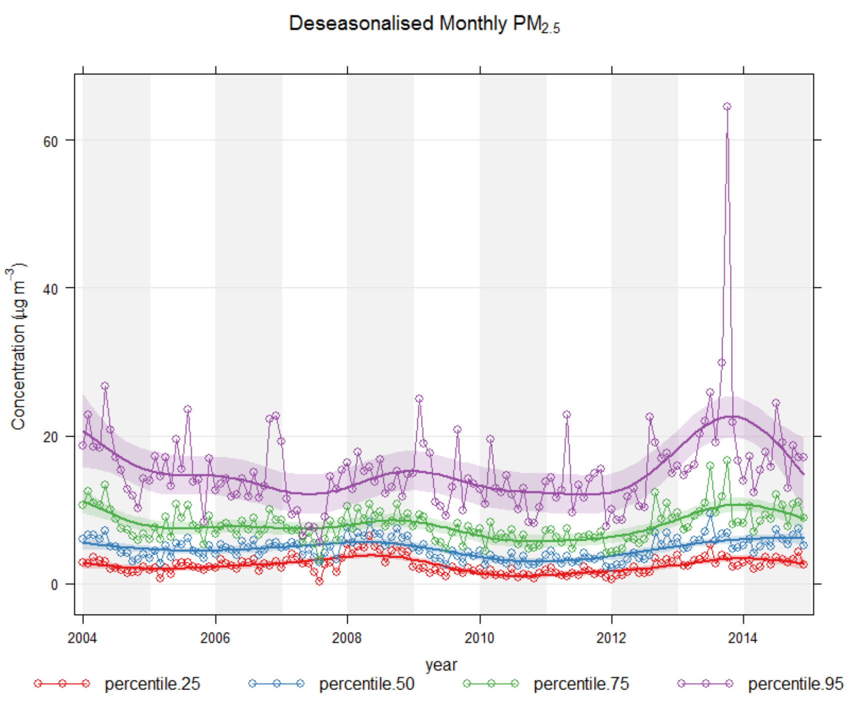
Earlwood	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

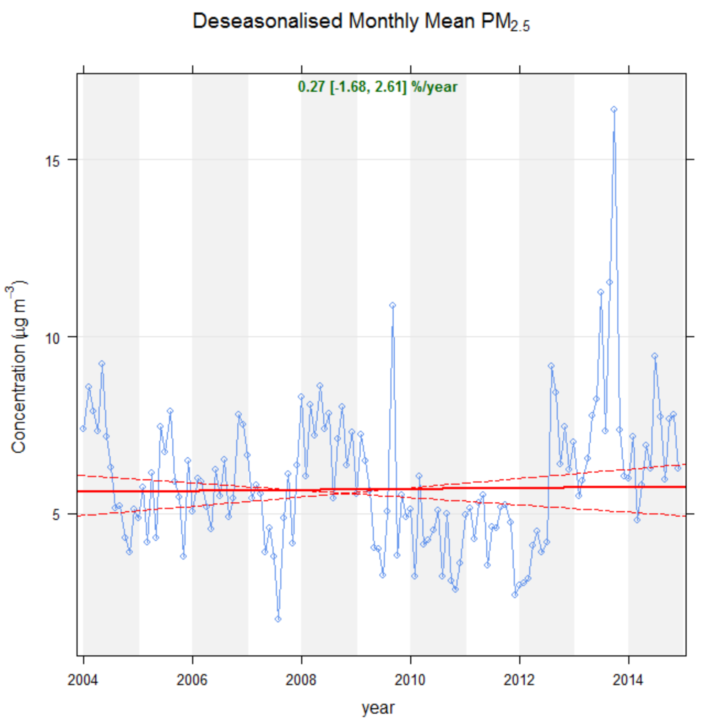
Earlwood	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

Richmond	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

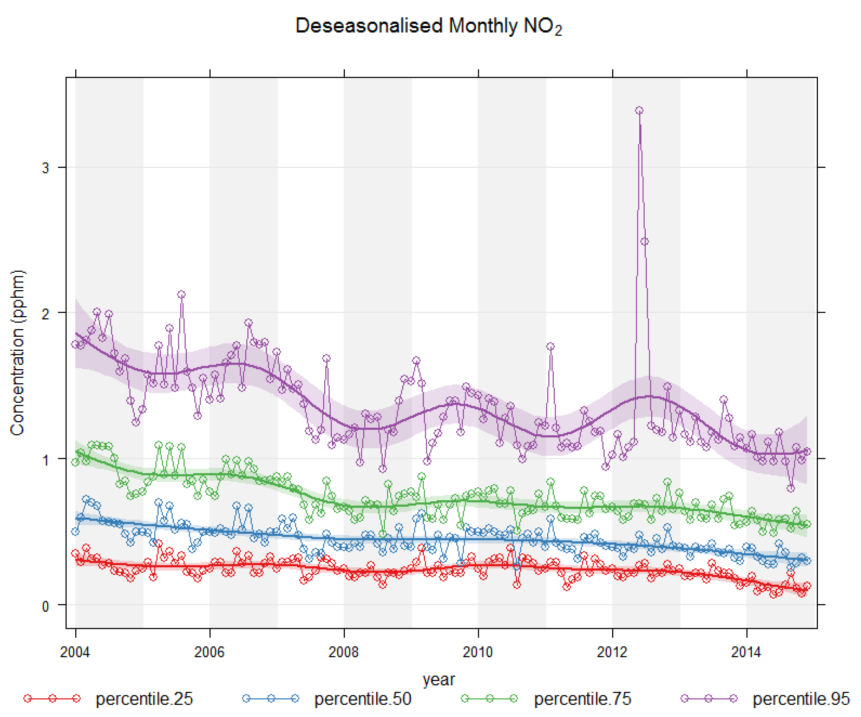
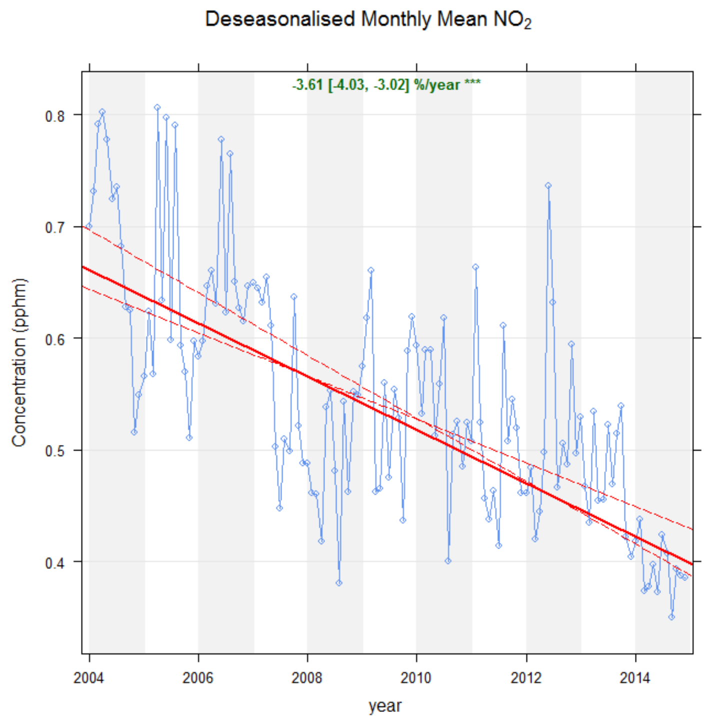
Richmond

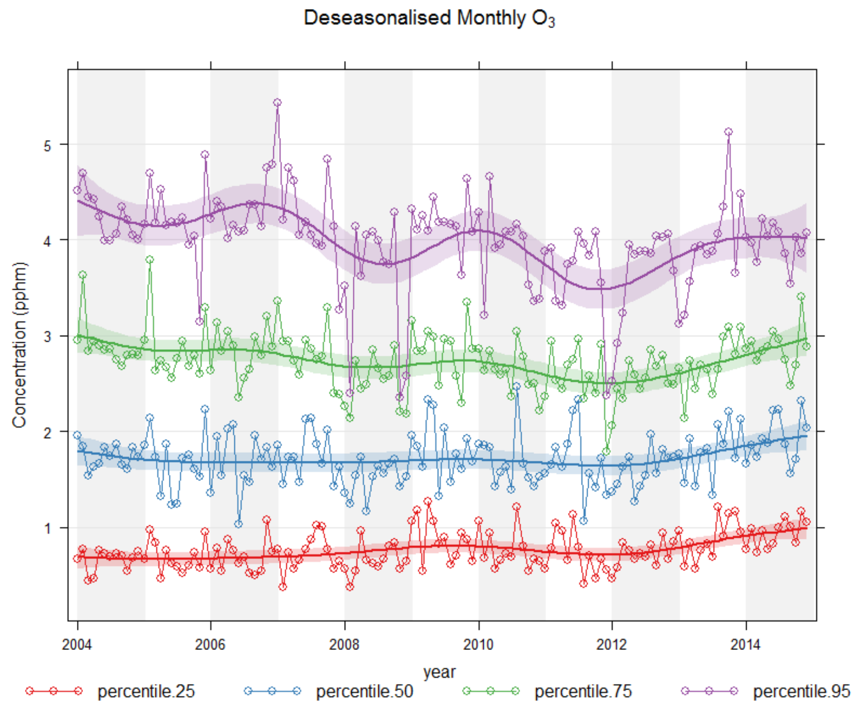
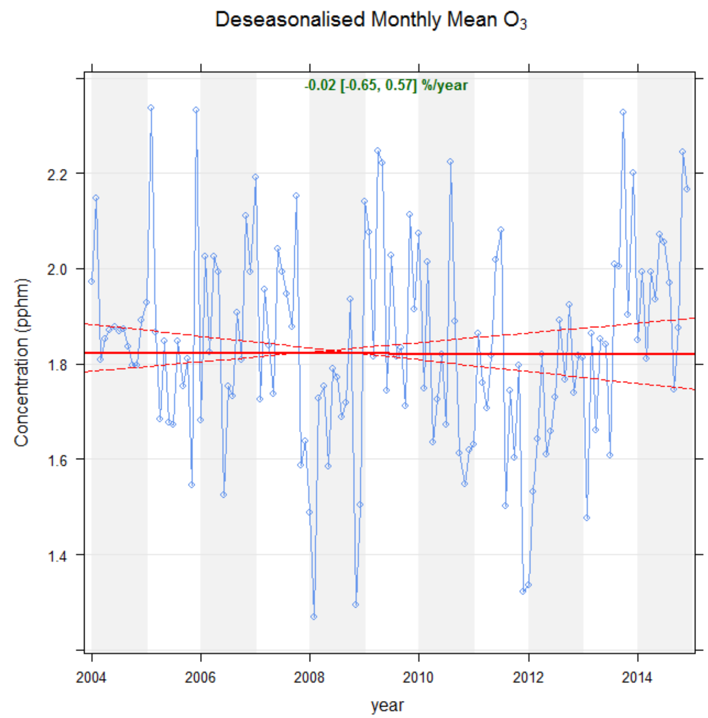


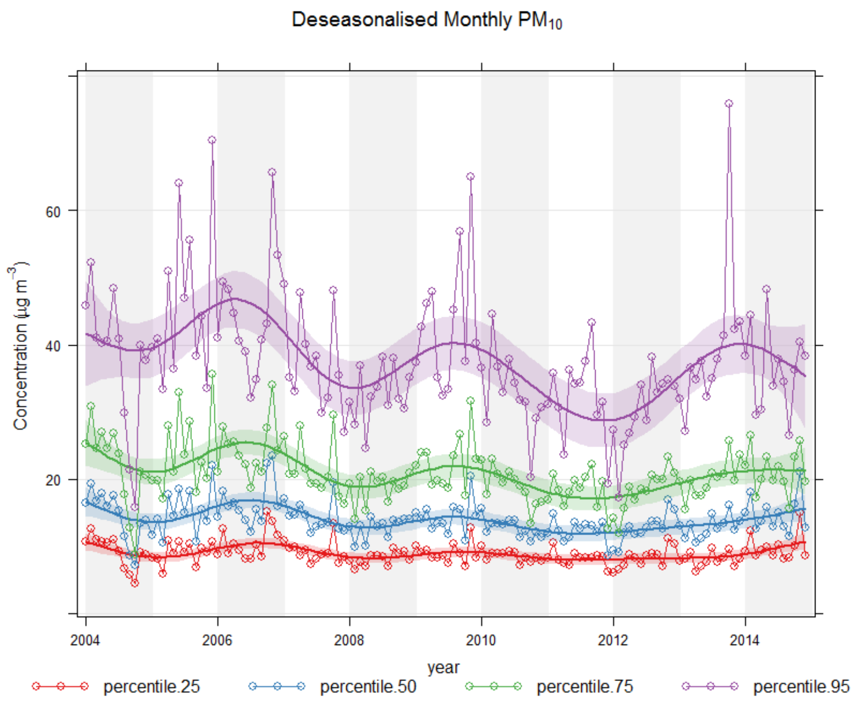
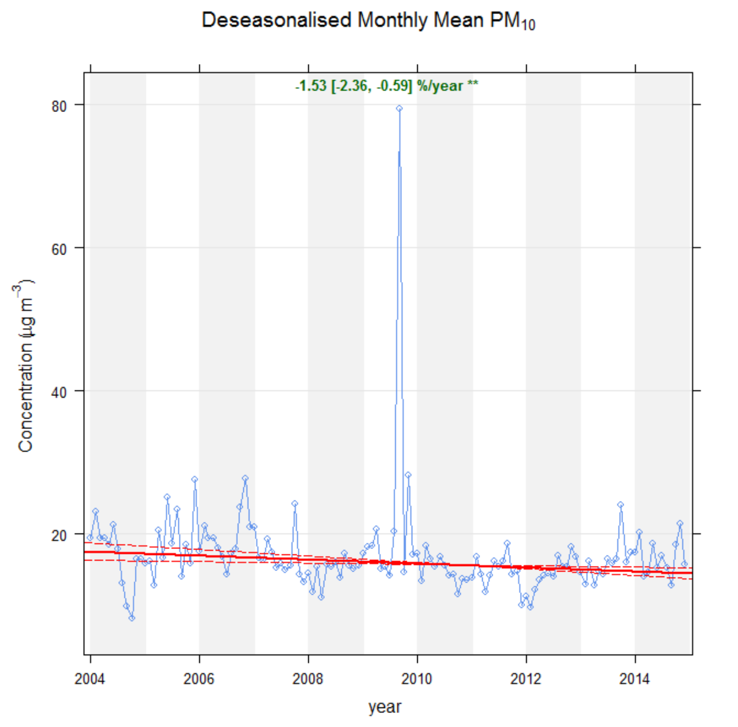
Monthly mean concentration with 95% confidence limits

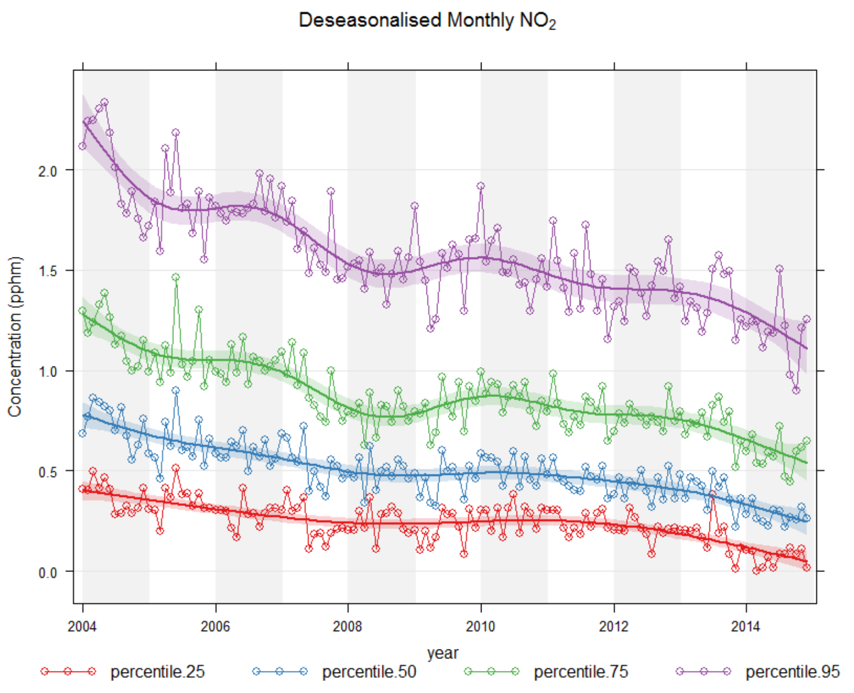
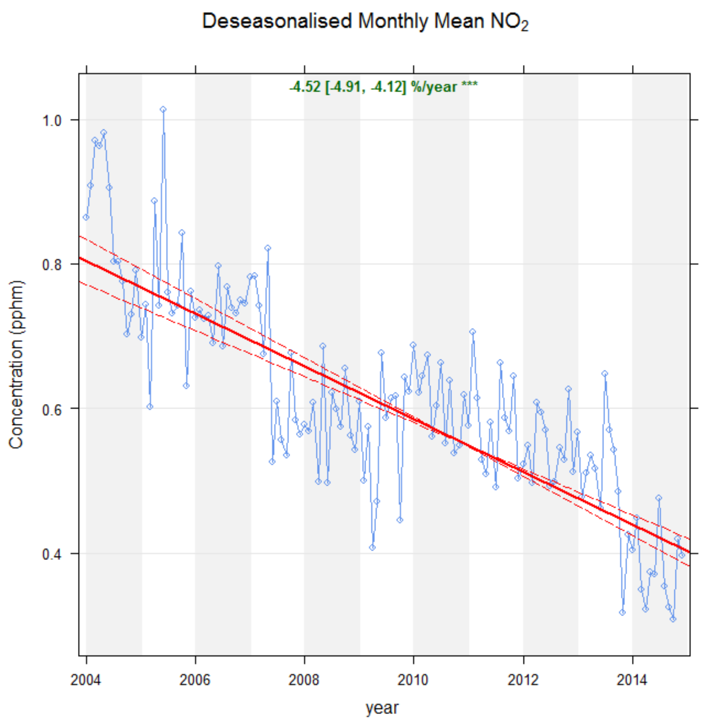


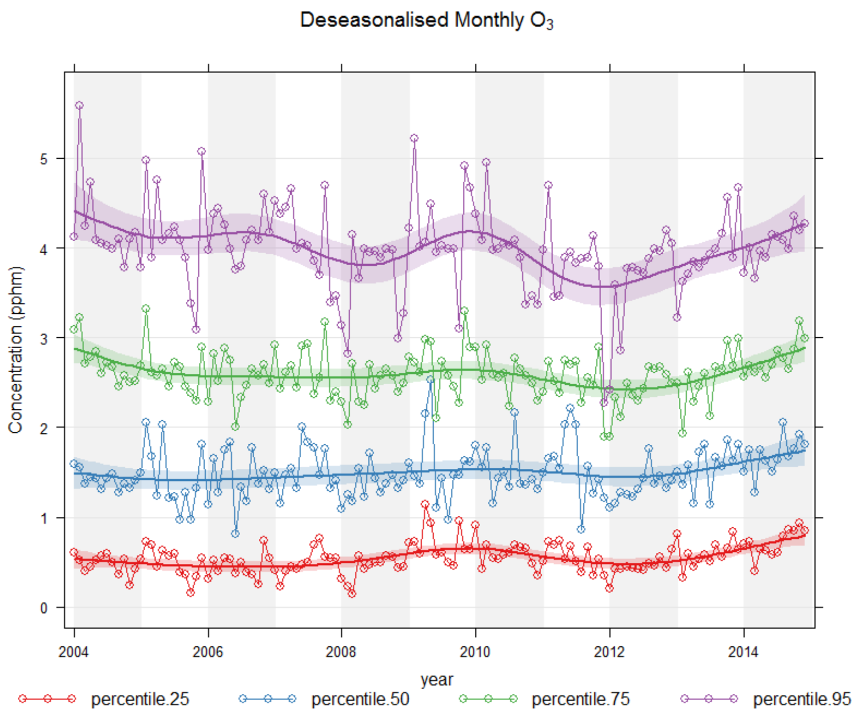
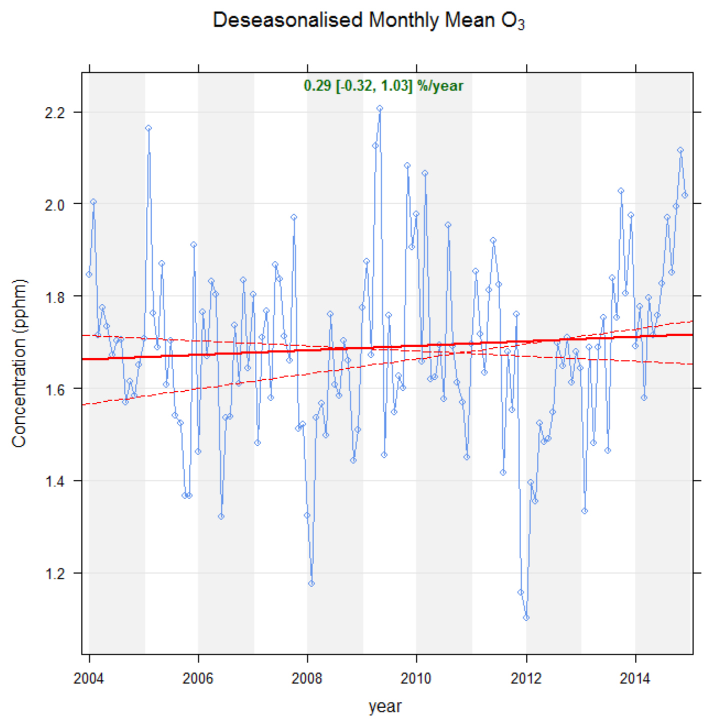
Trend in monthly mean concentration showing % change per year with 95% confidence limits

Richmond	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

Richmond	
 	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

St Marys	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

St Marys	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

St Marys	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

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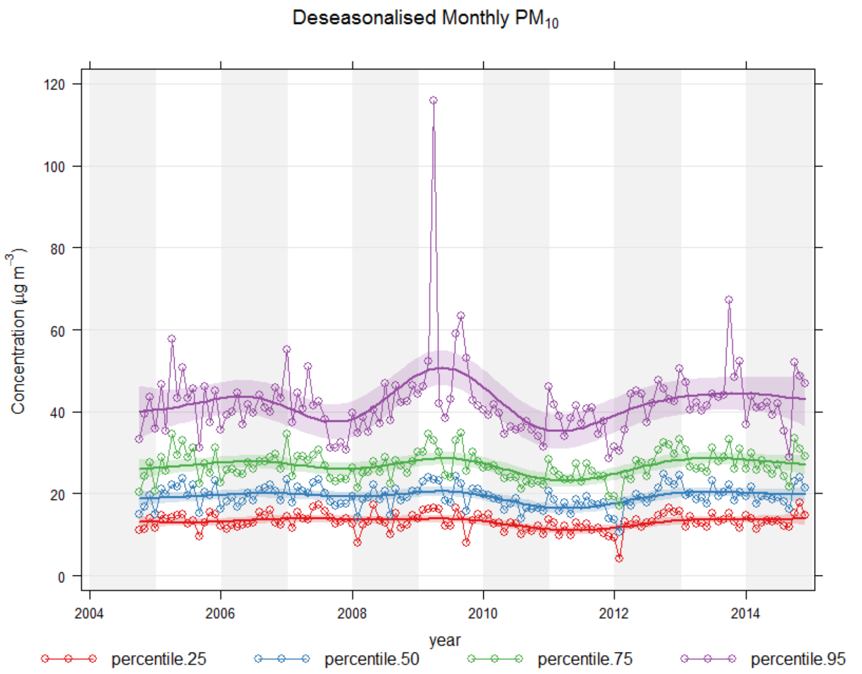
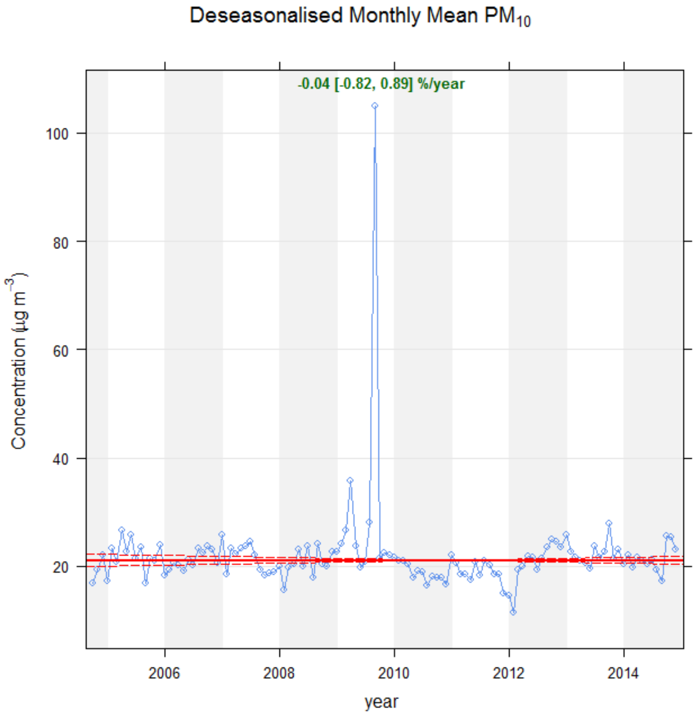
<tr><td>
</td><td>
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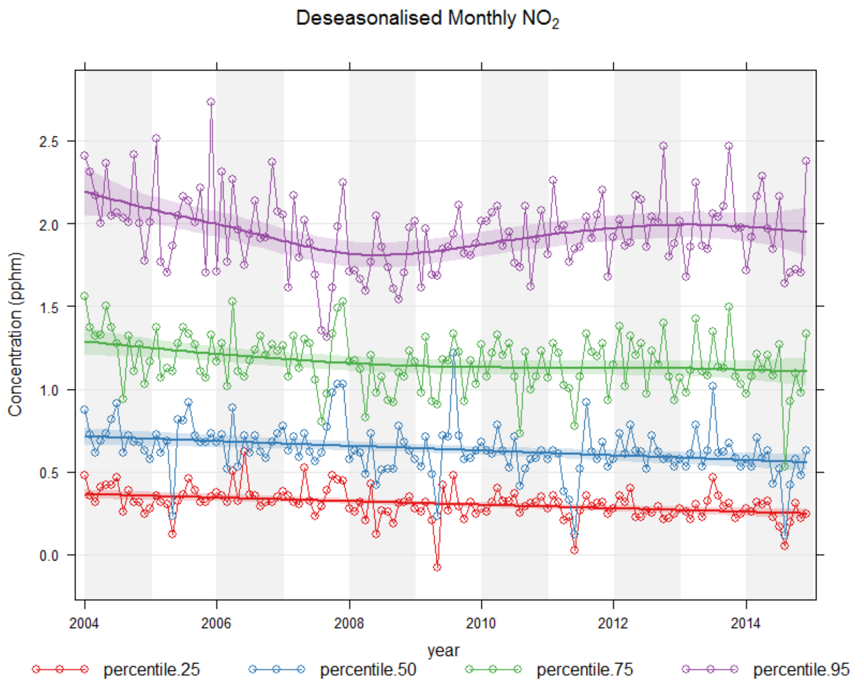	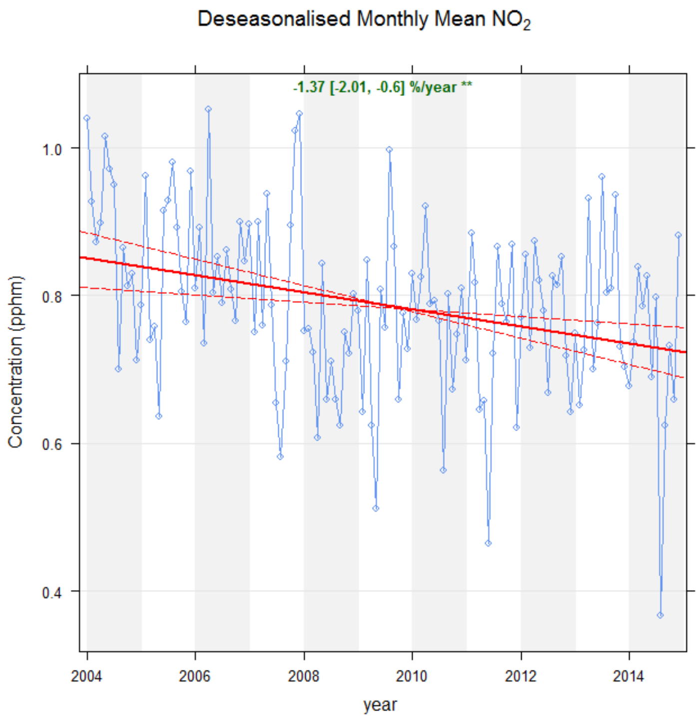
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

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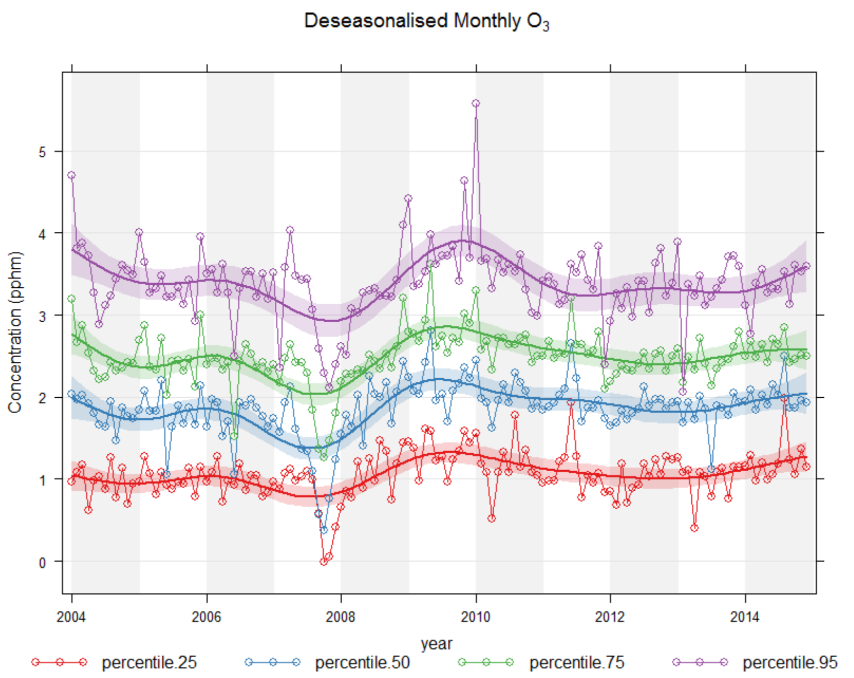	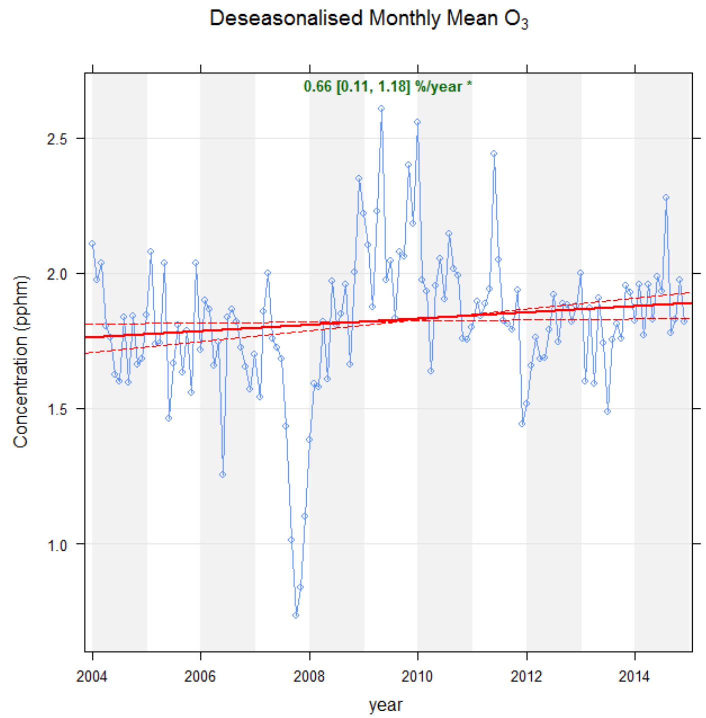
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

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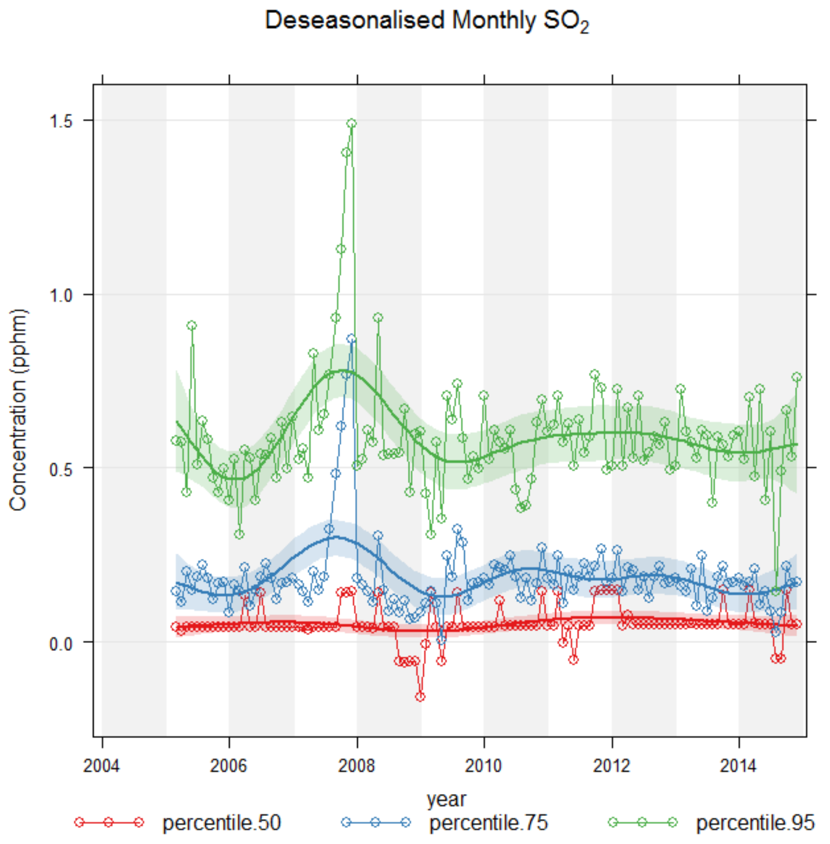
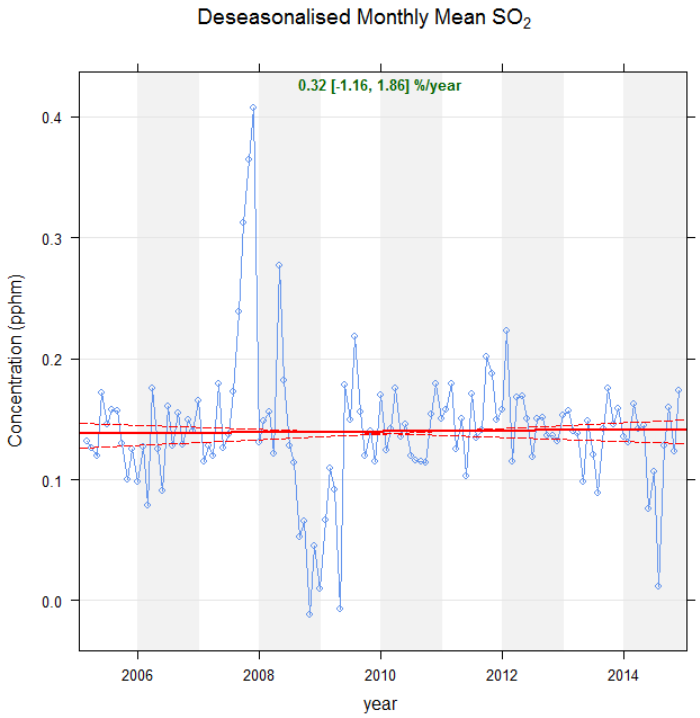
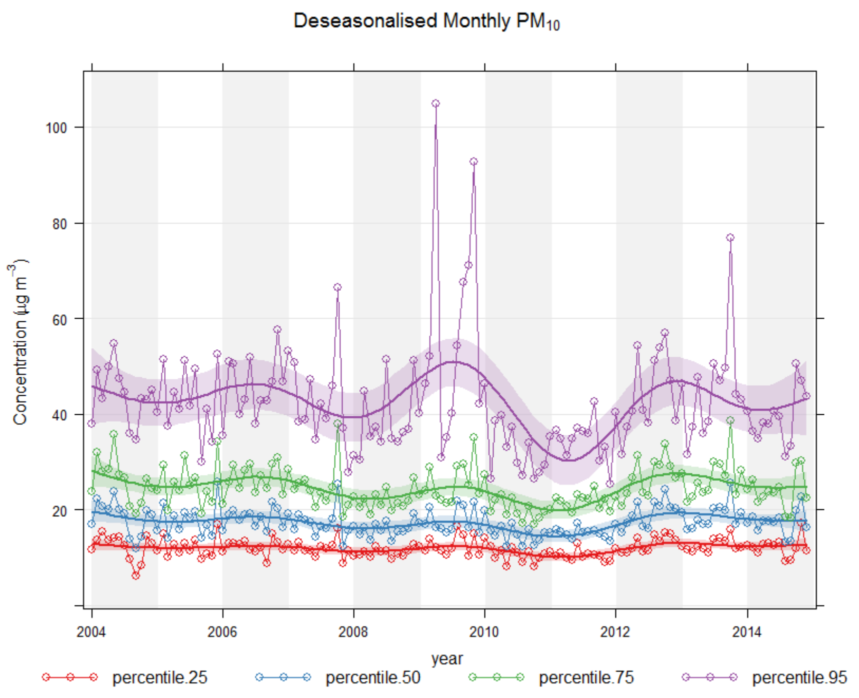
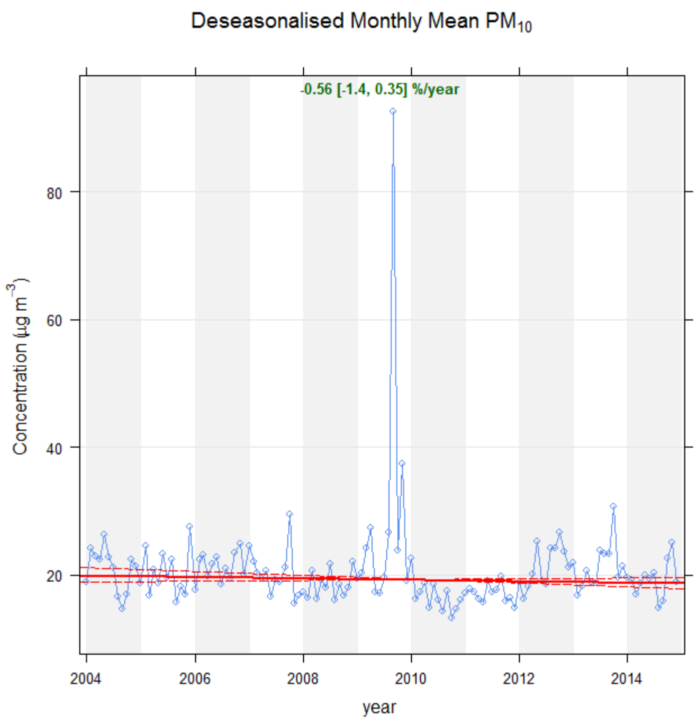
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

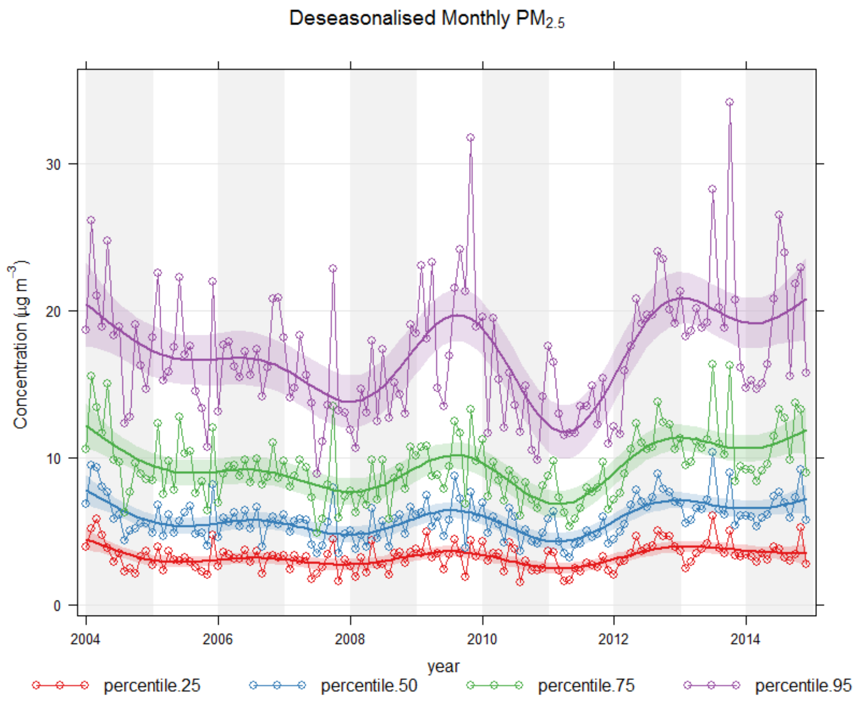
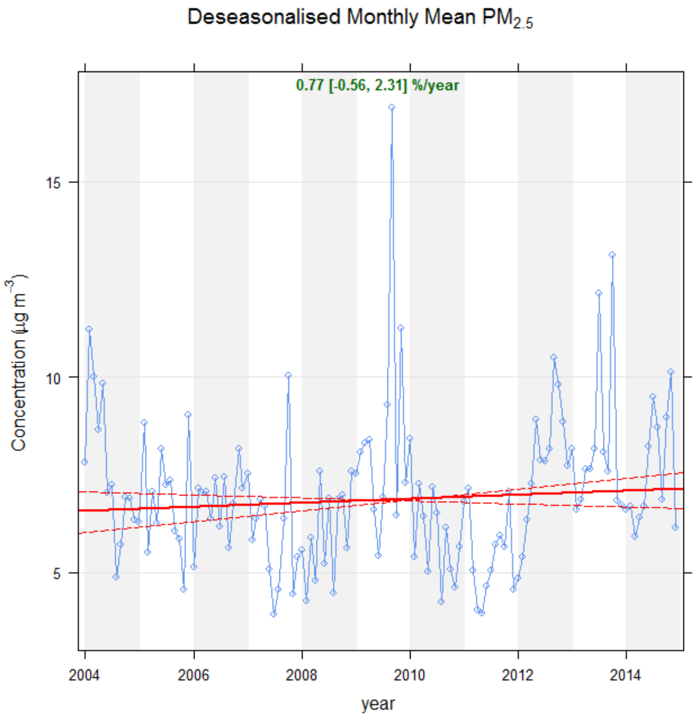
Beresfield



Monthly mean concentration with 95% confidence limits



Trend in monthly mean concentration showing % change per year with 95% confidence limits

Beresfield	
	
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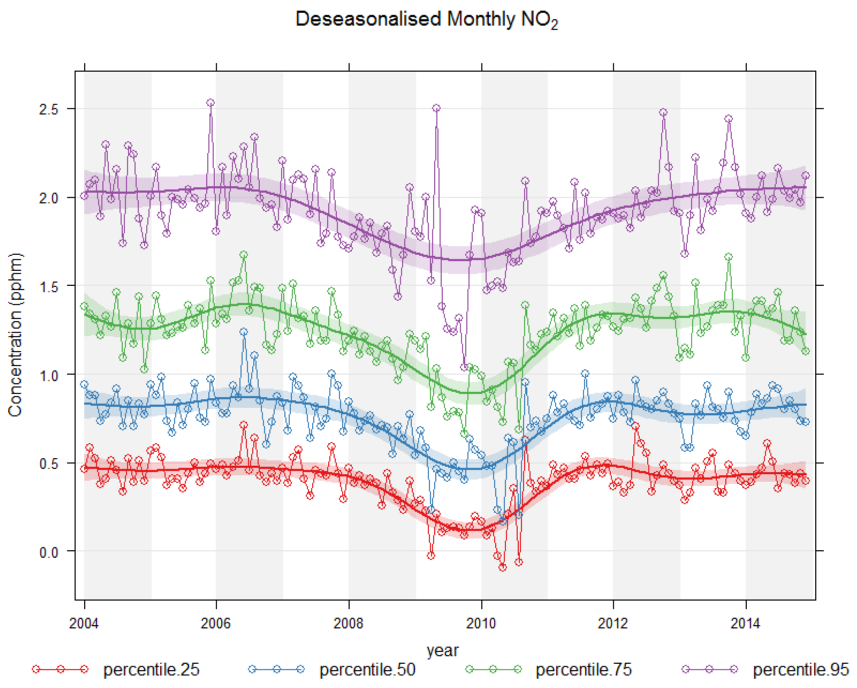	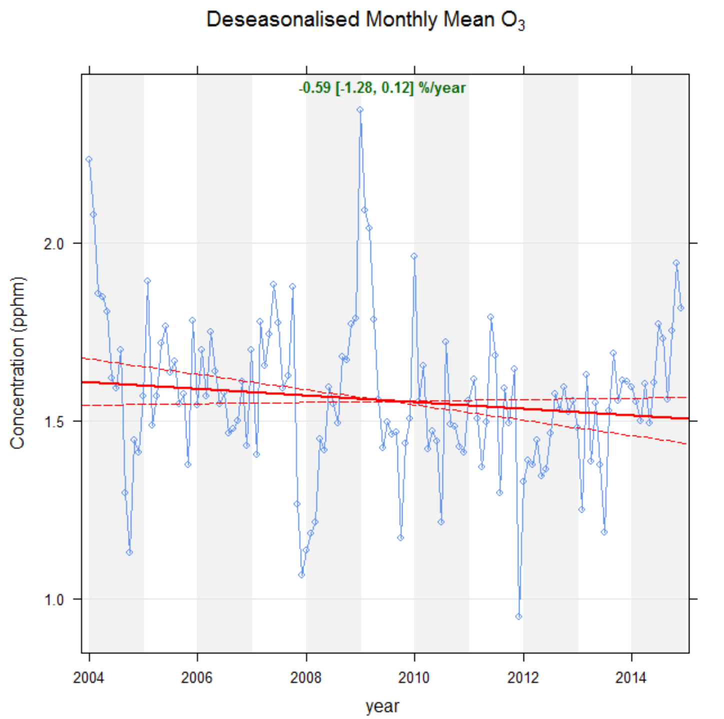
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

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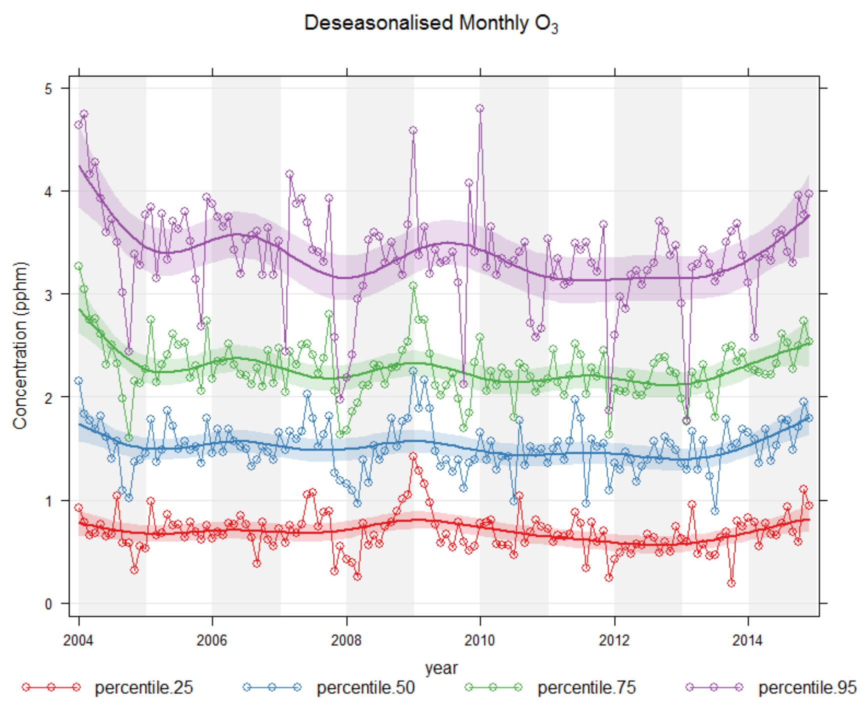	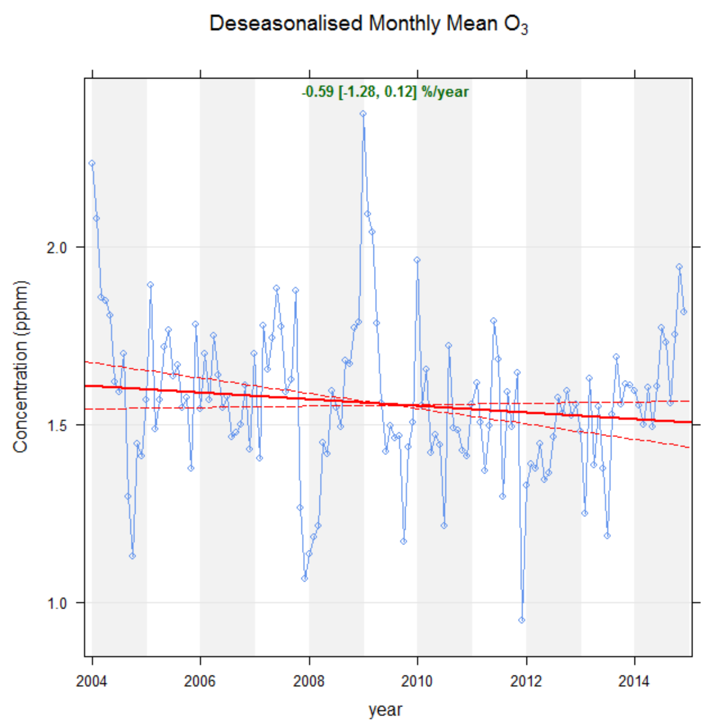
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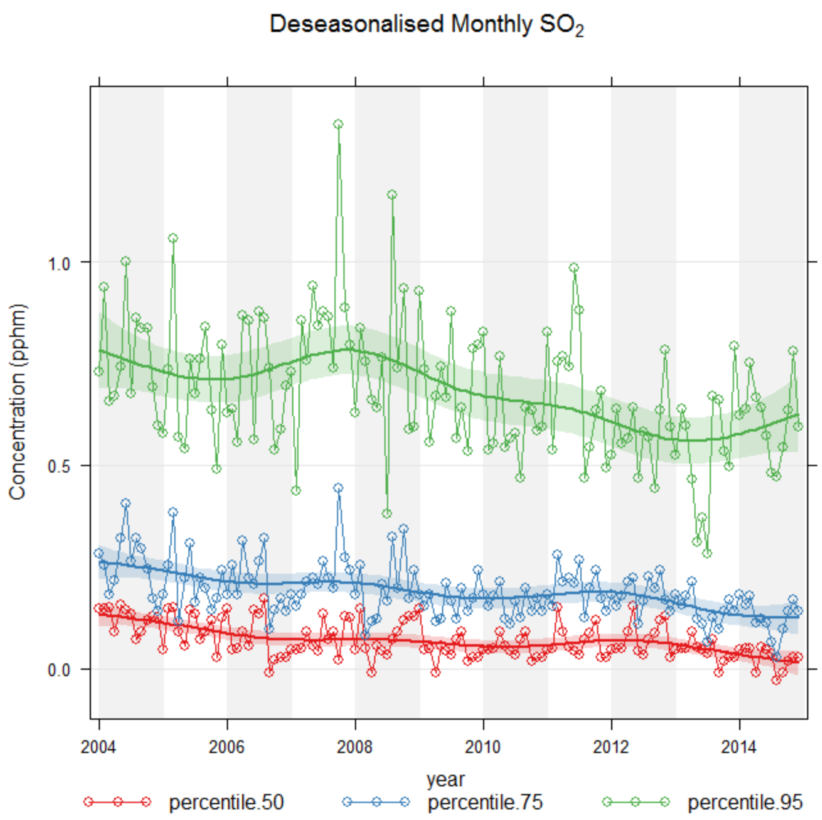
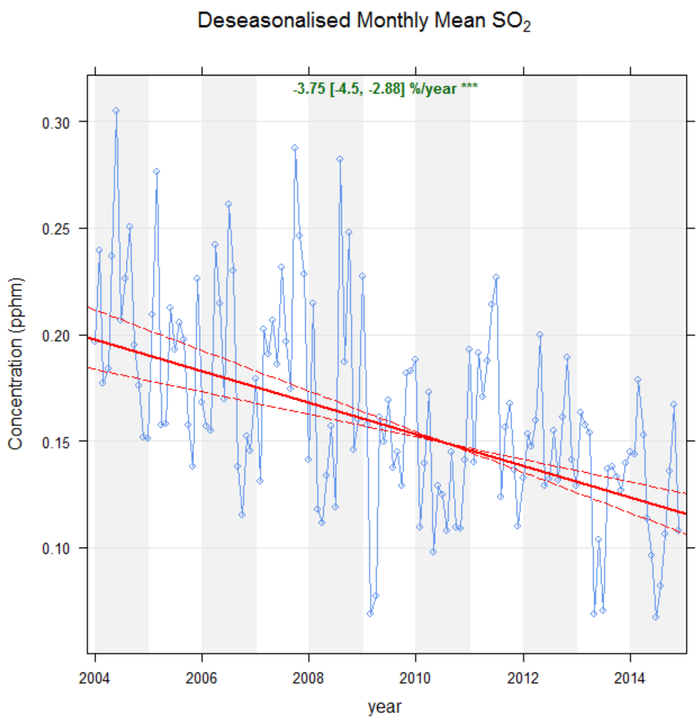
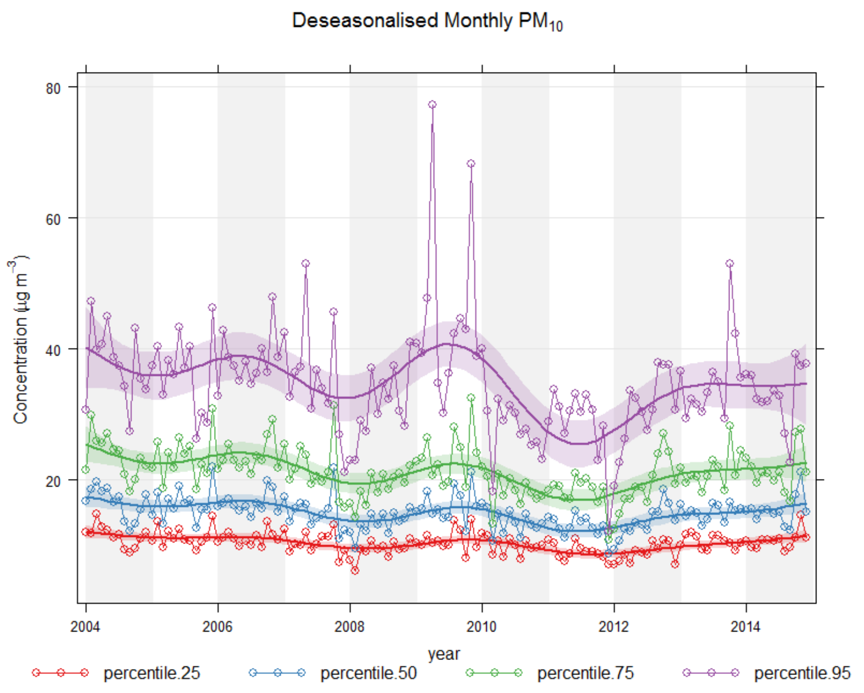
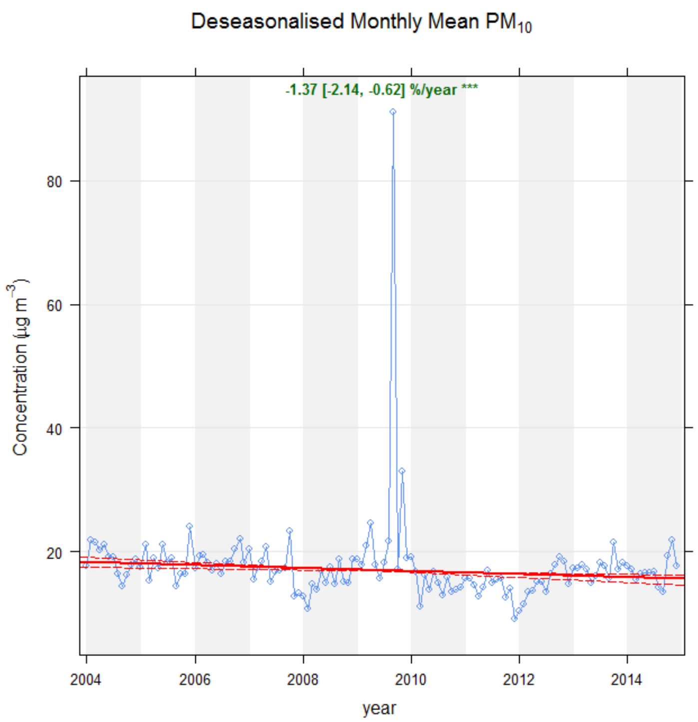
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

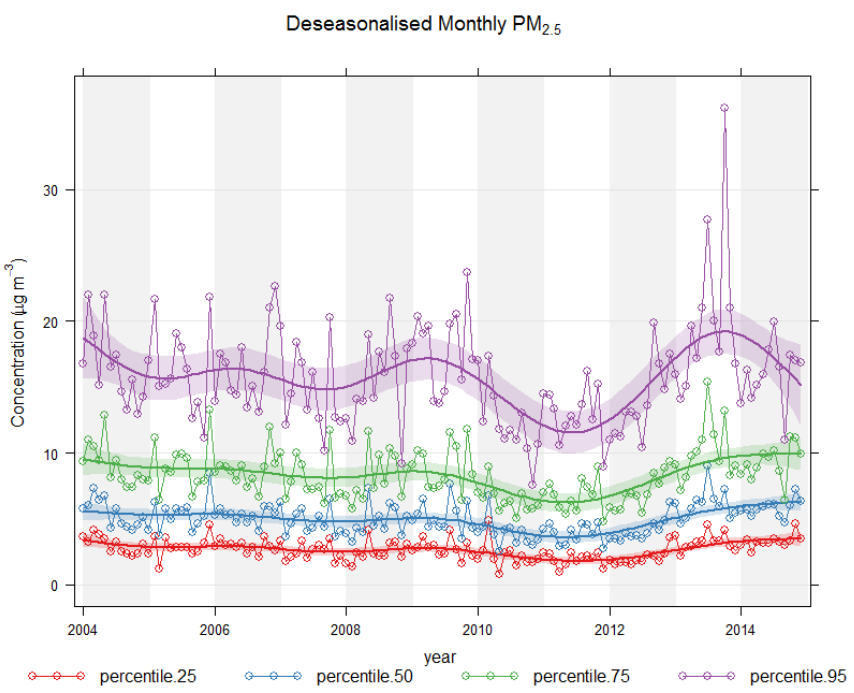
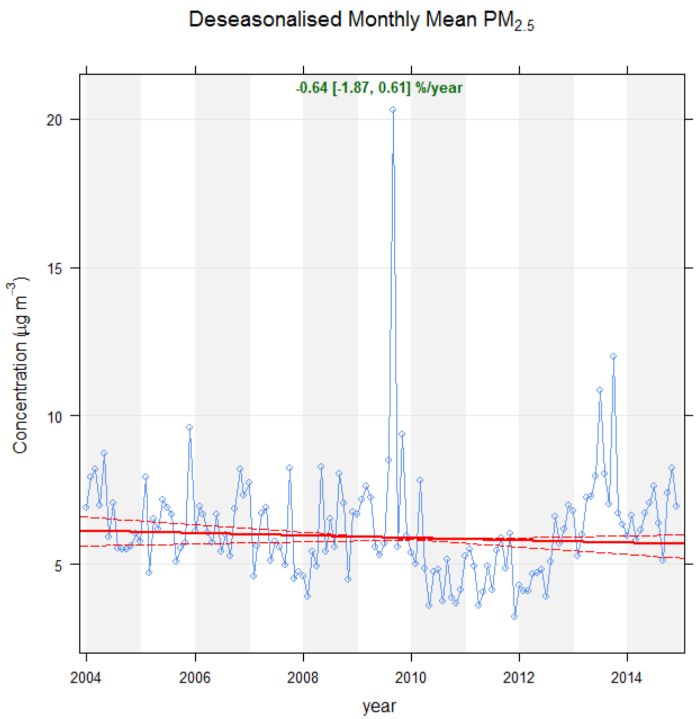
Wallsend

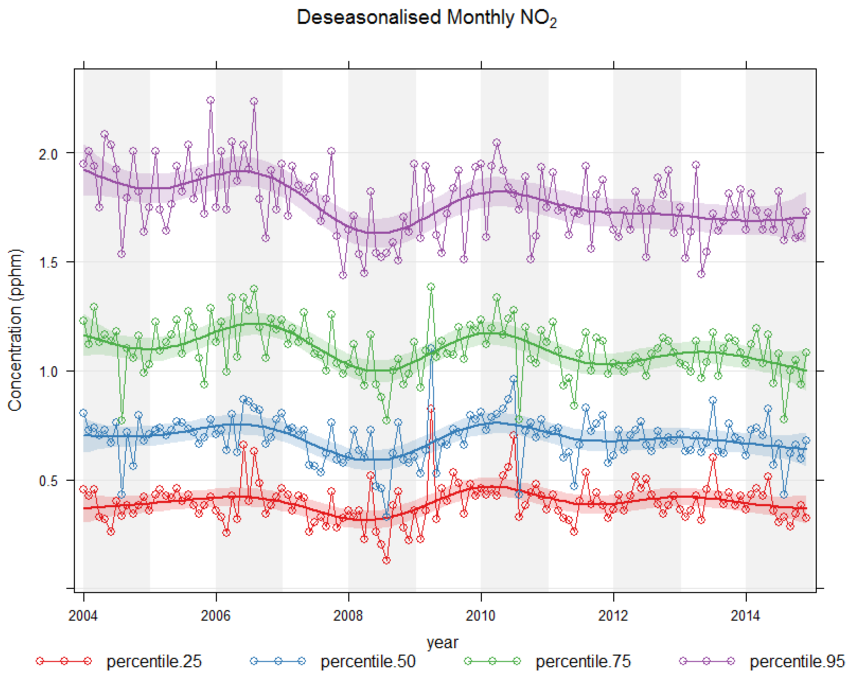
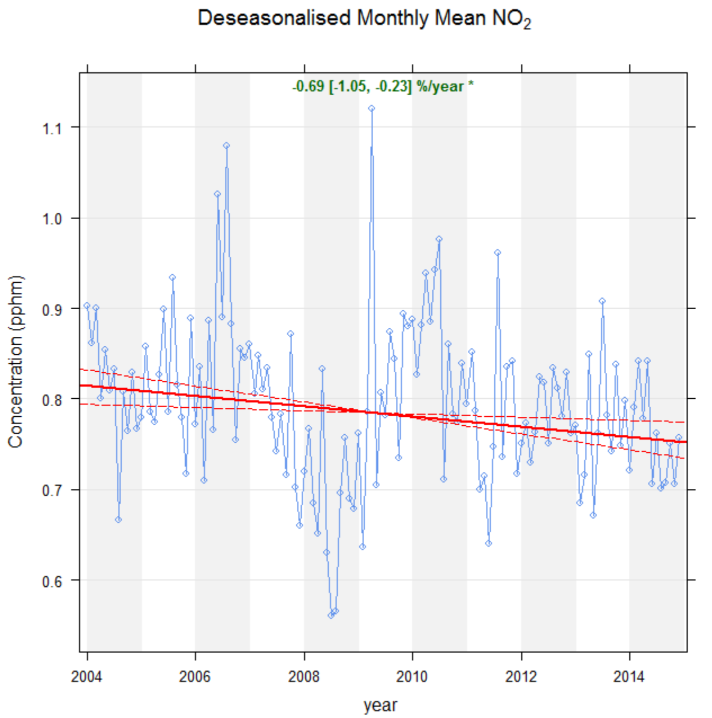


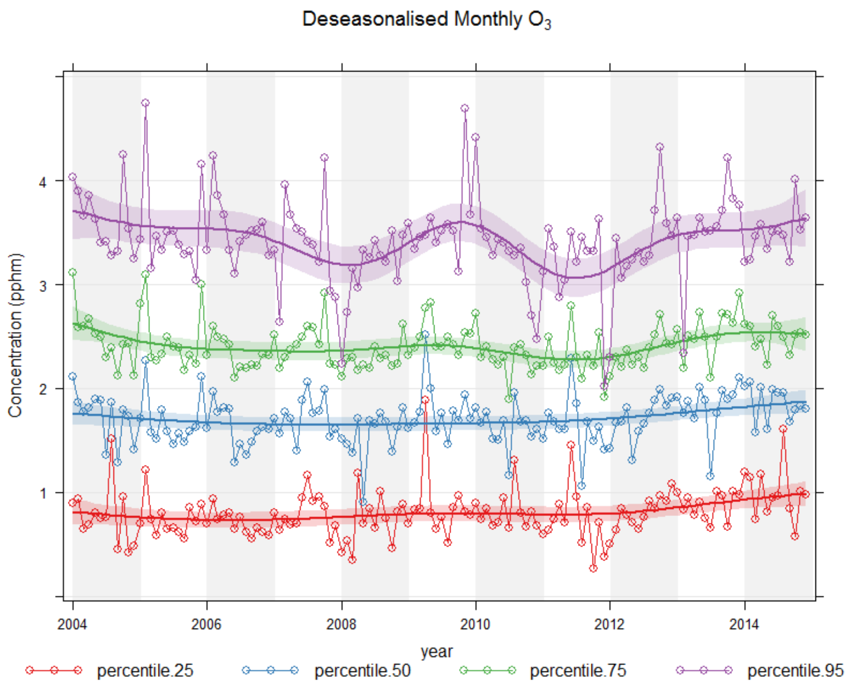
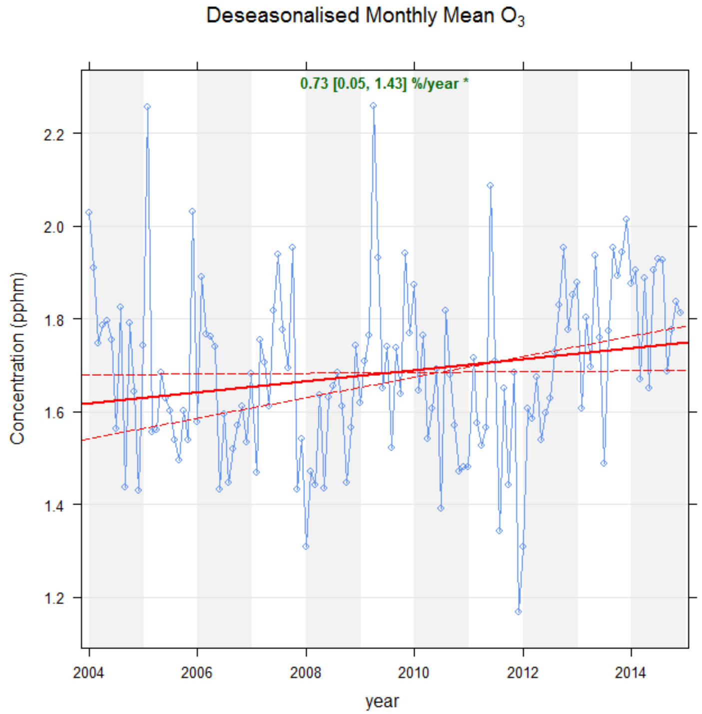
Monthly mean concentration with 95% confidence limits

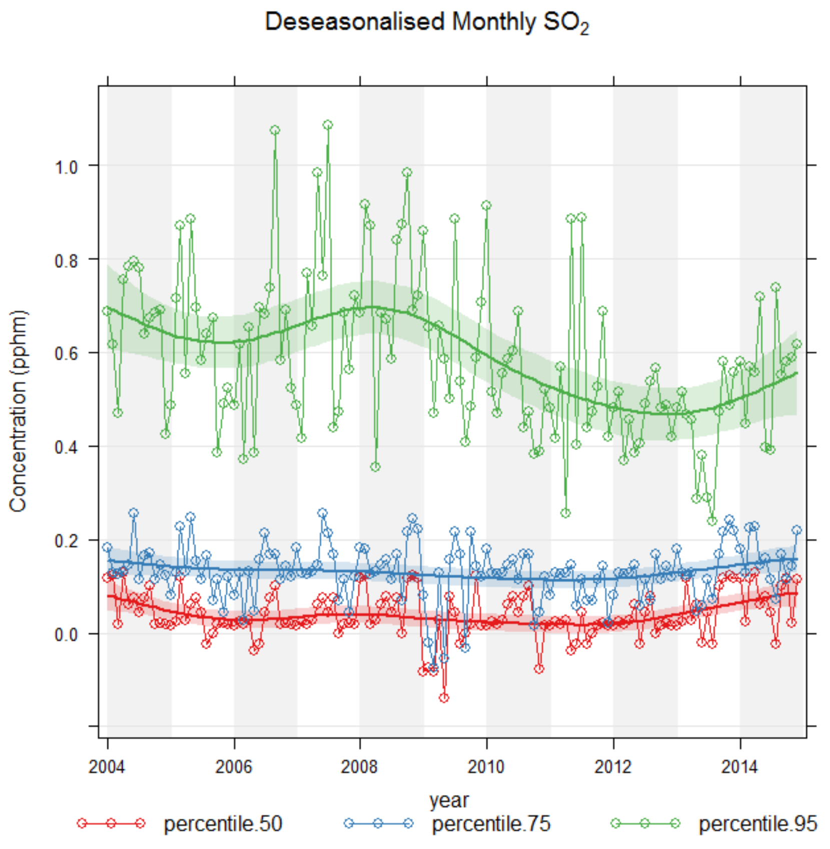
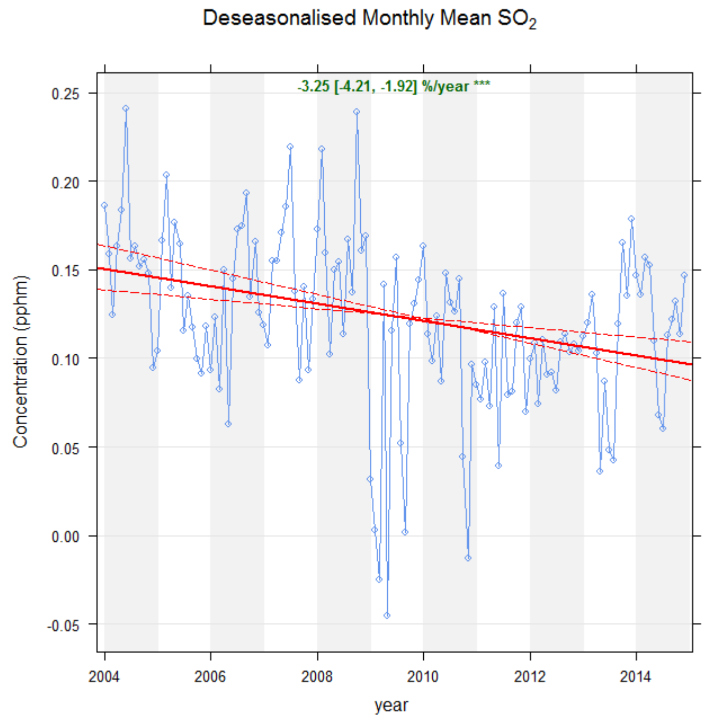


Trend in monthly mean concentration showing % change per year with 95% confidence limits

Wallsend	
 	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

Wallsend	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

Wallsend	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

Wallsend	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

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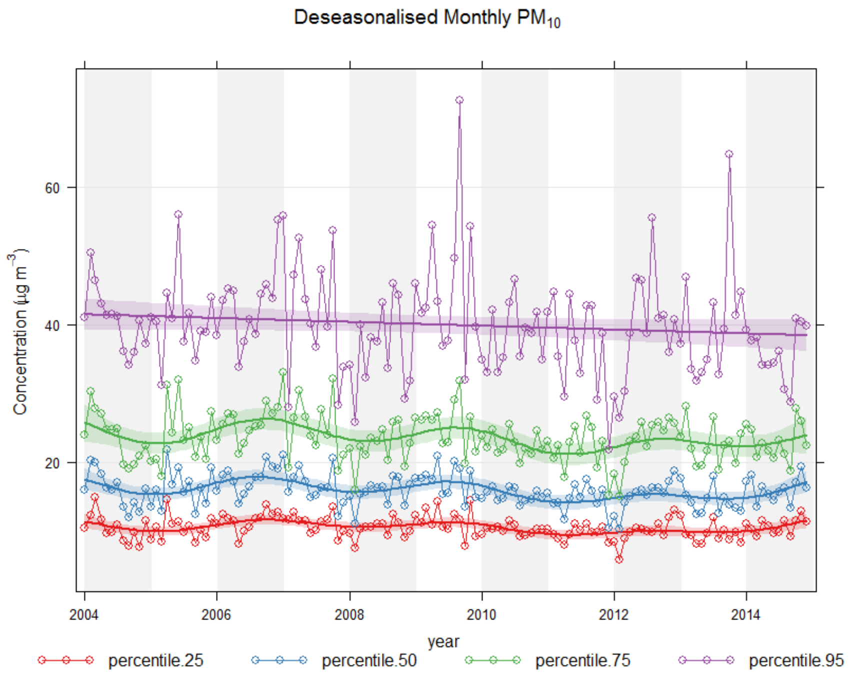
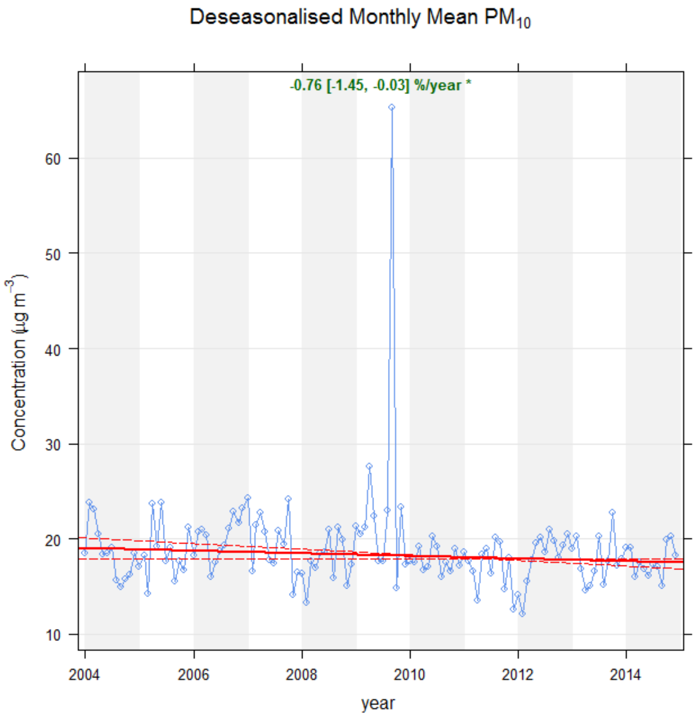
<tr><td></td><td></td></tr>
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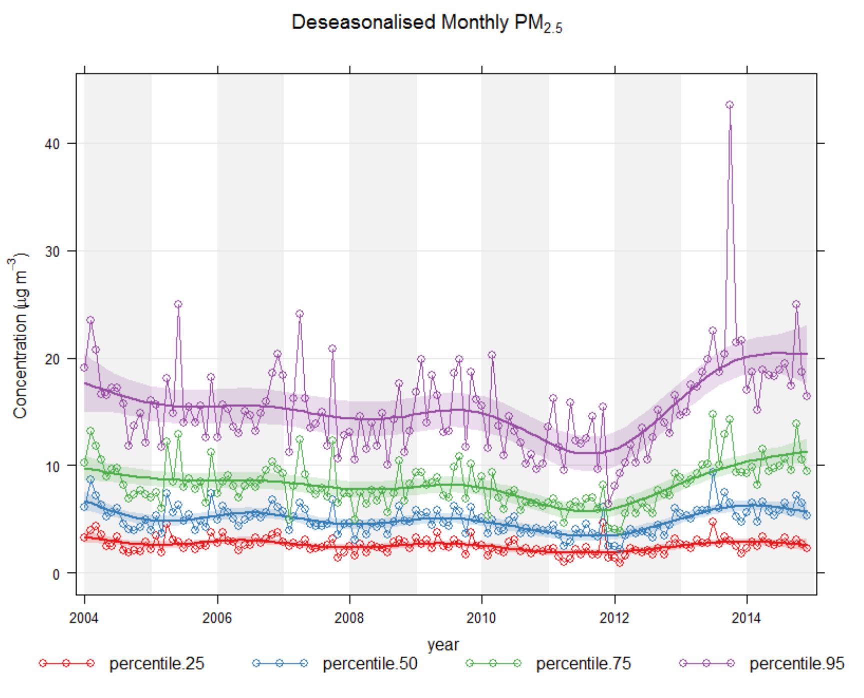
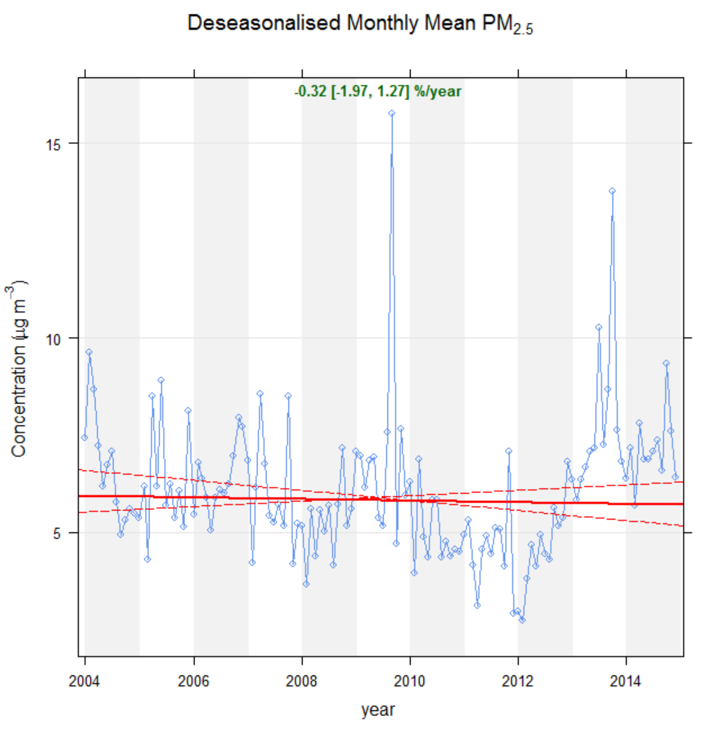
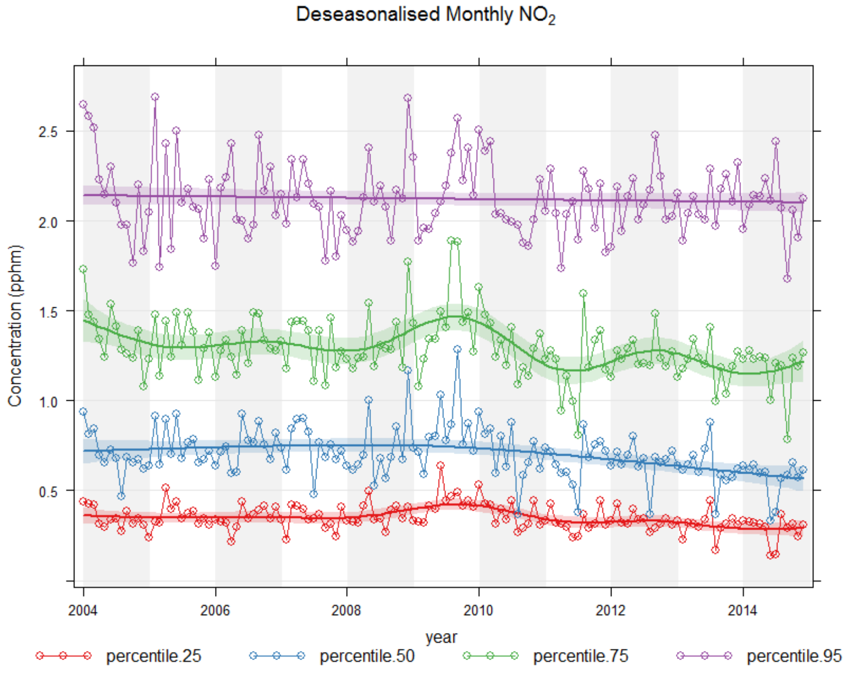
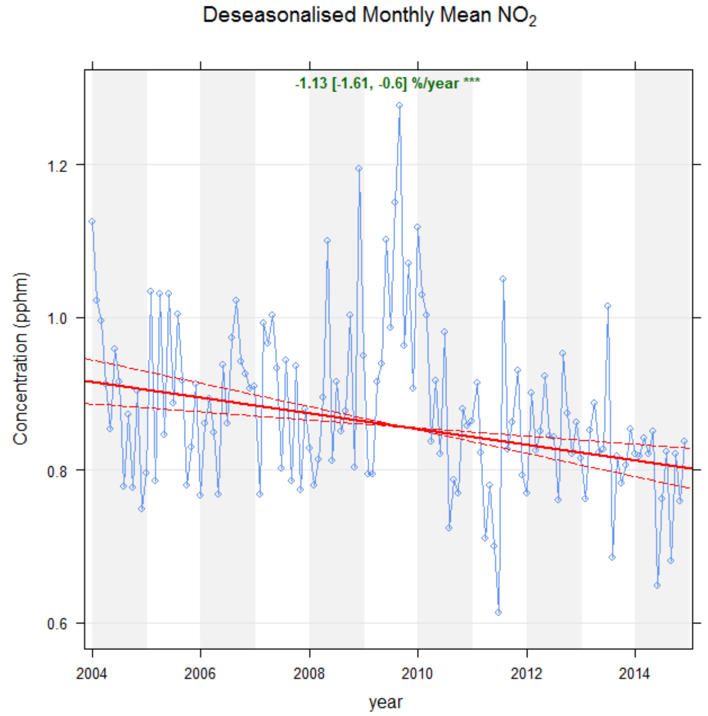
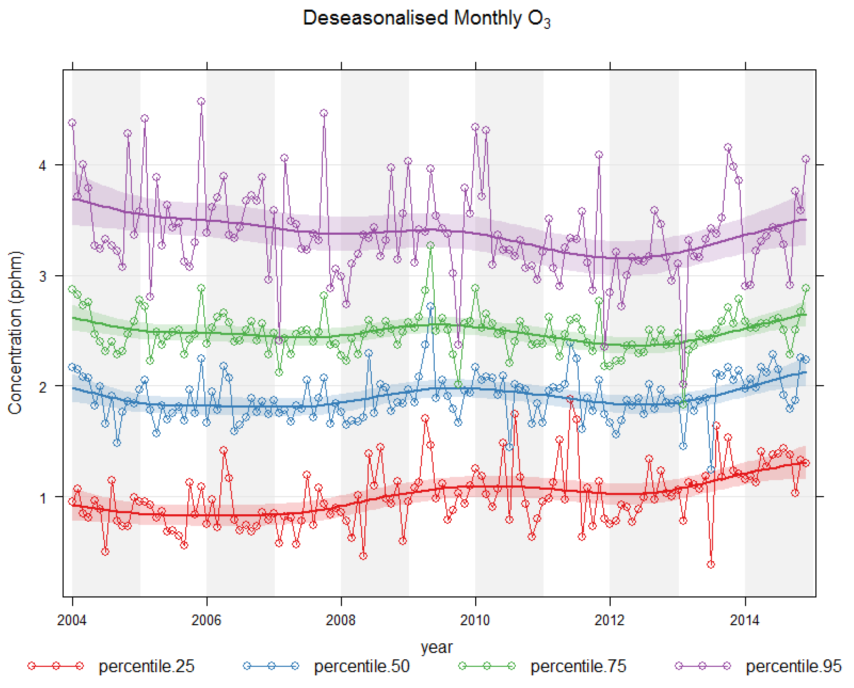
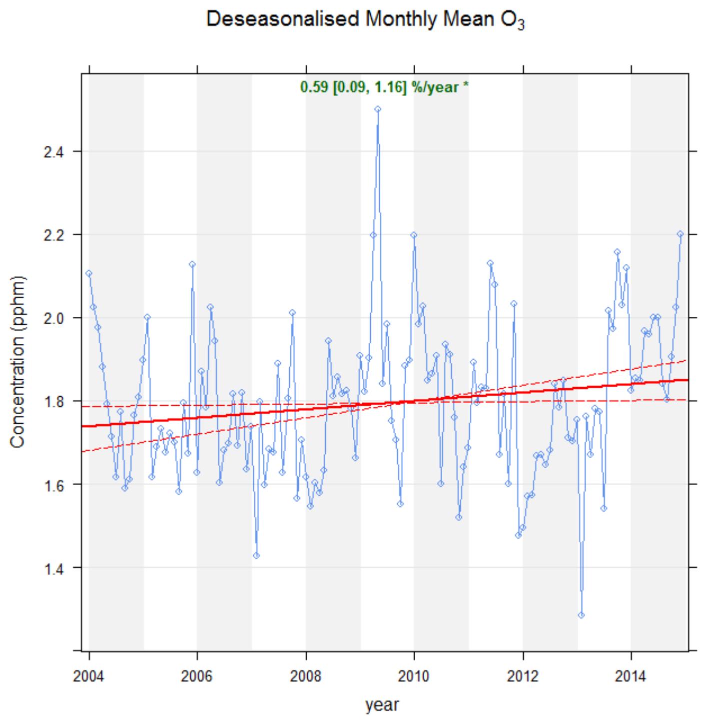
Wollongong	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

Wollongong	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

Wollongong



Monthly mean concentration with 95% confidence limits



Trend in monthly mean concentration showing % change per year with 95% confidence limits

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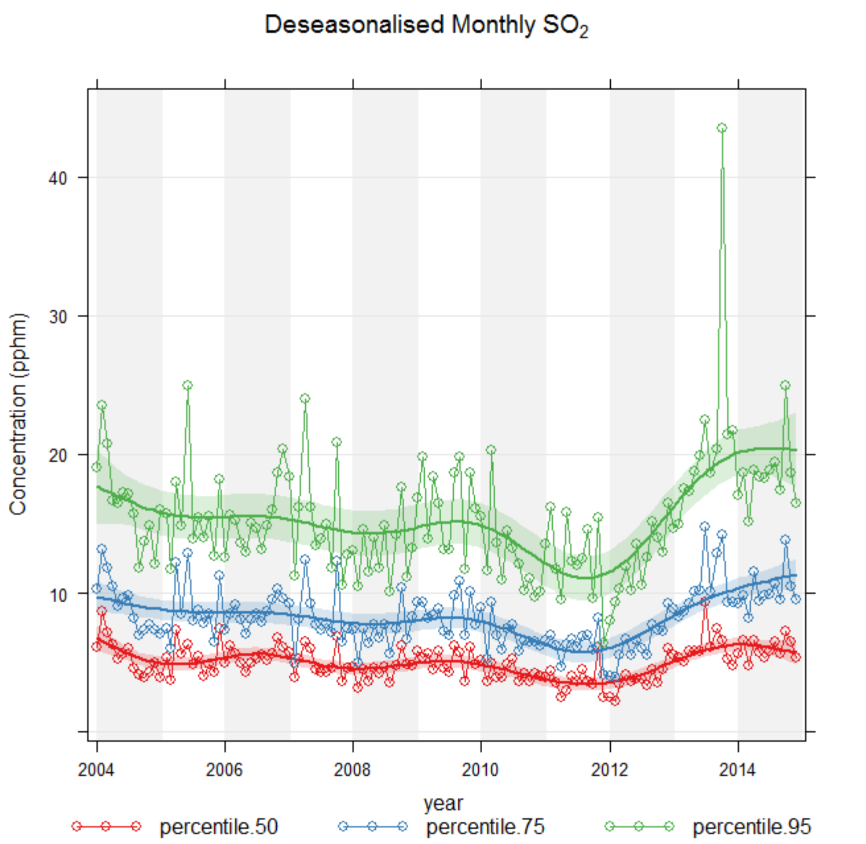
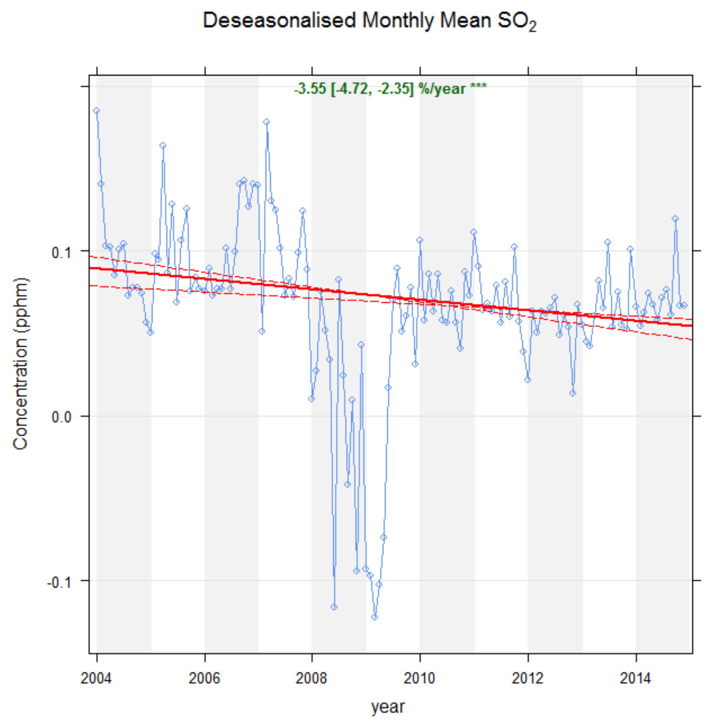
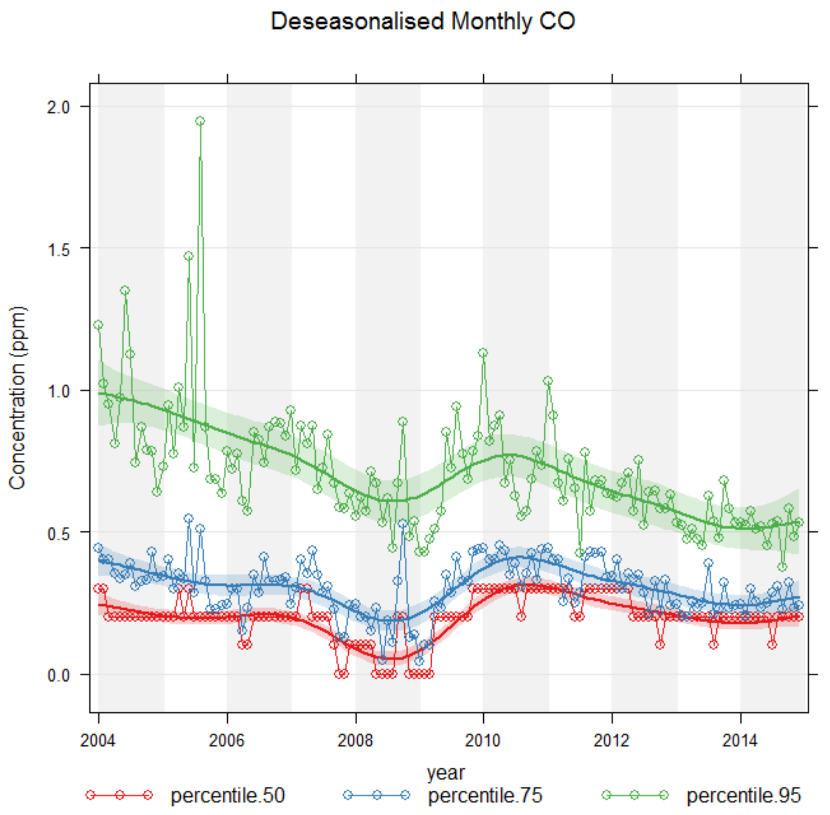
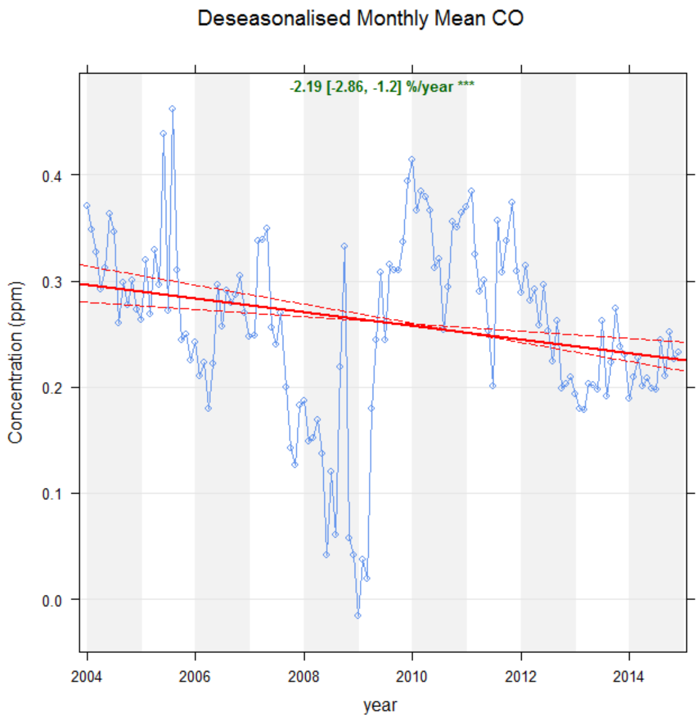
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

Wollongong	
	
Monthly mean concentration with 95% confidence limits	Trend in monthly mean concentration showing % change per year with 95% confidence limits

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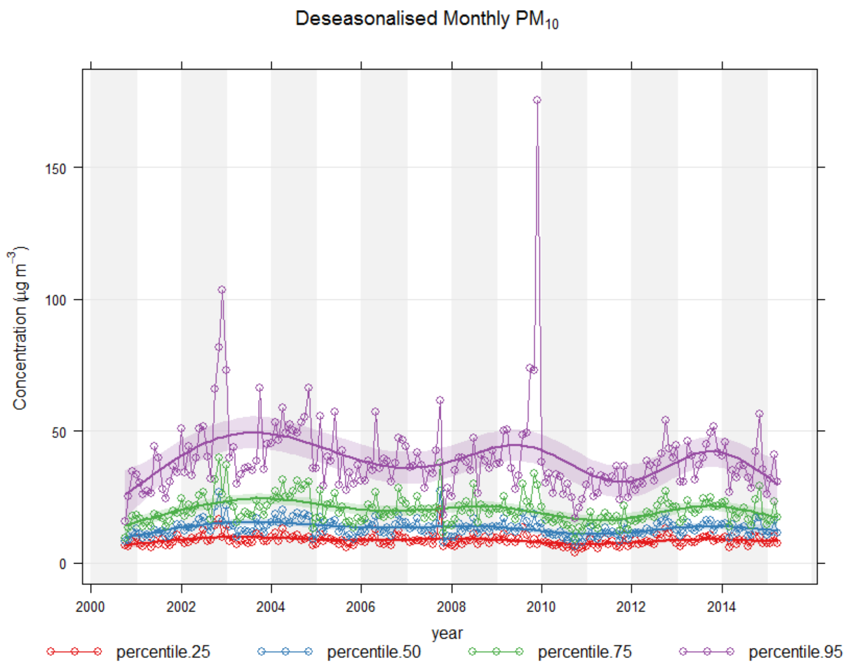
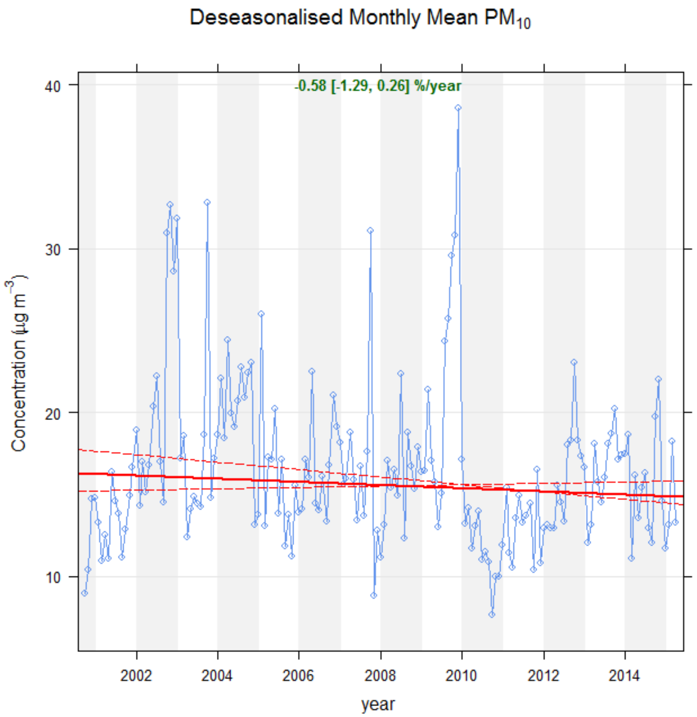
<tr><td>
</td><td>
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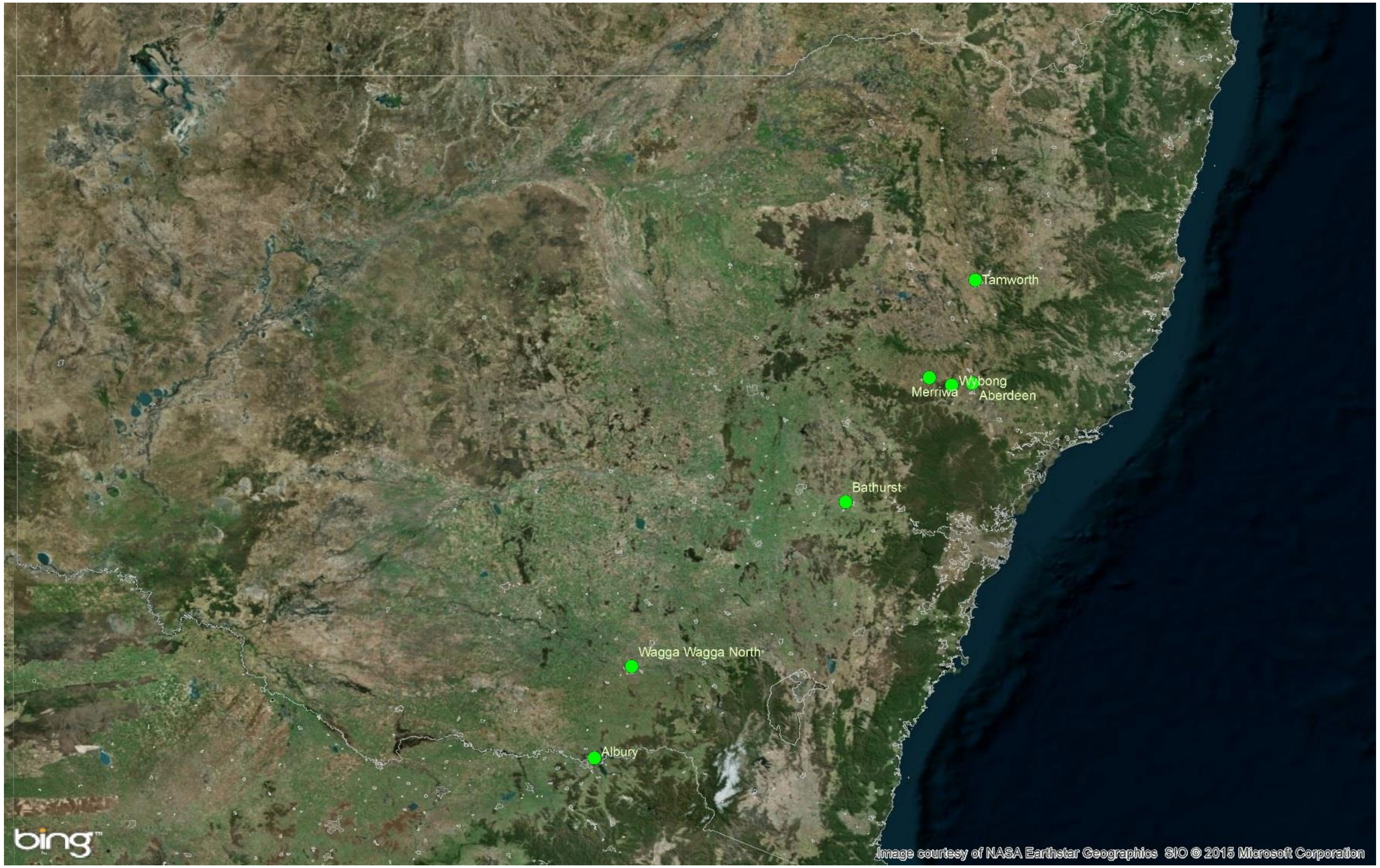
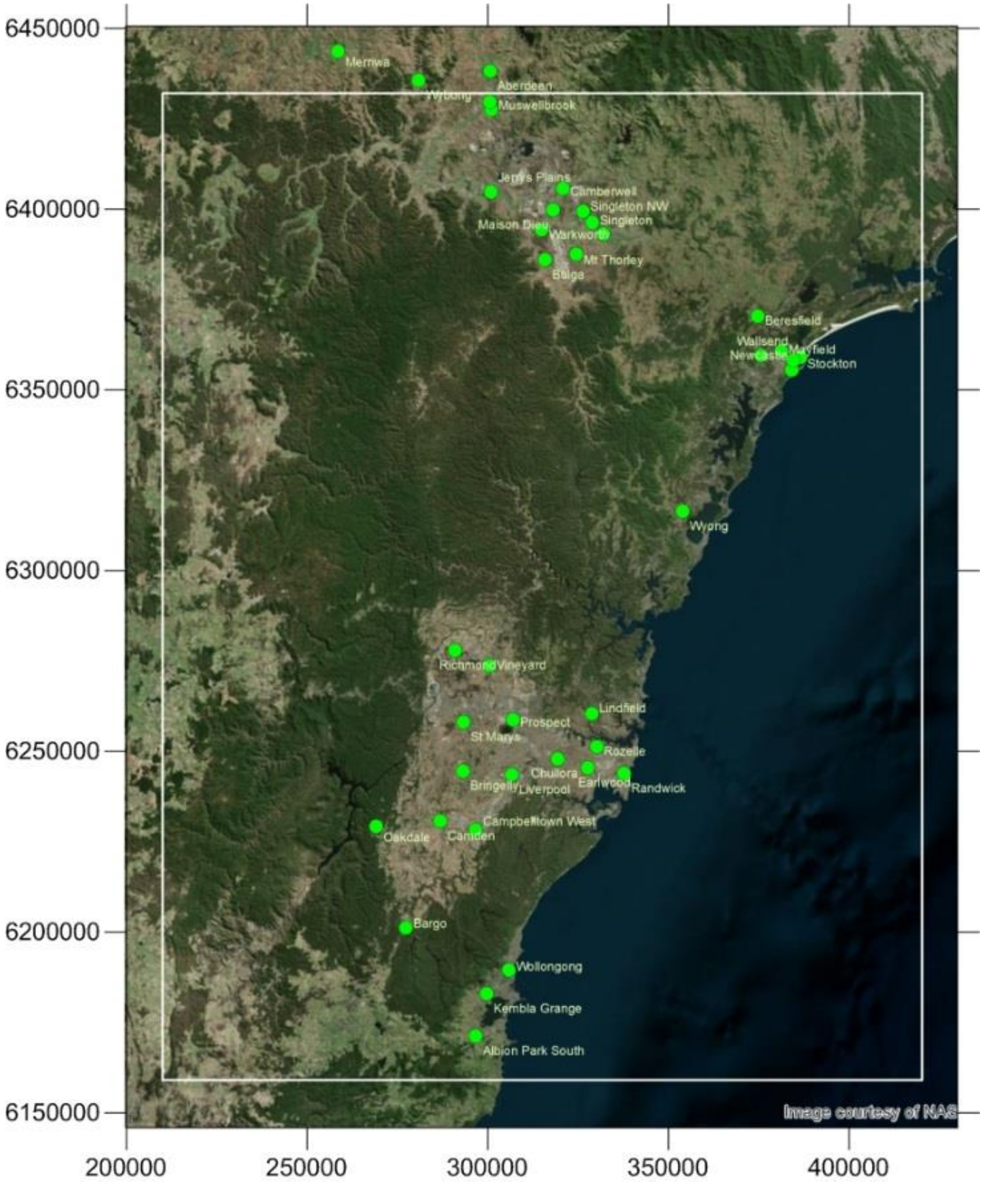
APPENDIX 3
SPATIAL COVERAGE AND POLLUTANTS MEASURED AT OEH MONITORING SITES

RAMBOLL ENVIRON

ENVIRONMENT
& HEALTH



Rural NSW coverage for OEH monitoring sites



NSW GMR coverage for OEH monitoring sites

Current OEH monitoring sites and pollutants measured

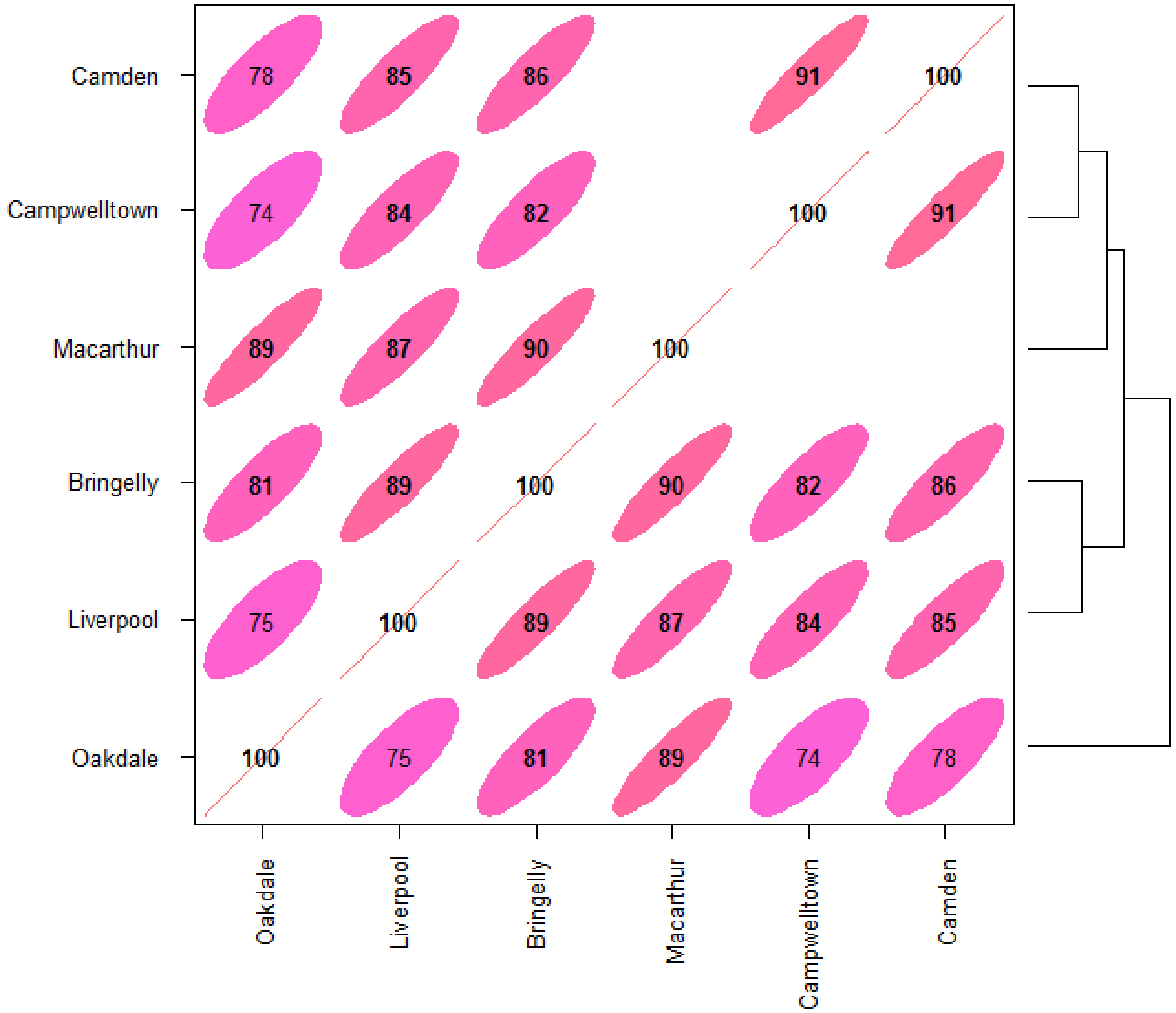
Site	Measured Parameters							
	O_3	NO_x	Neph	PM_{10}	$PM_{2.5}$	SO_2	CO	NH_3
Sydney								
Bargo	Yes	Yes	Yes		-	Yes	-	-
Bringelly	Yes	Yes	Yes	Yes	-	Yes	-	-
Camden	Yes	Yes		Yes	-		Yes	-
Campbelltown West	Yes	Yes	Yes	Yes	-	Yes	Yes	-
Chullora	Yes	Yes	Yes	Yes	Yes[T]	Yes	Yes	-
Earlwood	Yes	Yes	Yes	Yes	Yes[T]	-	-	-
Lindfield	Yes	Yes		Yes	-	Yes	-	-
Liverpool	Yes	Yes	Yes	Yes	Yes[T]		Yes	-
Oakdale	Yes	Yes	Yes	Yes	-	-	-	-
Prospect	Yes	Yes	Yes	Yes	-	-	Yes	-
Randwick	Yes	Yes	Yes	Yes	-	Yes	-	-
Richmond	Yes	Yes	Yes	Yes	Yes[T]	Yes	-	-
Rozelle	Yes	Yes	Yes	Yes	-	-	Yes	-
St Marys	Yes	Yes	Yes	Yes	-	-	-	-
Vineyard	Yes	Yes	Yes	Yes	-	Yes	-	-
Illawarra								
Albion Park South	Yes	Yes	Yes	Yes	-	Yes	-	-
Kembla Grange	Yes	Yes	Yes	Yes	-	-	-	-
Wollongong	**Yes**	**Yes**	**Yes**	**Yes**	**Yes[T]**	**Yes**	**Yes**	**-**
Rural								
Albury	-	-	-	Yes	-	-	-	-
Bathurst	-	-	-	Yes	-	-	-	-
Tamworth	-	-	-	Yes	-	-	-	-
Wagga Wagga North	-	-	-	Yes	Yes[B]	-	-	-
Lower Hunter								
Beresfield	**Yes**	**Yes**	**Yes**	**Yes**	**Yes[T]**	**Yes**	**-**	**-**
Newcastle	**Yes**	**Yes**	**Yes**	**Yes**	**-**	**Yes**	**Yes**	**-**
Wallsend	Yes	Yes	Yes	Yes	Yes[T]	Yes	-	-
Newcastle Local								
Carrington	-	Yes	-	Yes	Yes[T]	Yes	-	-
Mayfield	-	Yes	-	Yes	Yes[T]	Yes	-	-
Stockton	-	Yes	-	Yes	Yes[T]	Yes	-	Yes

Site	Measured Parameters							
	O_3	NO_x	Neph	PM_{10}	$PM_{2.5}$	SO_2	CO	NH_3
Central Coast								
Wyong	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-
Upper Hunter								
Singleton	-	Yes	-	Yes	Yes[B]	Yes	-	-
Muswellbrook	-	Yes	-	Yes	Yes[B])	Yes	-	-
Maison Dieu	-	-	-	Yes	-	-	-	-
Bulga	-	-	-	Yes	-	-	-	-
Mt Thorley	-	-	-	Yes	-	-	-	-
Camberwell	-	-	-	Yes	Yes[B]	-	-	-
Singleton NW	-	-	-	Yes	-	-	-	-
Singleton South	-	-	-	Yes	-	-	-	-
Warkworth	-	-	-	Yes	-	-	-	-
Jerrys Plains	-	-	-	Yes	-	-	-	-
Muswellbrook NW	-	-	-	Yes	-	-	-	-
Aberdeen	-	-	-	Yes	-	-	-	-
Wybong	-	-	-	Yes	-	-	-	-
Merriwa	-	-	-	Yes	-	-	-	-

Notes:
[1] Neph = fine particles by nephelometer.
[2] PM_{10} measured using TEOMs. $PM_{2.5}$ measured using TEOMs (T) and BAMs (B).

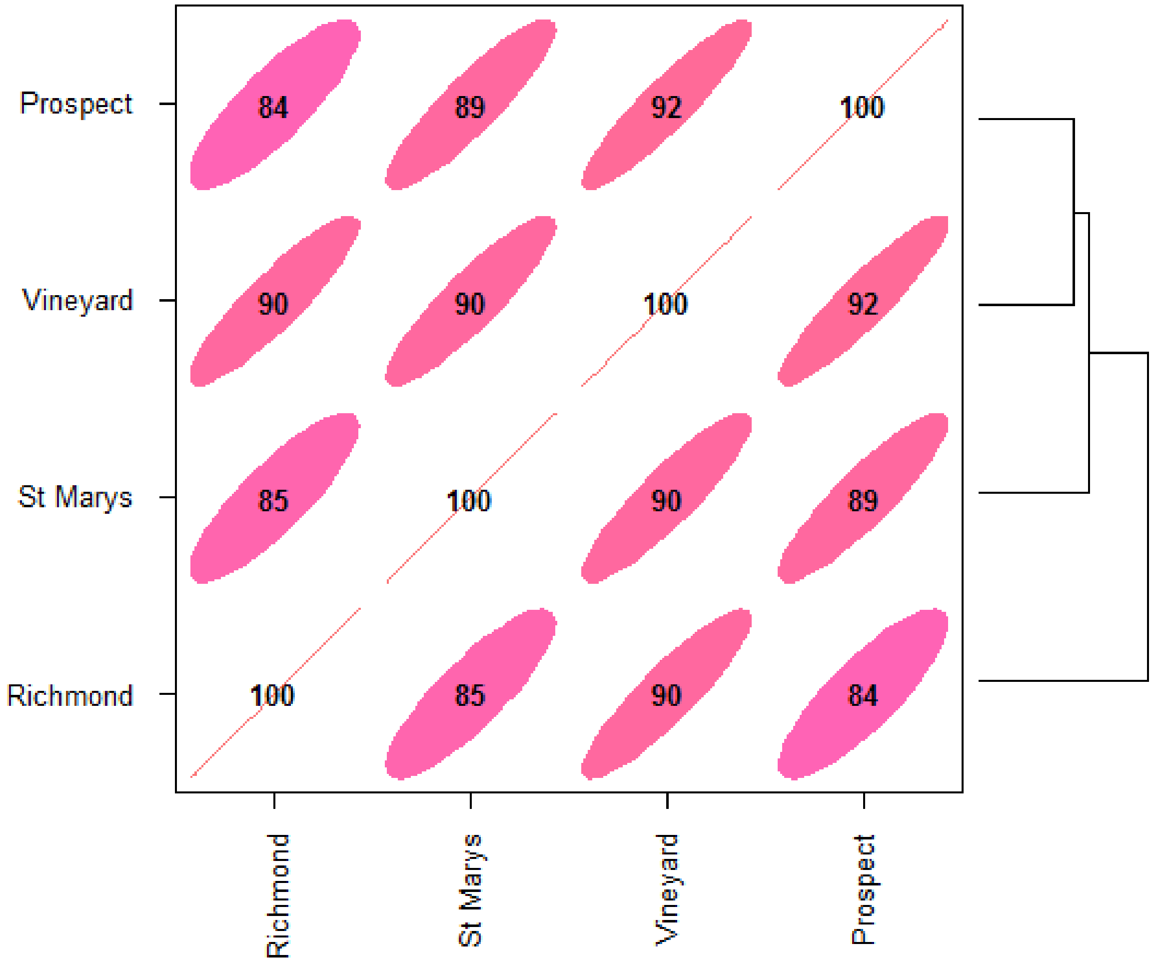
APPENDIX 4
CORRELATION ANALYSIS FOR SPATIAL VARIATION IN OEH MONITORING DATA

Sydney Southwest



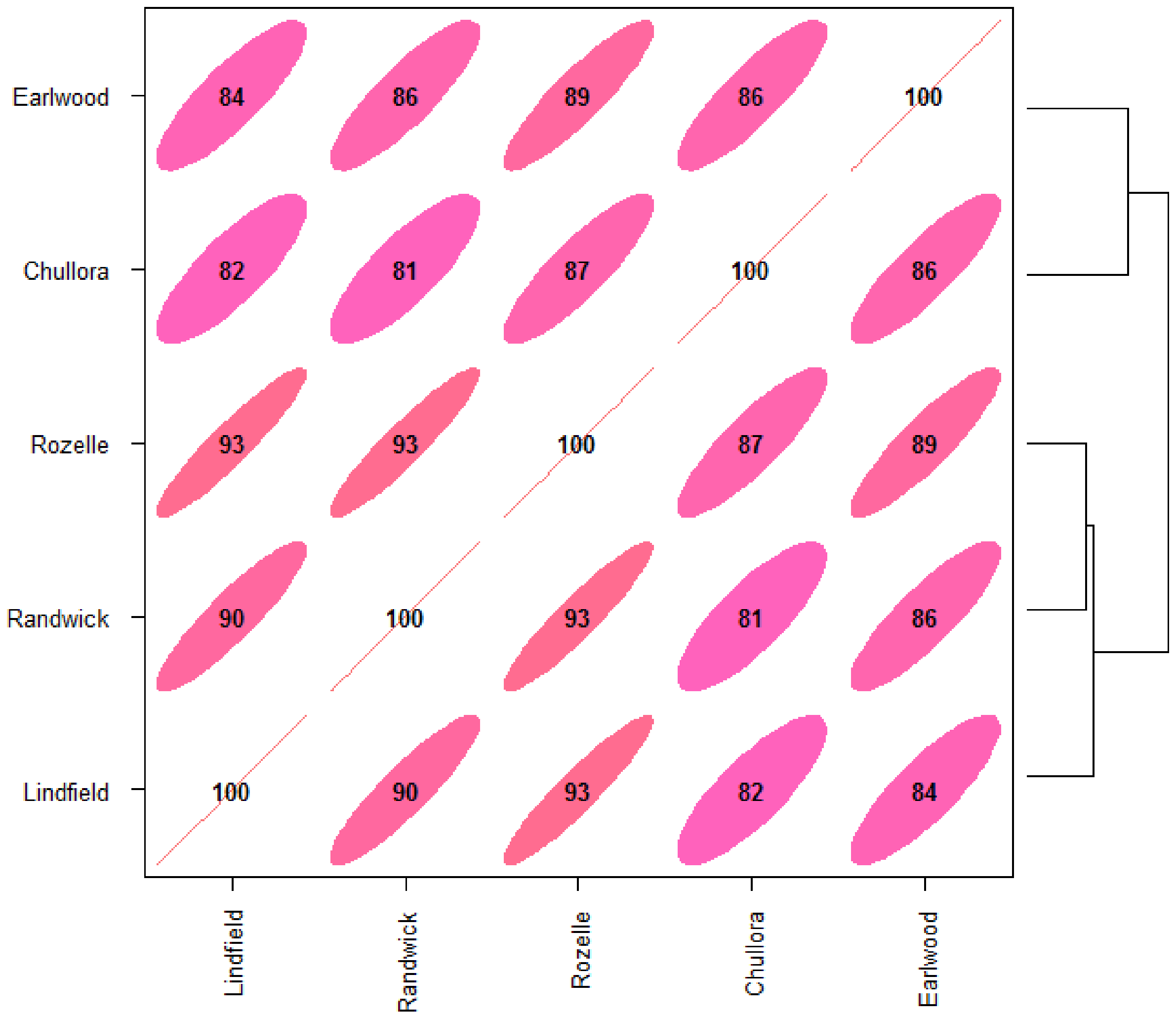
Correlation matrix of 24-hour average PM_{10} concentration with hierarchical cluster analysis. The ellipses can be thought of as a visual representation of scatter plot with the correlation coefficient (r) shown by the number. For zero correlation, the shape becomes a circle.

Sydney Northwest



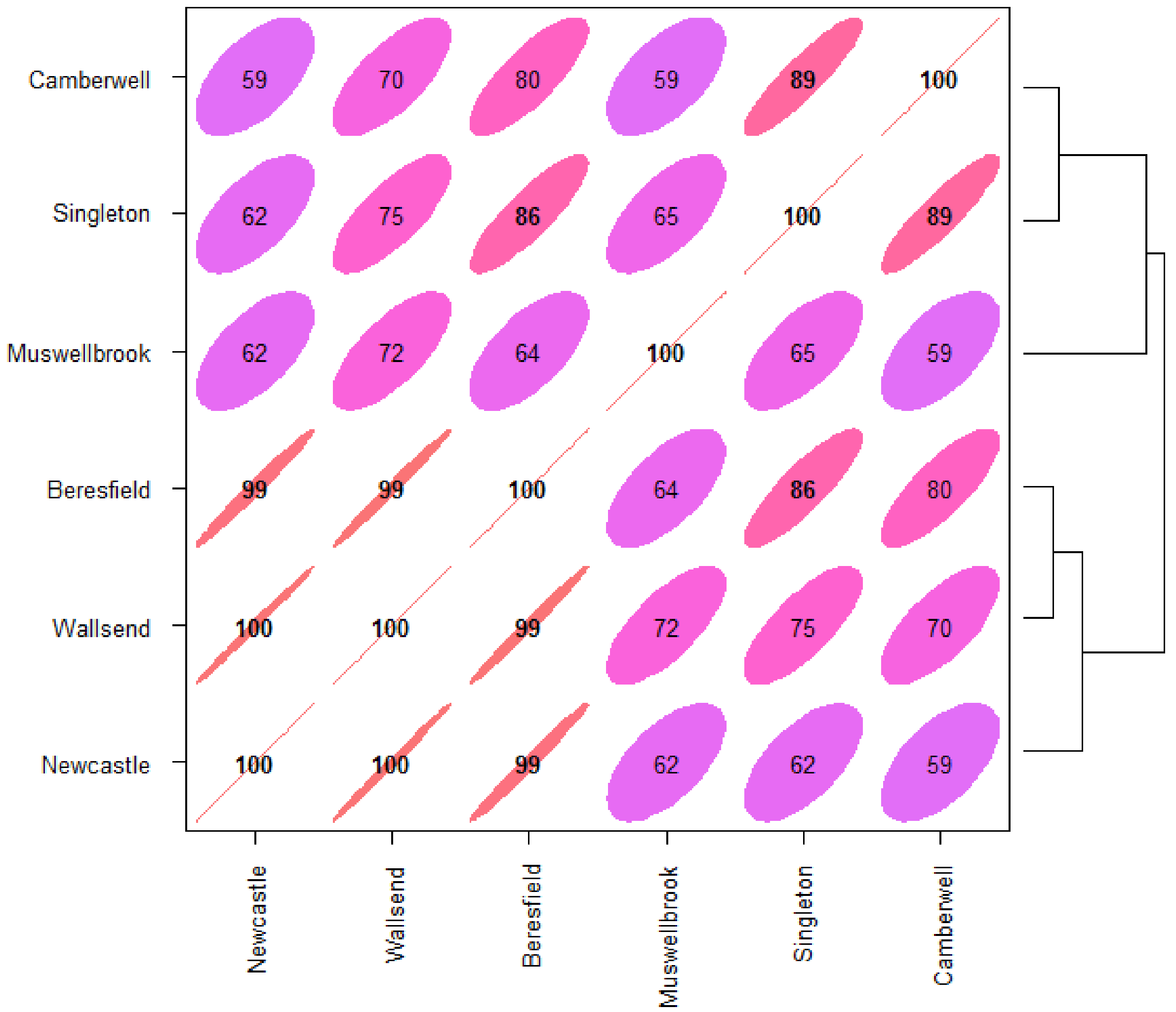
Correlation matrix of 24-hour average PM_{10} concentration with hierarchical cluster analysis. The ellipses can be thought of as a visual representation of scatter plot with the correlation coefficient (r) shown by the number. For zero correlation, the shape becomes a circle.

Sydney Central



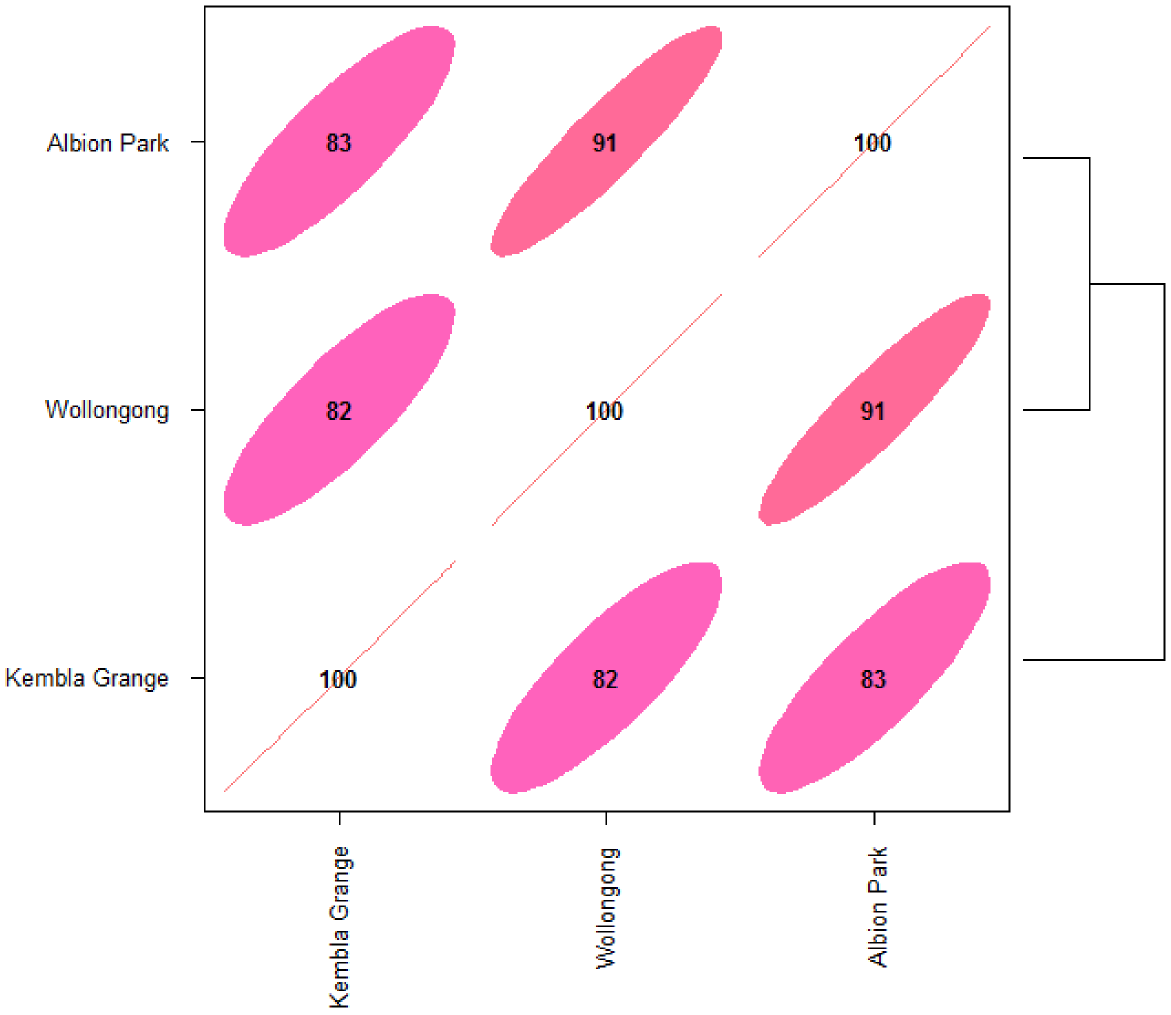
Correlation matrix of 24-hour average PM_{10} concentration with hierarchical cluster analysis. The ellipses can be thought of as a visual representation of scatter plot with the correlation coefficient (r) shown by the number. For zero correlation, the shape becomes a circle.

Hunter



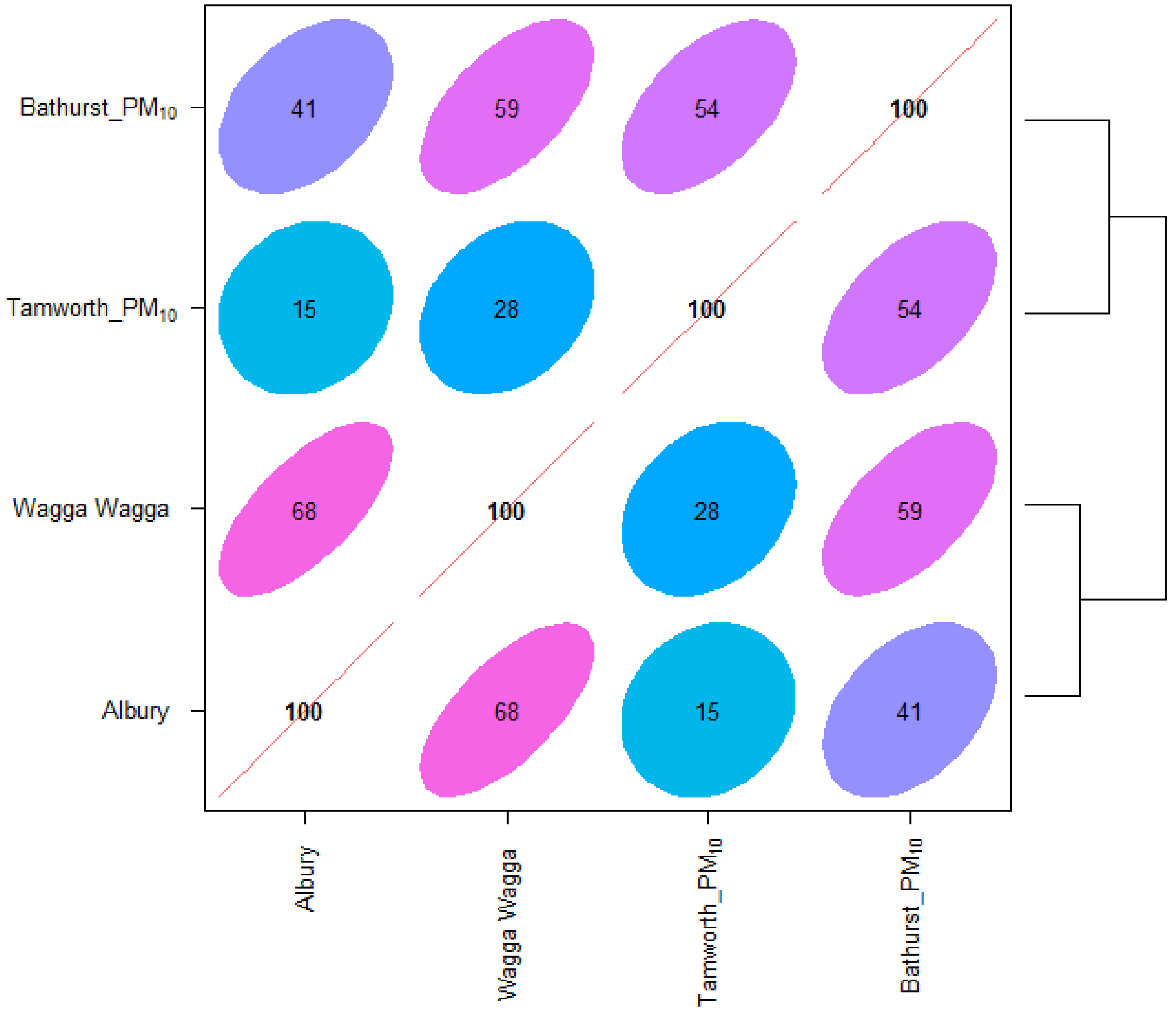
Correlation matrix of 24-hour average PM_{10} concentration with hierarchical cluster analysis. The ellipses can be thought of as a visual representation of scatter plot with the correlation coefficient (r) shown by the number. For zero correlation, the shape becomes a circle.

Illawarra



Correlation matrix of 24-hour average PM_{10} concentration with hierarchical cluster analysis. The ellipses can be thought of as a visual representation of scatter plot with the correlation coefficient (r) shown by the number. For zero correlation, the shape becomes a circle.

Rural



Correlation matrix of 24-hour average PM_{10} concentration with hierarchical cluster analysis. The ellipses can be thought of as a visual representation of scatter plot with the correlation coefficient (r) shown by the number. For zero correlation, the shape becomes a circle.

APPENDIX 5
EXAMPLES OF QUESTIONNAIRE RESPONSES

REGULATORY FRAMEWORK AND GUIDELINES		
Purpose: To gather information on the regulatory framework for air quality management in other jurisdictions, and in particular if there is any regulatory requirements or guidelines on how cumulative air impact assessment should be conducted for new/modified emissions sources. Note: the focus is for air impact assessment of new or modified emissions sources, for example in an approvals or permitting process.		
Question	**Answer**	
What is the jurisdiction for which the response is provided (country, state, region)?	England and Wales	
What are the main regulatory frameworks for Air Quality Management in your jurisdiction?	Environmental Permitting (England and Wales) Regulations 2010 which implements the EU Integrated Pollution Prevention and Control Directive	https://www.gov.uk/government/publications/environmental-permitting-guidance-integrated-pollution-prevention-and-control-ippc-directive-part-a-1-installations-and-part-a-1-mobile-plant
Does the regulatory framework specifically include requirements for cumulative air impact assessment?	Yes - the background concentration of a pollutant should be included within the assessment	
Does the regulatory framework follow a tiered approach to cumulative air impact assessment (for example, depending on low or high risk, low or high ambient background)?	Yes - if the process contribution is less than 1% of the annual standard or 10% of the short term standard the contribution can be screened as insignificant and there is no requirement to look at background concentrations	
Does the regulatory framework for cumulative air assessment approach differ or have specific requirements in certain circumstances (such as air pollution "hot spots")?	No	Note: specific questions on air pollution hot spots in next questionnaire
Is cumulative air impact impact assessment required for all pollutants or just 'criteria' pollutants?	No all pollutants, although for many there is no background information	
Is cumulative air impact impact assessment required in all situations, regardless of risk?	No see row 7	
If for example, cumulative impact assessment is not required in low risk scenarios, how is this determined?	see row 7	
Are guidance documents available for how cumulative air impact assessment should be conducted?	Yes	https://a465gilwern2brynmawr.files.wordpress.com/2014/02/dd562-ea-horizontal-guidance-note-h1-annex-f.pdf
Is there flexibility in the approach to cumulative air impact assessment? Can different / novel approaches be applied that differ from prescribe approaches	There is some flexibility, but approach needs to be accepted by Environment Agency	
Do you consider the cumulative air impact assessment methodologies applied in you jurisdiction effective?	yes	
What are the some of the challenges and limitations that you face in cumulative air asssessment?	Obtaining suitable background data	
Are specific impact assessment criteria prescribed for air impact assessment (i.e. modelling) that differ from national compliance reporting standards?	No	

How do they differ - form of the standard, incremental increase, percentile, averaging period)?		
Is a distinction made for threshold and non-threshold pollutants?	Not in the method of assessment	
Can you provide any publically available report/s with an example of how a prescribed, regulated or novel approach to cumulative air assessment was applied?		….please provide an ENVIRON BOX weblink.

BACKGROUND DATA		
Purpose: To understand how other jurisdictions process background AQ data and if some of the challenges we face have been solved elsewhere. Some of the challenges we face are: 1. accounting for non-modelled sources in BG data 2. significant spatial variation in background. 3. treatment of existing exceedances of 24-hour PM AQ standards. 4. temporal variation such as the effects of ENSO climate cycles. 5. how to characterise a future airshed for non-modelled sources. Note: there may be some overlap with 'hotspot' and 'short term impacts' questions.		
Question	**Answer**	
How many years of data are typically selected or analysed for background/baseline datasets?	no specific guidance, it would depend on what is available. We would typically report 5 if they were available.	
Are the number of years prescribed in guidance / regulation or simply based on standard practice or expert judgement?	see above	
Is climate change / climate cycles considered when choosing the number of years to consider for a background dataset? (i.e. for example to allow for drought affected years influencing background PM)	not applicable to the UK	
Are background data adjusted for climate effects (i.e. low rainfall years)?	no	
Is there a requirement to match background datasets for cumulative assesment to the meteorological modelling period?	no	
How are background/baseline datasets used when modelling future years? (are future changes considered or is same value applied for each modelled year)	same value applied for each year generally, although for certain pollutants the Department for the Environment Food and Rural Affairs has produced projected background concentration data and these can be used to project concentrations forward. However for some of the pollutants it is known that the projected decline is over optimistic	http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html
How is spatial variation in background accounted for in modelling assessment? For example do you use multiple sites to develope a spatially varying background or is a single value (whether an annual average or short term %ile) chosen to add to model predictions?	most likely would use a single value, but projected concentrations given above are provided for every 1 km grid square of the UK so spatial variation can be taken into acount.	
What are some of the methods used to account for spatial variation?		
Is there a standard / prescribed approach for the analysis and presentation of short term averages for cumulative air impact assessment?	Yes this is provided in the guidance document https://a465gilwern2brynmawr.files.wordpress.com/2014/02/dd562-ea-horizontal-guidance-note-h1-annex-f.pdf	
Do you have procedures for dealing with data gaps or non-continuous data in background datasets (i.e. substitution, interpolutation)?	No	
Do you have a % complete or minimum number of data points requirement for background data to describe baseline for cumulative air assessment?	Ideally it would be 90% complete, but it would depend on what else is available	
Are the procedures for dealing with data gaps prescribed in guidance / regulation or simply based on standard practice or expert judgement?	There is some guidance in the attached document but most is standard practice/expert judgement	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69334/pb13081-tech-guidance-laqm-tg-09-090218.pdf
Have you needed to complete cumulative impact assessment in data sparse areas?	Yes	
If your modelling area has insufficient background data (non-continuous data, different period to modelling, not representative of entire domain) how is baseline described?	using expert judgement and whatever is available	
Are the procedures for describing background in data sparse areas prescribed in guidance / regulation or simply based on standard practice or expert judgement?	standard practice and expert judgement	

Are different PM monitoring techniques / instruments considered when processing monitoring data? For example how different instrumcent might remove components of secondary PM / semi volatiles.	yes	
Background datasets in NSW can contain elevated PM from regional events such as bushfires or regional dust storms.	This is not applicable to the UK	
Do you exclude data from background datasets for impact assessment where known regional events have occur?		
How is a decision made to exclude what days?		
Are excluded days substituted with other data?		
Are these days also excluded from calculations of annual mean?		
Are datasets left intact and different statistic desciptors used instead (median instead of mean, percentiles instead of maximum)?		
Can you provide publically available report/s with an example of how a prescribed or novel approach was applied in an air pollutant hot spots?		….please provide an ENVIRON BOX weblink.

AIR POLLUTION HOT SPOTS		
Purpose: To understand how other jurisdictions deal with some of the particular challenges in air pollution hot spots and/or constrained airsheds. One of the challenges we face in NSW is in the Hunter Valley, where 31 coal mining operations currently operate. Coal production is forecast to increase through new mining operations and/or modifications to existing mines. PM levels across the Hunter Valley are approaching or ambient air quality guidelines and PM in winter months is compounded by woodheater emissions in populated areas. Some of the challenges we face are: 1. accounting for other emissions sources - i.e. often not practical to model all 31 mining operations - what sites to include and which to exclude? 2. significant spatial variation is evident in background. 3. existing exceedances of 24-hour AQ standards are common and how to assess the significance of additional days over. 4. how to consider cumulative short term (daily) impacts when modelling mining operations into the future. A key component of our review is to consider if a different approach for cumulative air impact assessment can be applied in constrained airsheds or whether a broad application approach is suitable.		
Question	**Answer**	
Does the methodological approach to air impact assessment differ in air pollution hot spots or is it consitent with standard approaches applied in all areas?	No it is consistent with standard appoaches applied in all areas	
Is the approach prescribed in guidance / regulation or simply based on standard practice or expert judgement?	It follows prescribed guidance, but is also based on standard practice	…..may have been answered in 'Regulatory Guidelines'
Have you had to deal with or resolve any of the following challenges in constrained airsheds?		
Selection process to decide what 'other sources' of emissions are included in modelling? (e.g. neighbouring sources, based on a radius of influence, where the sensitive receptors are located)	no	
Spatial variation in background from non-modelled sources, particularly for short term averages?	no	
Assessing the significance of risk when a project adds a small increment to an existing high background, resulting in exceedance of air quality goals?	Yes	
In low risk situations, a conservative modelling assessment is typically OK. In a constrained airshed, an overly conservative modelling assessment might produce high and restrictive assessment of risk. Is this something that is considered in your assessment work and how have you solved this? Do you perform 'model calibration'?	Yes - normally through sensitivity testing	
In situations where ambient air quality guidelines are already exceeded, how are new emission sources assessed?	using a risk based approach	
Are specific impact assessment criteria prescribed for air pollutant hot spots that differ from national ambient air quality standards?	No	
If applicable, what is the form, for example are they expressed as allowable incremental increases?		
If applicable, how are allowable increases determined, for example are they related to an existing baseline?		
If applicable, are the allowable increases specified for a particular area/baseline or do they apply everywhere?		
Are the assessment criteria related to health based compliance standards (i.e. % of an national ambient air quality standard)?		
Is there a 'no additional exceedance' rule for short term impacts (i.e. 24-hour PM10) or does the form of the standard allow for a certain number of exceedances (i.e. percentile)?	the standard allows for a certain number of exceedances	
Can you provide any publically available report/s with an example of how a prescribed or novel approach was applied in an air pollutant hot spots?		….please provide an ENVIRON BOX weblink.

SHORT TERM CUMULATIVE IMPACT ASSESSMENT		
Purpose: To understand how other jurisdictions present cumulative air impact assessment results for short term averaging periods. In NSW, impact assessment critieria are specified for averaging periods of 10-minute (SO2), 15-minute (CO), 1-hour (NO2, SO2, CO), 8-hour (CO) and 24-hour (PM, SO2). The biggest challenge we face in cumulative assessment relates to 24-hour average PM and 1-hour NO2, including: 1. having insufficient data 2. predicting short term variation into the future. 3. dealing wth existing exceedances. 4. deal with short term atmospheric transformation of NOx.		
Question	**Answer**	
The following are some methods used in cumulative 24-hour impact assessment in NSW (typically for PM). We are interested in your feedback on these methods, whether you have applied a similar method, whether that method is described or prescribed by regulation/guidance, any potential short-comings you see in the method.		
24-hour average modelling predictions added to daily background (contemporaneous period) to describe total cumulative impact.		
Monte carlo modelling used to combine 24-hour average modelling predictions with background data (can be multiple years and multiple stations). Freqency distribution is presented comparing background with cumulative to give indication of risk of additional exceedances of 24-hour goal.		
Combining every 24-hour average modelling prediction to every available background data point (multiple years and sites). Freqency distribution is presented comparing background with cumulative to give indication of risk of additional exceedances of 24-hour goal.	In some cases the Environment Agency has required this, but in the UK this is more likely for NO2 rather than PM10	
A single percentile value taken from the background dataset (i.e. 70th %ile) and added to maximum modelling prediction for a receptor to describe total cumulative impact.		
Please descibe other methods you have used (such as statistical techniques) used to combine background data with modelling predictions in cumulative air impact assessment.	to calculate the predicted environmental concentrations H1 suggests that the short term process contribution is added to twice the annual background. For PM10 this often results in an exceedance. LAQM.TG(09) suggests a different approach see Sheet 1	
Are these methods prescribed in guidance / regulation or simply based on standard practice or expert judgement?	see above	
Are you aware of any publically available tools for short term cumualtive assessment?	no	……i.e. spreadsheets for statistical analysis

METHOD FOR DEALING WITH NOX CONVERSION		
Purpose: To understand how other jurisdictions account for NOx to NO2 conversion, particularly for short term averaging periods. In NSW, the most commonly applied conversion methods are Full Conversion or OLM. Ambient ratios may be applied in certain circumstances. The biggest challenge we face in applying OLM is the lack of monitoring data for NO2 and O3 in rural mining areas.		
Question	**Answer**	
We are interested in your feedback on the various methods for NOx conversion. How is a method selected for use? Typical projects/situations where the method is applied? Whether that method and where is it applied is described or prescribed by regulation/guidance? Effectiveness or limitations of the method?	In the UK for most assessments we use a standard conversion ratio advised by the Environment Agency. At a screening level a 50% conversion rate is assumed for short term and 100% for long term. For a worse case scenario this is reduced to 35% and 70% for short and long term average concentrations respectively.	
Full conversion		
Ambient Ratio Method		
Ozone Limiting Method		
Plume Volume Molar Ratio Method		
Is guidance given for default in-stack NO2/NOX ratio if not known?		
Please describe any other methods used to account for Nox conversion.		
Can you provide publically available report/s with an example of how a prescribed or novel approach was applied for NOX conversion?		….please provide an ENVIRON BOX weblink.

DISPERION MODELLING		
Purpose: To understand how other jurisdictions deal with some of the modelling challenges in cumulative air impact assessment.		
Question	**Answer**	
What is the process for including 'other sources' of emissions in modelling?	done on a case by case basis - and through discussion with Environment Agency	…..may have been answered in 'Air Pollution Hotspots'
How are other sources selected for inclusion? i.e. is it an objective or subjective process, based on distance to receptors, magnitude of emissions, proximity to the 'subject' source, risk or impact from subject source, constrined by size of modelling domain?	subjective	
Is the process prescribed in guidance / regulation or simply based on standard practice or expert judgement?	expert judgement	
How are emissions data estimated / obtained for 'other sources'?	would be done on a case by case basis - AP42 or Corinair may be used	
How are source characteristics / parameters for modelling determined for 'other sources'?		
How Is the suitability of emissions data determined?	would be up to consultant to justify suitability	
What is the typical temporal resolution of emission data for 'other sources' - annual, daily, hourly?		
Do you include future emissions sources in modelling?	depends on how certain they are to arise	
Is this for committed development only?		
What information sources are used to identify future sources and estimate emissions?		
Do you typically allow for boundary conditions or emissions from outside the modelling domain?	no	
If so, what is the process and is it prescribed in guidance / regulation or simply based on standard practice or expert judgement?		
Is there a process or prescribed approach to avoid 'double counting' and / or calibrate model predictions? For example where existing emission sources are included in the modelling asssessment and also potentially contribute to the monitoring data used to describe background/baseline.	yes where contribution is included within the background and there is only one significant source	
Is an "existing scenario" typically modelled and used to 'calibrate' the model by comparing to monitoring data?	not for industrial sources, but we would do this when modelling roads	
Meteorological data for modelling.		
How many years of meteorological data are selected for modelling?	3 or 5	
Are the number of years prescribed in guidance / regulation or simply based on standard practice or expert judgement?	standard practice	
Are climate change or climate cycles considered when choosing the number of years to consider?	no	

If onsite / site specific data are not available, how are representative met data selected and demonstrated to be represenative?	it is up to consultant to justify choice of met data	
What are the prescribed percentage complete requirements?	nothing prescribed	
Do you have prescribed guidance for calm conditions?	no	
Is model uncertainty considered as part of an assessment of risk or in sensitivty analysis for cumuative assessment?	yes informally	
Have you modelled intermittant / instantaneous emissions such as NOx from blasting in mining applications? How are these intermittant / instantaneous sources considered cumulatively with other continuous sources such as diesel mining equipment?	have used variable files to look at intermittant releases	
Can you provide a publically available report with an example of how a this was done?		….please provide an ENVIRON BOX weblink.
Can you provide publically available report/s with an example of how a prescribed or novel approach was applied to deal with any of the above challenges?		….please provide an ENVIRON BOX weblink.

REGULATORY FRAMEWORK AND GUIDELINES		
Purpose: To gather information on the regulatory framework for air quality management in other jurisdictions, and in particular if there is any regulatory requirements or guidelines on how cumulative air impact assessment should be conducted for new/modified emissions sources. Note: the focus is for air impact assessment of new or modified emissions sources, for example in an approvals or permitting process.		
Question	**Answer**	
What is the jurisdiction for which the response is provided (country, state, region)?	United States (Federal air permitting)	
What are the main regulatory frameworks for Air Quality Management in your jurisdiction?	Clean Air Act and supporting regulaitons	U.S. Clean Air Act; regulations found in 40 C.F.R. 52.21 and 40 C.F.R. 51, Appendix W
Does the regulatory framework specifically include requirements for cumulative air impact assessment?	Yes. Federal permitting requires modeling to show compliance with National Ambient Air Quality Standards (NAAQS) and increments, which are allowable impacts above an area-specific baseline. There are also separate air quality increments for Class I areas (e.g., National Parks). So, cumulative modeling is needed for this analysis.	
Does the regulatory framework follow a tiered approach to cumulative air impact assessment (for example, depending on low or high risk, low or high ambient background)?	Yes. For a Fedeal air permit, you start by modeling your project (which might just be one piece of new equipment). If that has a "significant" impact (defined in the rules), then you need to model your whole faiclity, plus neighboring facilities plus a background.	
Does the regulatory framework for cumulative air assessment approach differ or have specific requirements in certain circumstances (such as air pollution "hot spots")?	No. The Fderal air permit rules do not have anything like this.	Note: specific questions on air pollution hot spots in next questionnaire
Is cumulative air impact impact assessment required for all pollutants or just 'criteria' pollutants?	Just criteria pollutants. There are no Federal modeling requirements for hazardous air pollutants (HAPs). States handle that and even where they require modeling at the State level, I am not aware of any State that requires cumulative modeling for HAPs.	
Is cumulative air impact impact assessment required in all situations, regardless of risk?	Yes (FYI - risk is not considered, only ambient air concentrations.)	
If for example, cumulative impact assessment is not required in low risk scenarios, how is this determined?	The decision about whether to do a cumulative analysis is based on whether the modeled impact from a project is considered "significant."	
Are guidance documents available for how cumulative air impact assessment should be conducted?	40 C.F.R. 51, Appendix W is the main regulation. EPA has hundreds of guidance documents on modeling that can be found on their website	EPA guidance on modeling: http://www.epa.gov/ttn/scram/guidance_permit.htm

Is there flexibility in the approach to cumulative air impact assessment? Can different / novel approaches be applied that differ from prescribe approaches	Usually no. Federal air permit modeling is approved by each State, who usually have their own prescriptive guidance on how to do modeling. So, it is possible to come up with novel approaches, but not common.	
Do you consider the cumulative air impact assessment methodologies applied in you jurisdiction effective?	Yes, for standards that have a longer averaging period, but not for 24-hour or 1-hr standards	
What are the some of the challenges and limitations that you face in cumulative air asssessment?	Availability of good data for other facilities; addressing double-counting when adding neighboring facility impacts on top of backgraound data that includes those impacts already. But one major challenge recently is that as EPA continues to lower the allowable air standards, the difference between background levels and the standard often provides very little room for new impacts.	
Are specific impact assessment criteria prescribed for air impact assessment (i.e. modelling) that differ from national compliance reporting standards?	No. The criteria for permitting are the same	
How do they differ - form of the standard, incremental increase, percentile, averaging period)?		
Is a distinction made for threshold and non-threshold pollutants?	No	
Can you provide any publically available report/s with an example of how a prescribed, regulated or novel approach to cumulative air assessment was applied?		….please provide an ENVIRON BOX weblink.

AIR POLLUTION HOT SPOTS

Purpose: To understand how other jurisdictions deal with some of the particular challenges in air pollution hot spots and/or constrained airsheds.

One of the challenges we face in NSW is in the Hunter Valley, where 31 coal mining operations currently operate. Coal production is forecast to increase through new mining operations and/or modifications to existing mines. PM levels across the Hunter Valley are approaching or ambient air quality guidelines and PM in winter months is compounded by woodheater emissions in populated areas. Some of the challenges we face are: 1. accounting for other emissions sources - i.e. often not practical to model all 31 mining operations - what sites to include and which to exclude? 2. significant spatial variation is evident in background. 3. existing exceedances of 24-hour AQ standards are common and how to assess the significance of additional days over. 4. how to consider cumulative short term (daily) impacts when modelling mining operations into the future. A key component of our review is to consider if a different approach for cumulative air impact assessment can be applied in constrained airsheds or whether a broad application approach is suitable.

Question	Answer	
Does the methodological approach to air impact assessment differ in air pollution hot spots or is it consitent with standard approaches applied in all areas?	No - approach is the same in all areas	
Is the approach prescribed in guidance / regulation or simply based on standard practice or expert judgement?	Modeling procedures can vary some by State, but are bounded by Federal regulaitons and guidance which tend to be very prescriptive	…..may have been answered in 'Regulatory Guidelines'
Have you had to deal with or resolve any of the following challenges in constrained airsheds?		
Selection process to decide what 'other sources' of emissions are included in modelling? (e.g. neighbouring sources, based on a radius of influence, where the sensitive receptors are located)	Yes, but most States have a datdandr methods for doing this.	
Spatial variation in background from non-modelled sources, particularly for short term averages?	Yes - this is a big problem in the US	
Assessing the significance of risk when a project adds a small increment to an existing high background, resulting in exceedance of air quality goals?	Yes	
In low risk situations, a conservative modelling assessment is typically OK. In a constrained airshed, an overly conservative modelling assessment might produce high and restrictive assessment of risk. Is this something that is considered in your assessment work and how have you solved this? Do you perform 'model calibration'?	Yes - we often run multiple iterations of a model before figuring out a way to get it to pass. This may include revising emissions, moving stacks, changing release parameters, etc.	
In situations where ambient air quality guidelines are already exceeded, how are new emission sources assessed?	If this is the case, the area is deemed to be a "nonattainment" area and modeling is no longer required. In that case, Federal permitting requires that increases in emissions must be offset by emission reduciton credits generated by reductions at other nearby sources.	
Are specific impact assessment criteria prescribed for air pollutant hot spots that differ from national ambient air quality standards?	No	
If applicable, what is the form, for example are they expressed as allowable incremental increases?		
If applicable, how are allowable increases determined, for example are they related to an existing baseline?		
If applicable, are the allowable increases specified for a particular area/baseline or do they apply everywhere?		
Are the assessment criteria related to health based compliance standards (i.e. % of an national ambient air quality standard)?		
Is there a 'no additional exceedance' rule for short term impacts (i.e. 24-hour PM10) or does the form of the standard allow for a certain number of exceedances (i.e. percentile)?	This varies by pollutant. Most NAAQS allow some exceedances, but some say no more than 1 exceedance per year, some use a multi-year average, and some say the 98th %ile must meet the standard	Here is a link that describes the form of each NAAQS: http://www.epa.gov/air/criteria.html
Can you provide any publically available report/s with an example of how a prescribed or novel approach was applied in an air pollutant hot spots?		….please provide an ENVIRON BOX weblink.

BACKGROUND DATA		
Purpose: To understand how other jurisdictions process background AQ data and if some of the challenges we face have been solved elsewhere. Some of the challenges we face are: 1. accounting for non-modelled sources in BG data 2. significant spatial variation in background. 3. treatment of existing exceedances of 24-hour PM AQ standards. 4. temporal variation such as the effects of ENSO climate cycles. 5. how to characterise a future airshed for non-modelled sources. Note: there may be some overlap with 'hotspot' and 'short term impacts' questions.		
Question	**Answer**	
How many years of data are typically selected or analysed for background/baseline datasets?	This varies by State. Many States actually have a specific background for each area that you are required to use	
Are the number of years prescribed in guidance / regulation or simply based on standard practice or expert judgement?	Determined by the State	
Is climate change / climate cycles considered when choosing the number of years to consider for a background dataset? (i.e. for example to allow for drought affected years influencing background PM)	I have not seen this before	
Are background data adjusted for climate effects (i.e. low rainfall years)?	No	
Is there a requirement to match background datasets for cumulative assesment to the meteorological modelling period?	Yes, States specify different backgrounds for each averaging period required to be modeled.	
How are background/baseline datasets used when modelling future years? (are future changes considered or is same value applied for each modelled year)	No - same value for each year	
How is spatial variation in background accounted for in modelling assessment? For example do you use multiple sites to develope a spatially varying background or is a single value (whether an annual average or short term %ile) chosen to add to model predictions?	You could do this, but it is not typical. Usually, you use one background value for the area.	
What are some of the methods used to account for spatial variation?		
Is there a standard / prescribed approach for the analysis and presentation of short term averages for cumulative air impact assessment?	Method is basically the same as for long-term averages.	
Do you have procedures for dealing with data gaps or non-continuous data in background datasets (i.e. substitution, interpolutation)?	No. You typically pick one background value that is considered representative of the area and use that.	
Do you have a % complete or minimum number of data points requirement for background data to describe baseline for cumulative air assessment?		
Are the procedures for dealing with data gaps prescribed in guidance / regulation or simply based on standard practice or expert judgement?		
Have you needed to complete cumulative impact assessment in data sparse areas?	Yes.	
If your modelling area has insufficient background data (non-continuous data, different period to modelling, not representative of entire domain) how is baseline described?	In that case, the State would assign a background value for pristine or undeveloped areas, based on monitored values in other undeveloped areas of their State	
Are the procedures for describing background in data sparse areas prescribed in guidance / regulation or simply based on standard practice or expert judgement?	Guidance usually	
Are different PM monitoring techniques / instruments considered when processing monitoring data? For example how different instrumcent might remove components of secondary PM / semi volatiles.	No. Monitoring data must be collected using Federally approved methods, so you would not consider this after data has been collected	
Background datasets in NSW can contain elevated PM from regional events such as bushfires or regional dust storms.		

Do you exclude data from background datasets for impact assessment where known regional events have occur?	Yes. EPA has a "natural events" policy where you can exclude this type fo data but this would require federal EPA approval, not just approval from the State issuing a permit	Natural events policy: http://www.epa.gov/ttn/oarpgold/t1/memoranda/nepol.pdf
How is a decision made to exclude what days?	Based on criteria in EPA's policy (see link)	
Are excluded days substituted with other data?	No	
Are these days also excluded from calculations of annual mean?	Yes	
Are datasets left intact and different statistic desciptors used instead (median instead of mean, percentiles instead of maximum)?	No, outliers are just removed from the data	
Can you provide publically available report/s with an example of how a prescribed or novel approach was applied in an air pollutant hot spots?		….please provide an ENVIRON BOX weblink.

SHORT TERM CUMULATIVE IMPACT ASSESSMENT

Purpose: To understand how other jurisdictions present cumulative air impact assessment results for short term averaging periods.

In NSW, impact assessment critieria are specified for averaging periods of 10-minute (SO2), 15-minute (CO), 1-hour (NO2, SO2, CO), 8-hour (CO) and 24-hour (PM, SO2). The biggest challenge we face in cumulative assessment relates to 24-hour average PM and 1-hour NO2, including: 1. having insufficient data 2. predicting short term variation into the future. 3. dealing wth existing exceedances. 4. deal with short term atmospheric transformation of NOx.

Question	Answer	
The following are some methods used in cumulative 24-hour impact assessment in NSW (typically for PM). We are interested in your feedback on these methods, whether you have applied a similar method, whether that method is described or prescribed by regulation/guidance, any potential short-comings you see in the method.		
24-hour average modelling predictions added to daily background (contemporaneous period) to describe total cumulative impact.	This could be approved in the US. The problem here is that many areas that collected 24-hr average data do not collect data every day. It is more common to collect samples once every 6 days to get samples from each day of the week over time.	
Monte carlo modelling used to combine 24-hour average modelling predictions with background data (can be multiple years and multiple stations). Freqency distribution is presented comparing background with cumulative to give indication of risk of additional exceedances of 24-hour goal.	I have heard of this proposed where someone has had trouble meeting a 24-hr standard. I have not used it myself, but it seems like a good approach.	
Combining every 24-hour average modelling prediction to every available background data point (multiple years and sites). Freqency distribution is presented comparing background with cumulative to give indication of risk of additional exceedances of 24-hour goal.	I am not sure about this one - it seems like the Monte Carlo approach would be more defensible	
A single percentile value taken from the background dataset (i.e. 70th %ile) and added to maximum modelling prediction for a receptor to describe total cumulative impact.	This is the norm in the US - most States want you to use one background value and add modeled impacts on top of that	
Please descibe other methods you have used (such as statistical techniques) used to combine background data with modelling predictions in cumulative air impact assessment.	None	
Are these methods prescribed in guidance / regulation or simply based on standard practice or expert judgement?		
Are you aware of any publically available tools for short term cumualtive assessment?	No	……i.e. spreadsheets for statistical analysis

METHOD FOR DEALING WITH NOX CONVERSION		
Purpose: To understand how other jurisdictions account for NOx to NO2 conversion, particularly for short term averaging periods. In NSW, the most commonly applied conversion methods are Full Conversion or OLM. Ambient ratios may be applied in certain circumstances. The biggest challenge we face in applying OLM is the lack of monitoring data for NO2 and O3 in rural mining areas.		
Question	**Answer**	
We are interested in your feedback on the various methods for NOx conversion. How is a method selected for use? Typical projects/situations where the method is applied? Whether that method and where is it applied is described or prescribed by regulation/guidance? Effectiveness or limitations of the method?		
Full conversion	EPA has a lot of guidance on this topic. Links to the right:	http://www.epa.gov/scram001/guidance/clarification/ClarificationMemo_AppendixW_Hourly-NO2-NAAQS_FINAL_06-28-2010.pdf http://www.epa.gov/scram001/guidance/clarification/Additional_Clarifications_AppendixW_Hourly-NO2-NAAQS_FINAL_03-01-2011.pdf http://www.epa.gov/scram001/guidance/clarification/NO2_Clarification_Memo-20140930.pdf
Ambient Ratio Method		
Ozone Limiting Method		
Plume Volume Molar Ratio Method		
Is guidance given for default in-stack NO2/NOX ratio if not known?	Yes: 0.75 for annual and 0.80 for hourly modeling	
Please describe any other methods used to account for Nox conversion.	None - the methods listed above are the only ones approved for use in EPA guidance	
Can you provide publically available report/s with an example of how a prescribed or novel approach was applied for NOX conversion?		….please provide an ENVIRON BOX weblink.

DISPERION MODELLING		
Purpose: To understand how other jurisdictions deal with some of the modelling challenges in cumulative air impact assessment.		
Question	**Answer**	
What is the process for including 'other sources' of emissions in modelling?		…..may have been answered in 'Air Pollution Hotspots'
How are other sources selected for inclusion? i.e. is it an objective or subjective process, based on distance to receptors, magnitude of emissions, proximity to the 'subject' source, risk or impact from subject source, constrined by size of modelling domain?	This is an objective test, although it is up to the State which criteria to use. Some say you have to include all permitted sources in the area. Some say you only include major sources (sources with high emissions). Some allow you to do a ratio of emissions to distance (Q/D method), and you only include sources where that ratio is above some threshold, defined by the State.	
Is the process prescribed in guidance / regulation or simply based on standard practice or expert judgement?	guidance / regulation	
How are emissions data estimated / obtained for 'other sources'?		
How are source characteristics / parameters for modelling determined for 'other sources'?	Many States maintain this in a database and will provide it to you, but sometimes you need to look through their files to gather this data	
How Is the suitability of emissions data determined?	This is not normally a consideration	
What is the typical temporal resolution of emission data for 'other sources' - annual, daily, hourly?	Most of the time, it is annual and you need to convert to calculate daily/hourly. It is rare to get temporally varying data from another facility	
Do you include future emissions sources in modelling?	You only include future sources if they filed a permit application before you.	
Is this for committed development only?	Anyone who files an air permit application is considered to be committed to development.	
What information sources are used to identify future sources and estimate emissions?	State will tell you who to include	
Do you typically allow for boundary conditions or emissions from outside the modelling domain?	Yes. The modeling domain is deifned as a radius around your facility, which might include other States	
If so, what is the process and is it prescribed in guidance / regulation or simply based on standard practice or expert judgement?	Guidance/regulation - if your modeling domain covers other States, you contact that State to get relevant data	
Is there a process or prescribed approach to avoid 'double counting' and / or calibrate model predictions? For example where existing emission sources are included in the modelling asssessment and also potentially contribute to the monitoring data used to describe background/baseline.	No - the State is supposed to have considered this in setting the baseline.	
Is an "existing scenario" typically modelled and used to 'calibrate' the model by comparing to monitoring data?	Not usually. You might only do this if your modeling shows a problem that you can't solve by revising inputs	
Meteorological data for modelling.		
How many years of meteorological data are selected for modelling?	5 years is the norm, but you can use 1 year if you gather meteorological data at your facility site	

Are the number of years prescribed in guidance / regulation or simply based on standard practice or expert judgement?	Guidance/regulation	
Are climate change or climate cycles considered when choosing the number of years to consider?	No	
If onsite / site specific data are not available, how are representative met data selected and demonstrated to be represenative?	You typically pick data from the nearest met station, often an airport. Often wind roses are used to show that a met station is representaitve of your site	
What are the prescribed percentage complete requirements?	Met data must be 90% complete	
Do you have prescribed guidance for calm conditions?	Yes. EPA recommends either re-setting low wind speeds to 1 m/s for steady-state models, or else using an approved non-steady-state model	
Is model uncertainty considered as part of an assessment of risk or in sensitivty analysis for cumuative assessment?	No	
Have you modelled intermittant / instantaneous emissions such as NOx from blasting in mining applications? How are these intermittant / instantaneous sources considered cumulatively with other continuous sources such as diesel mining equipment?	Yes. We often start by assuming these sources happen continuously, but if that is too conservative, our models (e.g., AERMOD) will allow you to create intermittent sources based on your knowledge of their operation	
Can you provide a publically available report with an example of how a this was done?		….please provide an ENVIRON BOX weblink.
Can you provide publically available report/s with an example of how a prescribed or novel approach was applied to deal with any of the above challenges?		….please provide an ENVIRON BOX weblink.

REGULATORY FRAMEWORK AND GUIDELINES		
Purpose: To gather information on the regulatory framework for air quality management in other jurisdictions, and in particular if there is any regulatory requirements or guidelines on how cumulative air impact assessment should be conducted for new/modified emissions sources. Note: the focus is for air impact assessment of new or modified emissions sources, for example in an approvals or permitting process.		
Question	**Answer**	
What is the jurisdiction for which the response is provided (country, state, region)?	Development of relative large sources (e.g., oil and gas or fossil-fueled electrical generation) on Federal land in the USA	
What are the main regulatory frameworks for Air Quality Management in your jurisdiction?	USA CAA National Environmental Policy Act (NEPA). http://www.epa.gov/compliance/nepa/	….please provide a reference or weblink.
Does the regulatory framework specifically include requirements for cumulative air impact assessment?	Can screen out with Categorical Exclusions for small source. Perform Environmental Assessment (EA) to see if individual facility is below AQ thresholds. If not then do Environmental Impact Statement (EIS) that includes cumulative assessment of all new sources in region.	
Does the regulatory framework follow a tiered approach to cumulative air impact assessment (for example, depending on low or high risk, low or high ambient background)?	Yes. Can start with conservative assumptions (e.g., for NO2 complete conversion of NOx) or models (CALPUFF) and then refine. NEPA approach is to use best science.	
Does the regulatory framework for cumulative air assessment approach differ or have specific requirements in certain circumstances (such as air pollution "hot spots")?	Need to address near-source AQ impacts of the Project using AERMOD and far-field AQ and AQRV impacts. Thresholds of Concern (TOC) vary by region, Class I areas (specific national parks and wilderness) are offered special protection (more stringent TOCs), every else is Class II areas.	Note: specific questions on air pollution hot spots in next questionnaire
Is cumulative air impact impact assessment required for all pollutants or just 'criteria' pollutants?	Cumulative assessments mainly for criteria pollutants near-source and far-field and visibility and acid (sulfur and nitrogen) deposition for far-field. For near-source cumulative assessment addressed by modeling Project with background. For far-field explicitly model the Project and all other Reasonable Foreseeable Development (RGD) sources.	
Is cumulative air impact impact assessment required in all situations, regardless of risk?	No. NEPA has Categorical Exclusions for small Projects, can do EA and if Project AQ impacts are below TOCs then don't need to do an EIS cumulative assessment. Larger Projects tend to jump right into doing an EIS. (http://www.epa.gov/compliance/nepa/epacompliance/index.html)	

If for example, cumulative impact assessment is not required in low risk scenarios, how is this determined?	USEPA has a Resource Guide for determining whether a source qualifies for a Categorical Exclusions (CATEXS): http://www.epa.gov/compliance/resources/policies/nepa/environmental-review-guide-grants-pg.pdf. If perform an EA and show that the Project AQ/AQRV impacts are all below the single-source TOC then may not be required to do a cumulative EIS assessment.	
Are guidance documents available for how cumulative air impact assessment should be conducted?	From USEPA Resource Guide: "Cumulative Impact: The impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over time. See 40 C.F.R. § 1508.7."	….please provide a reference or weblink.
Is there flexibility in the approach to cumulative air impact assessment? Can different / novel approaches be applied that differ from prescribe approaches	NEPA assessments differ from PSD permitting in that they don't necessary have to follow USEPA's air quality modeling guidance and can based the approach on the "best science." So can use different/novel approaches if better science. For example, cumulative assessments for Project and RFD oil and gas development in western U.S. have been using Photochemical Grid Models (PGMs) for far-field assessments instead of the EPA-recommended CALPUFF model as PGMs represent better science than CALPUFF.	
Do you consider the cumulative air impact assessment methodologies applied in you jurisdiction effective?	Yes. When cumulative AQ/AQRV impacts of a Project plus RFD exceed cumulative TOCs then Project needs to consider mitigation that is frequently adopted in the Record of Decision (ROD) for the Project.	
What are the some of the challenges and limitations that you face in cumulative air asssessment?	1-hour NO2 standard difficult to achieve when using conservative assumption with background and NO2 conversion rates. The visibility and sulfur/nitrogen TOCs at Class I areas are extremely low. Development of a cumulative emissions inventory of RFD sources also a challenge. Potential lower ozone NAAQS (65-70 ppb) will bring many rural areas in USA to above or close to the NAAQS.	
Are specific impact assessment criteria prescribed for air impact assessment (i.e. modelling) that differ from national compliance reporting standards?	NEPA TOCs tend to follow national compliance reporting standards. More flexibility in NEPA to use best science than just use USEPA recommended models.	
How do they differ - form of the standard, incremental increase, percentile, averaging period)?	NEPA assessment compared to same Significant Impact Levels (SILs) and PSD increments and AQRV TOCs as PSD permitting. However, there are more flexibility if exceedances occur.	
Is a distinction made for threshold and non-threshold pollutants?	No. Currently no SILs or PSD increments for ozone but still must disclose the Project's and Cumulative source's ozone impacts.	

Can you provide any publically available report/s with an example of how a prescribed, regulated or novel approach to cumulative air assessment was applied?	BLM Continental Divide-Creston (CD-C) oil and gas EIS to develop ~10,000 wells in Southwest Wyoming was first O&G EIS to use a Photochemical Grid Model (PGM; CAMx in this case) to perform the cumulative AQ and AQRV and ozone assessment. In past, CALPUFF was used for cumulative AQ and AQRV assessment. CD-C draft EIS published in Dec 2013 with final EIS coming out in Q2 2015. http://www.blm.gov/wy/st/en/info/NEPA/documents/rfo/cd_creston.html	….please provide an ENVIRON BOX weblink.

AIR POLLUTION HOT SPOTS

Purpose: To understand how other jurisdictions deal with some of the particular challenges in air pollution hot spots and/or constrained airsheds.

One of the challenges we face in NSW is in the Hunter Valley, where 31 coal mining operations currently operate. Coal production is forecast to increase through new mining operations and/or modifications to existing mines. PM levels across the Hunter Valley are approaching or ambient air quality guidelines and PM in winter months is compounded by woodheater emissions in populated areas. Some of the challenges we face are: 1. accounting for other emissions sources - i.e. often not practical to model all 31 mining operations - what sites to include and which to exclude? 2. significant spatial variation is evident in background. 3. existing exceedances of 24-hour AQ standards are common and how to assess the significance of additional days over. 4. how to consider cumulative short term (daily) impacts when modelling mining operations into the future. A key component of our review is to consider if a different approach for cumulative air impact assessment can be applied in constrained airsheds or whether a broad application approach is suitable.

Question	Answer	
Does the methodological approach to air impact assessment differ in air pollution hot spots or is it consistent with standard approaches applied in all areas?	Generally, NEPA addresses hot spots in standard fashion using near-source plume model (AERMOD in this case) with monitored background levels. Tiered approach in how to combined background and modeled approach from most conservative (max background combined with max modeled) to time matched modeled and background concentrations.	
Is the approach prescribed in guidance / regulation or simply based on standard practice or expert judgement?	Pretty much standard practice with common sense.	…..may have been answered in 'Regulatory Guidelines'
Have you had to deal with or resolve any of the following challenges in constrained airsheds?		
Selection process to decide what 'other sources' of emissions are included in modelling? (e.g. neighbouring sources, based on a radius of influence, where the sensitive receptors are located)	For near-source assessment include Project with possibly other local sources with other sources represented by background concentrations. For far-field/ozone determine all Reasonable Foreseeable Development (RFD) sources within modeling domain. Modeling domains needs to encompass all Class I areas within 300 km of the Project with buffer.	
Spatial variation in background from non-modelled sources, particularly for short term averages?	Typical several levels of background with lessening conservatisms.	
Assessing the significance of risk when a project adds a small increment to an existing high background, resulting in exceedance of air quality goals?	Have not addressed issues with that large of a background.	
In low risk situations, a conservative modelling assessment is typically OK. In a constrained airshed, an overly conservative modelling assessment might produce high and restrictive assessment of risk. Is this something that is considered in your assessment work and how have you solved this? Do you perform 'model calibration'?	We start with the most conservative assumptions. 1-hour NO2 tends to be worst case so start with maximum 1-hour PTE emission running 24/7 365 days a year, assume full conversion of NOx to NO2 and assume maximum background. Then refine emissions operating schedules, maximum actual hourly emissions, include ozone limiting method (OLM) to convert NOx to NO2 and paired background concentrations.	
In situations where ambient air quality guidelines are already exceeded, how are new emission sources assessed?	Look at the Project's contribution to exceedances of the NAAQS. Try to demonstrate that when NAAQS is exceeded the Project contribution is de minimus.	
Are specific impact assessment criteria prescribed for air pollutant hot spots that differ from national ambient air quality standards?	For NEPA National Ambient Air Quality Standards (NAAQS) are protective of hot spots	
If applicable, what is the form, for example are they expressed as allowable incremental increases?		
If applicable, how are allowable increases determined, for example are they related to an existing baseline?		
If applicable, are the allowable increases specified for a particular area/baseline or do they apply everywhere?		
Are the assessment criteria related to health based compliance standards (i.e. % of an national ambient air quality standard)?		
Is there a 'no additional exceedance' rule for short term impacts (i.e. 24-hour PM10) or does the form of the standard allow for a certain number of exceedances (i.e. percentile)?	Some short-term standards allow for some exceedances: 1hour NO2 98th percentile (8th highest); 1-hour SO2 99th percentile (4th highest), ozone 3-year average of 4th highest.	
Can you provide any publically available report/s with an example of how a prescribed or novel approach was applied in an air pollutant hot spots?	BLM CD-C EIS discussed previously for O&G assumed maximum 2-years of drilling and 1-year of production so that 1-hour NO2 NAAQS was achieved since maximum time drill rig would be at any one location was less than 2-years. (http://www.blm.gov/wy/st/en/info/NEPA/documents/rfo/cd_creston.html).	….please provide an ENVIRON BOX weblink.

BACKGROUND DATA		
Purpose: To understand how other jurisdictions process background AQ data and if some of the challenges we face have been solved elsewhere. Some of the challenges we face are: 1. accounting for non-modelled sources in BG data 2. significant spatial variation in background. 3. treatment of existing exceedances of 24-hour PM AQ standards. 4. temporal variation such as the effects of ENSO climate cycles. 5. how to characterise a future airshed for non-modelled sources. Note: there may be some overlap with 'hotspot' and 'short term impacts' questions.		
Question	**Answer**	
How many years of data are typically selected or analysed for background/baseline datasets?	Try to use the latest 3-years of monitoring data.	
Are the number of years prescribed in guidance / regulation or simply based on standard practice or expert judgment?	Try to match the form of the NAAQS which is based on 3-years of data.	
Is climate change / climate cycles considered when choosing the number of years to consider for a background dataset? (i.e. for example to allow for drought affected years influencing background PM)	Not so much climate change, but you can make a case to exclude anomalous conditions from your background.	
Are background data adjusted for climate effects (i.e. low rainfall years)?	No.	
Is there a requirement to match background datasets for cumulative assessment to the meteorological modelling period?	No.	
How are background/baseline datasets used when modelling future years? (are future changes considered or is same value applied for each modelled year)	Future year background is assumed to be the same as current year observations.	
How is spatial variation in background accounted for in modelling assessment? For example do you use multiple sites to develope a spatially varying background or is a single value (whether an annual average or short term %ile) chosen to add to model predictions?	For NEPA, sources tend to be more rural (e.g., oil and gas, power generation, etc.) so there are limited number of monitors nearby so typically use just the closest most representative monitoring site.	
What are some of the methods used to account for spatial variation?	Have different background for subregional areas of a development for a sprawled out source (e.g., oil and gas) and monitoring data support it. For existing source can base background data on wind direction to make sure source is not included in background.	
Is there a standard / prescribed approach for the analysis and presentation of short term averages for cumulative air impact assessment?	For the United States NAAQS, match the modeling results to the form of the NAAQS. For example, 1-hour NO_2 NAAQS is usually most limiting so compare the worst case three-year average of the 8th highest daily maximum 1-hour NO_2 concentrations added with the 98th percentile 3-year background for comparison with the NAAQS.	
Do you have procedures for dealing with data gaps or non-continuous data in background datasets (i.e. substitution, interpolutation)?	Try to find years with capture.	
Do you have a % complete or minimum number of data points requirement for background data to describe baseline for cumulative air assessment?	Same as meteorological data, 90% capture by quarter.	
Are the procedures for dealing with data gaps prescribed in guidance / regulation or simply based on standard practice or expert judgement?	For NEPA based on standard practice, but follows PSD permitting guidance.	
Have you needed to complete cumulative impact assessment in data sparse areas?	Yes.	

If your modelling area has insufficient background data (non-continuous data, different period to modelling, not representative of entire domain) how is baseline described?	Try to be conservative tending to overstate background. Have used regional modeling results for some background species that are not routinely measured (e.g., ammonia).	
Are the procedures for describing background in data sparse areas prescribed in guidance / regulation or simply based on standard practice or expert judgement?	For NEPA standard practice.	
Are different PM monitoring techniques / instruments considered when processing monitoring data? For example how different instrumcent might remove components of secondary PM / semi volatiles.	Not typically.	
Background datasets in NSW can contain elevated PM from regional events such as bushfires or regional dust storms.		
Do you exclude data from background datasets for impact assessment where known regional events have occur?	Yes, in United States can remove exceptional events from background and consideration of attainment/nonattainment, such as wildfires, regional windblown dust storms and stratospheric ozone intrusion.	
How is a decision made to exclude what days?	If days have already been flagged and accepted by USEPA exceptional event days than easy to exclude. Otherwise, document anomalous conditions.	
Are excluded days substituted with other data?	Data are excluded and not substituted for as long as still meet 90% capture conditions.	
Are these days also excluded from calculations of annual mean?	Yes.	
Are datasets left intact and different statistic desciptors used instead (median instead of mean, percentiles instead of maximum)?	Typically use form of NAAQS that is percentiles.	
Can you provide publically available report/s with an example of how a prescribed or novel approach was applied in an air pollutant hot spots?		….please provide an ENVIRON BOX weblink.

SHORT TERM CUMULATIVE IMPACT ASSESSMENT		
Purpose: To understand how other jurisdictions present cumulative air impact assessment results for short term averaging periods. In NSW, impact assessment critieria are specified for averaging periods of 10-minute (SO2), 15-minute (CO), 1-hour (NO2, SO2, CO), 8-hour (CO) and 24-hour (PM, SO2). The biggest challenge we face in cumulative assessment relates to 24-hour average PM and 1-hour NO2, including: 1. having insufficient data 2. predicting short term variation into the future. 3. dealing wth existing exceedances. 4. deal with short term atmospheric transformation of NOx.		
Question	**Answer**	
The following are some methods used in cumulative 24-hour impact assessment in NSW (typically for PM). We are interested in your feedback on these methods, whether you have applied a similar method, whether that method is described or prescribed by regulation/guidance, any potential short-comings you see in the method.		
24-hour average modelling predictions added to daily background (contemporaneous period) to describe total cumulative impact.	Typically use form of the standard, which is 98th percentile (8th highest assuming complete data capture). So add modeled 98th PM to monitoring 98th PM.	
Monte carlo modelling used to combine 24-hour average modelling predictions with background data (can be multiple years and multiple stations). Freqency distribution is presented comparing background with cumulative to give indication of risk of additional exceedances of 24-hour goal.	Have not used. Would be a hard sell to U.S. regulators.	
Combining every 24-hour average modelling prediction to every available background data point (multiple years and sites). Freqency distribution is presented comparing background with cumulative to give indication of risk of additional exceedances of 24-hour goal.	Have not done. Regulators want to show that you would not exceed the NAAQS with margin of conservatism, not the probability a violation would occur.	
A single percentile value taken from the background dataset (i.e. 70th %ile) and added to maximum modelling prediction for a receptor to describe total cumulative impact.	Typically use form of standard for both modeling results and background and then add together.	
Please descibe other methods you have used (such as statistical techniques) used to combine background data with modelling predictions in cumulative air impact assessment.	Have used concurrent temporally matched background with modeling results.	
Are these methods prescribed in guidance / regulation or simply based on standard practice or expert judgement?	Not for BEPA.	
Are you aware of any publically available tools for short term cumualtive assessment?	Not for BEPA.	……i.e. spreadsheets for statistical analysis

METHOD FOR DEALING WITH NOX CONVERSION		
Purpose: To understand how other jurisdictions account for NOx to NO2 conversion, particularly for short term averaging periods. In NSW, the most commonly applied conversion methods are Full Conversion or OLM. Ambient ratios may be applied in certain circumstances. The biggest challenge we face in applying OLM is the lack of monitoring data for NO2 and O3 in rural mining areas.		
Question	**Answer**	
We are interested in your feedback on the various methods for NOx conversion. How is a method selected for use? Typical projects/situations where the method is applied? Whether that method and where is it applied is described or prescribed by regulation/guidance? Effectiveness or limitations of the method?	Have a tiered approach for addressing NOx conversion to NO2 for 1-hour NO2 NAAQS:	
Full conversion	Tier 1 -- if pass done/	
Ambient Ratio Method	Tier 2 -- ARM2 http://www.epa.gov/scram001/models/aermod/ARM2_Development_and_Evaluation_Report-September_20_2013.pdf	
Ozone Limiting Method	Tier 3 -- OLM, or	
Plume Volume Molar Ratio Method	Tier 3 -- PVMRM	
Is guidance given for default in-stack NO2/NOX ratio if not known?	USEPA maintains a database of in-stack NO2/NOx ratios. 20% default for unknown.	
Please describe any other methods used to account for Nox conversion.	Photochemical Grid Models (PGMs; e.g., CMAQ, CAMx, TAPM) and photochemical plume models (e.g., SCICHEM) as alternative models.	
Can you provide publically available report/s with an example of how a prescribed or novel approach was applied for NOX conversion?	http://www.slideserve.com/haig/application-of-scichem-2012-for-1-hour-no-2-concentration-assessments	….please provide an ENVIRON BOX weblink.

DISPERION MODELLING		
Purpose: To understand how other jurisdictions deal with some of the modelling challenges in cumulative air impact assessment.		
Question	**Answer**	
What is the process for including 'other sources' of emissions in modelling?	For NEPA have to include reasonably foreseeable development (RFD) sources. RFD includes approved, proposed and anticipated new sources that will come online in the future.	…..may have been answered in 'Air Pollution Hotspots'
How are other sources selected for inclusion? i.e. is it an objective or subjective process, based on distance to receptors, magnitude of emissions, proximity to the 'subject' source, risk or impact from subject source, constrined by size of modelling domain?	For near-field assessment typically within 50 km of source. For far-field assessment typically with 300 km of receptors of interest.	
Is the process prescribed in guidance / regulation or simply based on standard practice or expert judgement?	EPA modeling guidance restrict near-field models to within 50 km of source.	
How are emissions data estimated / obtained for 'other sources'?	Review of NEPA EIS and EA documents and permit applications. Contact state and federal agencies.	
How are source characteristics / parameters for modelling determined for 'other sources'?	From EIS/EA and permit applications. And engineering judgement if unavailable.	
How Is the suitability of emissions data determined?	Through engineering judgement.	
What is the typical temporal resolution of emission data for 'other sources' - annual, daily, hourly?	Typically have annual average emissions for annual NAAQS and deposition, max hourly for 1-hour NO2 and SO2 and maximum 24-hour for 24-hour averages (e.g., PM).	
Do you include future emissions sources in modelling?	Yes.	
Is this for committed development only?	No, RFD includes all potential sources including reasonably anticipated development.	
What information sources are used to identify future sources and estimate emissions?	Contact state and federal agencies	
Do you typically allow for boundary conditions or emissions from outside the modelling domain?	For Photochemical Grid Model (PGM) applications always. For near-source AERMOD applications assume represented bin background.	
If so, what is the process and is it prescribed in guidance / regulation or simply based on standard practice or expert judgement?	For PGM modeling typically use output from a Global Chemistry Model (GCM) to provide day-specific diurnally varying boundary conditions. USEPA draft modeling guidance (2014) recommends using GCM output (http://www.epa.gov/ttn/scram/guidance/guide/Draft_O3-PM-RH_Modeling_Guidance-2014.pdf).	
Is there a process or prescribed approach to avoid 'double counting' and / or calibrate model predictions? For example where existing emission sources are included in the modelling asssessment and also potentially contribute to the monitoring data used to describe background/baseline.	Not typically as conservative. But can make case to excludes days in background when modeled source has impact or have background a function of wind direction.	

Is an "existing scenario" typically modelled and used to 'calibrate' the model by comparing to monitoring data?	No.	
Meteorological data for modelling.		
How many years of meteorological data are selected for modelling?	Typically a minimum of 3 years, 5 years also used sometimes.	
Are the number of years prescribed in guidance / regulation or simply based on standard practice or expert judgement?	PSD permitting has guidance. For NEPA use minimum 3 years to be consistent with NAAQS.	
Are climate change or climate cycles considered when choosing the number of years to consider?	No.	
If onsite / site specific data are not available, how are representative met data selected and demonstrated to be represenative?	Examination of topography and distance to source.	
What are the prescribed percentage complete requirements?	At least 90% data capture for each quarter.	
Do you have prescribed guidance for calm conditions?	AERMOD treats calms as missing.	
Is model uncertainty considered as part of an assessment of risk or in sensitivty analysis for cumuative assessment?	Not typically	
Have you modelled intermittant / instantaneous emissions such as NOx from blasting in mining applications? How are these intermittant / instantaneous sources considered cumulatively with other continuous sources such as diesel mining equipment?	Initially (Tier 1) assume maximum hourly emissions operating 8760 hours per year for all sources. If exceed NAAQS, then refine assumptions using operating schedules, actual emissions, etc.	
Can you provide a publically available report with an example of how a this was done?	Provided link to BLM CD-C EIS previously.	….please provide an ENVIRON BOX weblink.
Can you provide publically available report/s with an example of how a prescribed or novel approach was applied to deal with any of the above challenges?	See CD-C FEIS.	….please provide an ENVIRON BOX weblink.